Understanding Motor Development

INFANTS • CHILDREN • ADOLESCENTS • ADULTS

SEVENTH EDITION

DAVID L. GALLAHUE
JOHN C. OZMUN
JACQUELINE D. GOODWAY

SeventhE dition

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Infants, Children, Adolescents, Adults

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To *the Sunshine of My Life:*
Ellie, David Lee and Julie (Adam, Alec & Ian),
Jennifer and Dan (Paul, Anna & Bethany); and to Ruy Jordana Krebs, PhD, my esteemed Brazilian colleague, who lived a life in the search for truth concerning the motor development and movement education of children and youth

David L. Gallahue

To *the Treasures of My Heart:*
Ruth, Chet, Gus, Johnny, and Ray

John C. Ozmun

To my daughter Blaize who keeps the inner child in me alive and to my parents who gave me the wings to fly

Jackie D. Goodway

Brief Contents

Contents

Preface

Audience

Understanding Motor Development is written for students taking a first course in motor development. It is presented in an easy-to-understand and easy-to-use manner to be of significant value to educators from a variety of disciplines, including kinesiology, physical and occupational therapy, special education, early childhood education, and elementary and secondary education. This text provides both descriptive and explanatory profiles of the individual from conception through adulthood.

Approach

Development is a process that begins at conception and continues throughout life. This text discusses motor development from conception through adulthood. By incorporating dynamic systems theory and phase stage theory, the Triangulated Hourglass Model provides the reader with a metaphor for conceptualizing both the explanatory and descriptive aspects of both the processes and products of motor development.

Content

Organization

Unit I: Background, provides the reader with essential introductory information on the study of motor development. Chapter 1, "Understanding Motor Development: An Overview," examines the history, methods of study, research problems, and terminology used in the study of motor development. Chapter 2, "Models of Human Development," offers a discussion of developmental models of child development. Particular attention is given to dynamic systems theory as well as the works of Jean Piaget, Erik Erikson, and Urie Bronfenbrenner and the implications of each for motor development. In chapter 3, "Motor Development: A Theoretical Model," a theoretical framework for studying the process of motor development is presented. The phases and stages of this life span model, as well as the subsystems of the task, the individual, and the environment, are presented as a triangulated hourglass metaphor, or heuristic device, and serve as the organizational framework for the remainder of the text. In chapter 4, "Selected Factors Affecting Motor Development," there is an important discussion of critical factors within the individual, environment, and movement tasks that influence the process of development throughout life.

Unit II: Infancy, deals with a variety of important developmental topics of infancy. Chapter 5, “Prenatal Factors Affecting Development,” is devoted to discussion of those factors prior to birth that may affect later motor development. “Prenatal and Infant Growth” is the topic of chapter 6. This chapter provides the reader with a descriptive profile of early growth processes. Chapter 7 examines “Infant Reflexes and Rhythmical Stereotypies” in the neonate and young infant. Particular attention is given to the integration of both into the expanding movement repertoire of the young child. Chapter 8, “Rudimentary Movement Abilities,” discusses the rapidly expanding movement repertoire of infants. The major stability, locomotor, and manipulative tasks of this period are outlined and summarized. An extensive discussion of “Infant Perception” in chapter 9 concludes the section on infancy. This chapter relates perceptual development to the motor behavior of infants.

Unit III: Childhood, provides the reader with a wealth of important information about childhood motor development. Chapter 10, “Childhood Growth and Development,” offers a general overview of cognitive, affective, and motor characteristics during early and later childhood. This sets the stage for the three chapters that follow. Chapters 11 and 12, “Development of Fundamental Movements—Manipulative Skills” and “Development of Fundamental Movements—Locomotor Skills” provide a practical, easy-to-use, stage approach (initial stage, emerging stage, proficient stage) to observing and assessing the fundamental movement patterns of childhood. Mechanically correct line drawings provide a visual description that coincides with a brief verbal description of each stage, along with frequently encountered developmental difficulties. “Physical Development of Children” is the topic of chapter 13. A review of the latest information on children’s health-related fitness and motor fitness is presented along with information on fitness training for children. “Perceptual-Motor Development and Motor Skill Intervention” is the topic of chapter 14. Important information on both of these topics is reviewed and synthesized with a view toward their complex interaction with the motor behavior of the individual.

Unit IV: Adolescence, examines a number of important topics. Chapter 15, “Adolescent Growth, Puberty, and Reproductive Maturity,” opens this section with a wealth of important and useful information about physical change during this critical developmental period. Chapter 16, “Specialized Movement Skills,” centers on the topics of specialized movement skill development, fostering improvement, and the developmental sequence of specialized movement skills. This is followed by a discussion of the “Fitness Changes During Adolescence” in chapter 17 with a view toward their rapidly changing health-related and performance-related fitness.

Unit V: Adulthood, provides the latest information available on the rapidly developing area of adult motor development. Chapter 18, “Physiological and Psychosocial Development in Adults,” attempts to answer the question: Why do we age? A lively discussion is offered concerning changes in the adult musculoskeletal system, central nervous system, circulatory and respiratory systems, and sensory systems. Chapter 19, “Motor Performance in Adults,” examines reaction time, balance and postural control, falls, gait, activities of daily living, and the elite performer.

Featured in This Edition

Key Terms and Chapter Competencies

Important terms that will be used and competencies that should be attained through careful and reflective reading of each chapter are found at the beginning of each chapter. Take a few minutes to look these over in preparation for reading each of thec hapters.

Key Concepts and Chapter Concepts

At the beginning of each chapter we provide a text box with a Key Concept. That concept is the overarching thought that we are trying to convey in the chapter. Several more Concepts boxes throughout the chapter highlight particular topics of discussion. For us, understanding motor development is not a matter of memorizing isolated facts, but very much a matter of understanding important developmental concepts and being able to apply these concepts as a parent, teacher, coach, or therapist in real-lifes ettings.

Developmental Dilemmas

The study of human development is fascinating. It not only helps us better understand our own personal developmental journey and that of others, it also raises many interesting and perplexing questions. In this edition we explore Developmental Dilemmas within a box in each chapter.

International Perspectives

Although human growth and development is a universal process, perspectives on various aspects differ depending on cultural norms, ethnicity, socioeconomic conditions, and a host of other factors. In this edition we try to bring some of these perspectives to light with a box in each chapter focusing on varying International Perspectives. They should not only be quite interesting to read and consider, but should also generate thought-provoking discussion.

Critical Readings

At the conclusion of each chapter we provide a brief list of Critical Readings for those interested in learning more about the topics covered. We have selected these carefully with the intent of providing the reader with additional information from top authorities in their respective fields.

Questions for Reflection

At the conclusion of each chapter is a list of questions to consider. Take time to look these over and see how well you can answer them. They are intended to serve as a guide to better understanding motord evelopment.

Figures and Tables

Throughout the text we have included a wide variety of figures and tables. They are intended to synthesize information and to provide a visual reference for better understanding motor development.

Glossary of Terms

Words have meaning and it is important in the field of motor development, as with any other movement science, to be certain we are using terminology that conveys similar meaning. The Glossary provides a brief definition of words highlighted throughout the text. This is done to ensure that we and our readers worldwide are "on the same page" when discussing a topic.

Bibliography

We provide a chapter-by-chapter bibliography at the end of the book. These references have been selected because of their timeliness and because they represent seminal works in the particular area of motor development being discussed.

Annotated Web Resources

Each chapter includes Web Resources, a listing of websites that students can explore to find chapter-related information on the Internet. This feature allows students to expand their knowledge according to their abilities and goals and offers a springboard for independent learning. They are now annotated in this new edition to provide even further information regarding what students will gain by searching those sites.

Appendix A: Professional Position Papers Related to Motor Development Issues

This updated appendix provides a comprehensive list of position papers on a wide variety of topics in motord evelopment.

Appendix B: Professional Organizations Related to Motor Development Issues

This updated appendix provides a reference list of the major organizations and their website information, which will be a handy guide for students doing research or interested in becoming a member of the organization.

New or Expanded Topics

This new edition has been significantly revised and updated to include the latest research, reference information, and suggested readings in the field. Tables and figures have been updated throughout the text to reflect the latest research. Definitions and key terminology have been enhanced throughout for further clarity. Following is a sampling of topics in each unit that are either new to this edition or greatly expanded since the last edition:

Unit I: Background

- Expanded explanations and discussions of leading theoretical perspectives on the processes and products of motor development across the lifes pan
- Revised and clarified presentation of the *Triangulated Hourglass Model* of motor development, and how it serves as a metaphor for conceptualizing the processes and products of motor development
- Expanded discussion on risk factors affecting motord evelopment
- New International Perspectives on the processes and products of motor development
- New Developmental Dilemmas to stimulate criticalt hinkinga nddi scussion

Unit II: Infancy

- Updated data presented on vital statistics with infants
- Enhanced discussion on intervention strategies
- Enhanced International Perspectives on motor development during infancy
- New Developmental Dilemmas to stimulate critical thinking and discussion.
- Inclusion of current information related to obesity in infancy
- Enhanced International Perspectives on infancy

Unit III: Childhood

- Adjusted age-ranges to reflect developmental rather than chronological timeframes
- Enhanced discussion of gender-related differences with fundamental skills
- Extensive updating of fitness-related materials to reflect current knowledge
- Increased focus on childhood obesity from the psychomotor and affective perspective
- Enhanced International Perspectives on childhood motor development
- New Developmental Dilemmas to stimulate critical thinking and discussion.

Unit IV: Adolescence

- Adjusted age-ranges to reflect developmental rather than chronological timeframes
- Extensive discussion of overweight and obesity issues during the pre-adolescence and adolescencep eriods
- Enhanced discussion related to the foundation of specialized movement skills
- Enhanced discussion related to the foundation of youth sport participation
- Extensive updating of fitness-related materials to reflect current knowledge
- Increased focus on childhood obesity from the psychomotor and affective perspective
- Enhanced International Perspectives on motor development during adolescence
- New Developmental Dilemmas of adolescence to stimulate critical thinking and discussion

Unit V: Adulthood

- Expanded and updated information on aging and muscular strength characteristics
- Inclusion of current information related to overweight and obesity with aging
- Expanded discussion on the influence of physical activity and mental health
- Enhanced International Perspectives on adult motord evelopment
- New Developmental Dilemmas of adulthood to stimulatec ritical thinkinga nd discussion

ANCILLARIES

Online Learning Center (www.mhhe.com/gallahue7e)

The website that accompanies the text provides additional opportunities for learning the material and conducting research. Access to the website is free to instructors.

The Instructor's Manual, PowerPoint presentations, and Quizzes are all available to instructors at the Online Learning Center (www.mhhe.com/gallahue7e).

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SeventhE dition

UNDERSTANDING MOTOR DEVELOPMENT

Infants, Children, Adolescents, Adults

UNIT I

Background

With chiselled touch
The stone unhewn and cold
Becomes a living mould.
The more the marble wastes,
The more the statue grows.

—Michelangelo

CHAPTER 1

UNDERSTANDING MOTOR DEVELOPMENT: AN OVERVIEW

KEY TERMS

Longitudinalm ethod
Cross-sectionalm ethod
Mixed-longitudinalm ethod
Biologicala ge
Growth
Development
Maturation
Experience
Motor
Learning
Motorlea rning
Motors kill
Motorb ehavior
Motorc ontrol
Motord evelopment
Motorp erformance
Movement
Movementp attern
Fundamentalm ovementp attern
Movements kill
Sports kill
Environmentalc ontext

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Be familiar with the research of several historical and contemporary scholars in motor development
- Compare and contrast motor development with other studies in motor behavior (motor learning and motor control)
- Demonstrate knowledge of the various forms of analysis used in the study of motor development
- Discuss advantages and shortcomings of the major methodologies associated with the study ofc hange
- Identify key methods of assessing biological maturity
- List the chronological age classifications of human development across the life span
- Define and apply terminology used in motor development
- Discuss the advantages and shortcomings of various methods ofc lassifying movement skills

KEY CONCEPT

Motor development is continuous change in motor behavior throughout the life cycle, brought about by interaction among the requirements of the movement task, the biology of the individual, and the conditions of the environment.

Movement is life. All that we do in our work and our play involves movement. Our very existence depends on the beating of our heart, the inhaling and exhaling of our lungs, and a host of other life-giving voluntary, semiautomatic, and automatic movement processes. Understanding how we gain motor control and movement coordination is fundamental to understanding how we live. Understanding the developmental process for the typically developing individual provides critically important guidelines for effective teaching and learning. For individuals with developmental disabilities, understanding motor development provides a sound basis for intervention, therapy, and remediation. Knowledge of the processes of development lies at the core of education whether in the classroom, the gymnasium, or on the playing field. Without sound knowledge of the developmental aspects of human behavior, we can only guess at appropriate educational techniques and intervention procedures. Developmentally based instruction incorporates learning experiences that are not only age-appropriate, but also developmentally appropriate and fun. Instruction is an important aspect of the teaching-learning process. Instruction, however, does not explain learning; development does.

CONCEPT 1.1

Instruction does not explain learning; developmentd oes.

Until relatively recently, the research conducted on the developmental aspects of movement behavior has been more limited in scope and magnitude than that conducted on cognitive and affective development. Historically, developmental psychologists tended to be only marginally interested in motor development, and then frequently only as a visual indicator of cognitive functioning or social-emotional status.

The primary thrust of motor development research has come from the many branches of psychology, so it is natural that motor development has frequently been viewed through its potential influences on other areas of behavior, and as a convenient and readily observable means of studying behavior, rather than a phenomenon worthy of study for its own sake.

CONCEPT 1.2

The study of motor development in the past was overshadowed by interest in cognitive and affective development.

The study of motor development cuts across the fields of exercise physiology, biomechanics, motor learning, and motor control, as well as the fields of developmental psychology and social psychology (Thomas & Thomas, 1989). The quest for understanding progressed at a slow but steady pace in the 1960s, and then began to escalate in the 1970s as developmental kinesiologists and psychologists shifted their focus away from a normative-descriptive approach back to the study of the underlying developmental processes.

During the 1980s an ever-expanding body of research by a new generation of scholars heightened interest in the study of motor development. An unprecedented amount of theory-based research has been conducted since the 1980s with developmentalists from a variety of fields interfacing with motor development scholars. The study of motor development has taken its place as an area of scientific inquiry within the fields of kinesiology and developmental psychology. Now, in the twenty-first century, scholars are studying the underlying processes of development and its many and varied products. They are doing so in a coordinated manner to better understand movement control and coordination from a developmental perspective. Their research results are now being implemented in practical teaching-learning scenarios by dedicated parents, teachers, coaches, and therapists.

The term *developmental kinesiologist*, first coined by Smoll (1982), has come into popular use today to describe those who study motor development. These developmentalists recognize that the specific physical and mechanical demands of a movement task transact with the biology of the individual and the conditions of the learning environment. Transactional models like the one depicted in Figure 1.1 imply that factors (constraints) within the task, the individual, and the environment are not only influenced by one another (interaction) but also may be modified (transaction) by one another.

The information contained here is not the last word on motor development, but it is an honest attempt to be the latest word. Because research and study in this area are expanding rapidly, it is difficult to encompass all that is happening in this unfolding field. If it is to be of practical value to parents, teachers, coaches, and therapists, the study of motor development must not focus only on the skilled performer in controlled laboratory settings. It must also analyze and document what individuals of all ages can do under both normal and augmented circumstances. Take time to reflect on the important concepts that are contained in text boxes throughout each chapter. These concepts synthesize what we currently know from systematic research and scholarly inquiry. Research is probably best defined as "the search for truth." Research serves as the basis for *Understanding Motor Development*, the very title of this text, and expands our knowledge base as to what we do not know yet. As the authors of this textbook, our goal is to help you make practical application of this information in order to be more effective as a parent, teacher, coach, or therapist.

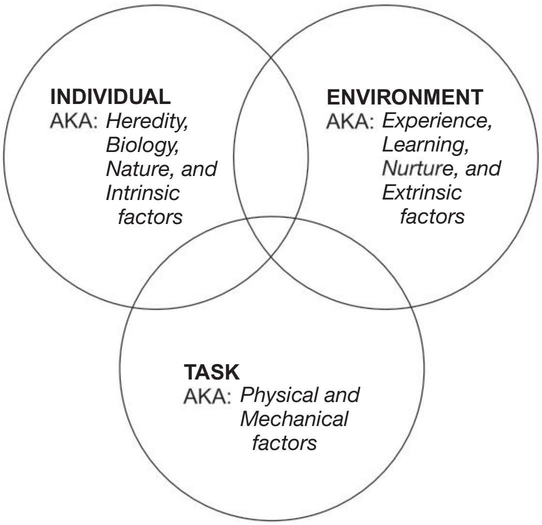

Figure 1.1
A transactional view of causation in motor development.

Life Span Study of the Developmental Process

Development is a continuous process beginning at conception and ceasing only at death. Development encompasses all aspects of human behavior and as a result may only be artificially separated into "domains," "stages," or "age periods." The acceptance of the concept of "life span" development is important to keep in mind. As study of the skilled athlete during adolescence and adulthood is important, so also is the study of movement during infancy, childhood, and later life. Much can be gained by learning about motor development at all ages and by viewing it as a lifelong process.

Concept 1.3

Development is a lifelong process beginning at conception and ceasing only at death.

Life span perspectives do not view development as domain-specific, stagelike, or age-dependent. Instead, the life span perspective suggests that *some* aspects of one's development can be conceptualized into domains, as being stagelike or age-related, whereas others cannot. Furthermore, the concept of life span development encompasses all developmental change—the positive changes generally associated with infancy, childhood, and adolescence as well as the changes that take place with the regressive aging process.

Motor development is highly specific. The once commonly accepted notion of *general* motor ability has been disproved to the satisfaction of most scholars in the field. Superior ability in one area does not guarantee similar ability in others. The outmoded concept that one either possesses or does not possess ability in movement situations has been replaced by the concept that each person has specific capabilities within each of the many performance areas. Various factors involving movement abilities and physical performance interact in complex ways with cognitive and affective development. Each of these factors is in turn affected by a wide variety of biological, environmental, and specific task-related demands.

The process of development, and more specifically the process of motor development, should constantly remind us of the individuality of the learner. Each individual has a unique timetable for the acquisition of *movement abilities* (i.e., the maturationally based actions of early infancy) and *movement skills* (i.e., the experientially based actions of early childhood and beyond). Although one's "biological clock" is rather specific when it comes to the sequence of movement skill acquisition (maturation), the rate and extent of development is individually determined (experience) and dramatically influenced by the performance demands of the task. Typical age periods of development are just that: typical, and no more. Age periods merely represent approximate time ranges during which certain behaviors may be observed. Overreliance on these periods would negate the concepts of continuity, specificity, and the individuality of the developmental process.

CONCEPT 1.4

Development is age-related but not age-dependent.

The study of motor development dates back only to the early part of the twentieth century. The following sections briefly review the history and methods of study in motor development.

History of Motor Development

The first serious attempts to study motor development, the youngest of the movement sciences, were made from a maturational perspective, led by Arnold Gesell (1928) and Myrtle McGraw (1935). The maturationalists contended that development is a function of inborn biological processes that result in a universal sequence in infant movement skill acquisition. Theorists also contended that although the environment may influence developmental rate, the effects are only temporary because of the powerful influence of one's genetic inheritance. Since these early pioneering efforts Gesell's and McGraw's names have become legend in motor development research. Much of what we know about the sequence of infant movement skill acquisition is based on the descriptive work of Gesell and McGraw as well as that of Mary Shirley (1931) and Nancy Bayley (1935). The surge of research that these scholars brought about was largely motivated by their interest in the relationship of maturation and learning processes to cognitive development. In their separate but remarkably similar studies, these early researchers chronicled the well-known sequences of motor development during infancy. Their naturalistic observations of children provided a great deal of information about the sequential progression of normal development from the acquisition of early rudimentary movements to mature patterns of behavior.

The studies of Gesell and Thompson (1929, 1934) and McGraw (1935, 1940) are classics in the use of the co-twin control method of studying development. Their hypothesis was that if two infants with identical sets of genes were given different experiences it would be possible to demonstrate the relative influence of both heredity and the environment on learning the specific skills incorporated into the study design. The results of their studies concluded that although the <u>rate</u> at which the trained twin acquired the selected movement skills was faster than that of the nontrained twin, the sequence was invariable and the advantage short-lived. This research provided better understanding the differences between developmental rate and developmental sequence. In essence, the rate of motor development can be influenced by persistent environmental conditions, but the sequence of development in acquisition of the rudimentary movement abilities of infancy are highly resistant to change.

Monica Wild's study of throwing behavior (1938) was the first inquiry into developmental movement patterns in school-aged children. Unfortunately, after her study, outstanding in depth and completeness, there was little interest in exploring the various aspects of motor development until the end of World War II.

After World War II a new breed of motor developmentalists emerged. Led by Anna Espenschade, Ruth Glassow, and G. Lawrence Rarick (as cited in Rarick, 1981), these individuals focused on describing the motor performance capabilities of children. All three were physical educators and as such were interested in understanding the outcomes of motor development for its own sake. Furthermore, their work focused on movement skill acquisition in school-aged youth rather than on infant motor performance. Although the extent of research during this period was limited and the pace slow, the work of these three early leaders did much to keep motor development alive as a legitimate field of scholarly inquiry. Clark and Whitall (1989) credit Espenschade, Glassow, and Rarick for motor development's emergence as a separate field of study within the physical education (kinesiology) profession.

Since 1960 the knowledge base in the study of motor development has grown steadily. The work of Lolas Halverson (1966) and several of her graduate students at the University of Wisconsin (Halverson & Roberton, 1966; Halverson, Roberton, & Harper, 1973; Halverson & Williams, 1985) on the acquisition of mature fundamental movement patterns did much to revive interest in children's research because of its emphasis on identifying the mechanisms behind the acquisition of skill rather than the final skill. *Fundamental Motor Patterns* (1983) by Ralph Wickstrom and the research conducted by Vern Seefeldt (1972) and his associates (Branta, Haubenstricker, & Seefeldt, 1984; Seefeldt & Haubenstricker, 1982) at Michigan State University on fundamental movement skill acquisition set the stage for the exciting research of the 1980s and beyond.

During the 1980s and 1990s, the emphasis of study in motor development again shifted dramatically. Instead of focusing on the product of development as with the normative/descriptive approaches of the preceding three decades, emphasis shifted back to understanding the underlying processes involved in motor development. Although the critical importance of heredity was recognized, complementary importance was now accorded to the conditions of the learning environment and the specific requirements of the movement task or action.

Researchers led by the seminal work of Kugler, Kelso, and Turvey (1980) formulated new theoretical frameworks for the control and development of motor behavior. Since then the work of Esther Thelen and her colleagues (1986a, 1986b, 1987a, 1987b, 1991, 1994), Jane Clark and her colleagues (1988, 1989), and others led to the formulation of a systems theory of motor development, guiding much of the research being conducted at the present time.

Three guiding principles drive what has become known as dynamic systems theory. First, the body is viewed as being composed of several systems (muscular, skeletal, neural, perceptual, biomechanical) that are self-organizing and can form patterns of behavior that come about from interaction of the component parts. Second, these systems and their various subsystems self-organize in complex and cooperative ways based on the specific requirements of the movement task and in response to various affordances and constraints. And third, development is seen as a discontinuous process with new patterns of movement replacing old ones (Thelen & Ulrich, 1991).

Concept 1.5

Historically, the study of motor development has gone through periods that have emphasized various explanations of the developmental process.

In summary, the years from about 1930 through World War II could be characterized as the "maturational period" and those from 1946 through the 1970s as the "normative/descriptive period" for the study of motor development. The time from the 1980s to the present may be described as the "process-oriented period" (Clark & Whitall, 1989). The study of motor development began with a process orientation (i.e., studying the underlying biological processes governing maturation), then shifted to a product orientation (i.e., describing the mechanics of various stages of movement skill acquisition, and developing normative criteria for a variety of motor performance measures), and moved back to a process orientation (i.e., explaining the processes causing change in motor behavior over time). Important research is now being conducted throughout much of the world on the critically important topic of motor development from infancy through adulthood.

Methods of Studying Development

Motor development is studied in three ways: the longitudinal method, the cross-sectional method, and the mixed-longitudinal method. Because motor development research involves the study of changes that occur in motor behavior over time, the longitudinal method of study is ideal and the only true means of studying development.

The **longitudinal method** of data collection attempts to explain behavior changes over time (i.e., developmental time) and involves charting various aspects of an individual's motor behavior for several years. The longitudinal approach allows one to observe changes in selected variables over time and, although time consuming, treats the study of motor development as a function of developmental time rather than age (i.e., real time). The longitudinal method involves study of a single group of individuals, all at the same age, over several years. The major purpose of the longitudinal study is to measure age-related *changes* in behavior. It does not, however, permit measurement of age *differences* in development. In short, the longitudinal method permits study of intraindividual change over time.

The Medford Boys Growth Study conducted by H. Harrison Clarke (1971) from 1956 to 1968 is one of the most complete longitudinal studies of growth ever carried out. The motor development study, begun in 1966 by Vern Seefeldt at Michigan State University and continuing for over thirty years, collected extensive anthropometric data as well as thousands of feet of film footage on children performing selected fundamental movement skills. The treadmill stepping research of Beverly and Dale Ulrich when at Indiana University (1995) collected extensive data on the onset of quality walking in infants with Down syndrome. All are fine examples of longitudinal studies of growth and motor development.

The longitudinal method of data collection is time consuming. Additionally, the dropout rate is often great because participants move or become ill or disabled. Therefore, large numbers of participants need to be tested to retain a representative sample at the end of the five- to ten-year study period. Problems in methodology and design are also likely to creep into the longitudinal study. Varying levels of reliability and objectivity in testers over the course of the study period may cause problems in data interpretation. The potential accrued learning effects from repeated performances on the measured items have also proven troublesome. These difficulties have prompted many researchers to opt for the cross-sectional approach.

The **cross-sectional method** of study permits the researcher to collect data on different groups of people at varying age levels at the same point in time. The major purpose of the cross-sectional study is to measure age-related differences in behavior. This method does not permit measurement of age-related *change* and so has attracted controversy. The cross-sectional method yields only average *differences* in groups across real time and not individual changes across developmental time. The basic assumption behind the cross-sectional study has been that random selection of research participants will provide a representative sample of the population for each age group tested. It is questionable, however, that this assumption can be met in most cases. In reality, cross-sectional studies, although simple and direct, can only describe typical behaviors at the specific ages studied. As a result, they are not considered by most authorities to be true developmental studies. The problem is that historically the vast majority of motor development research has used the cross-sectional approach.

To overcome the glaring weakness of the cross-sectional technique, developmental psychologists and motor development researchers frequently combine the cross-sectional and longitudinal research designs in individual research investigations. This sequential method of studying development, or **mixed-longitudinal method,** combines the best aspects of the cross-sectional and longitudinal methods. It covers all of the possible data points necessary for describing and/or explaining both differences and change over time as functions of development as well as functions of age. Research participants are selected and studied cross-sectionally, but they also are followed longitudinally for several years. This permits comparison of cross-sectional data results with longitudinal results and serves as a means of validating or refuting age-related changes with true developmental changes. It also gives the researcher an opportunity to analyze and report on preliminary data early in the investigation rather than waiting five or more years.

CONCEPT 1.6

Whereas age-related changes in motor behavior can be studied through cross-sectional research designs, true developmental change can only be studied through longitudinal and mixed-longitudinal research designs.

The longitudinal, cross-sectional, and mixed-longitudinal methods of study may be applied to a variety of research formats. An investigation may take the form of an experimental study, the most powerful method because of the rigid controls required, or it may be cross-cultural, involving naturalistic observation, surveys, interviews, case history reports, or a combination of these techniques. Table 1.1 provides a brief overview of these formats for studying development.

As noted earlier, there has been a shift in the study of motor development from process to product and now back to process again. The early researchers emphasized the importance of *process-oriented research,* that is, form and function. H. M. Halverson (1931, 1937), Shirley (1931), and Wild (1938) all focused on the sequential acquisition of movement patterns. Their suggestions for studying the process of motor skill development went largely unheeded until the 1980s, when interest in such study was revived; since then, it has been a focus of motor development research. The use of cinematography, electrogoniometry, and electromyographic techniques in conjunction with computer analysis has enhanced our knowledge of the process of movement, its underlying motor mechanisms, and resulting influence on the movement product.

Product-oriented research, or research on the performance capabilities of individuals, has been conducted for many years. This type of research is concerned typically with the outcome of the individual's performance. The distance a ball travels, the velocity with which it can be kicked, or how far one can jump are examples of motor performance

TABLE 1.1 Primary Methods of Studying Motor Development

Longitudinal study: The same individuals are studied over a five- to ten-year period

Cross-sectional study: Different individuals representing a variety of ages are studied at the same point in time

Mixed-longitudinal study: A sequential method of studying development that combines essential elements of both the longitudinal and cross-sectional methods

Experimental method: Random selection and/or assignment of participants to treatment conditions
Rigid control of influencing variables

Cross-cultural: May or may not use an experimental design. Comparison of various factors across different cultures

Naturalistic observation: Nonobtrusive observation of behavior in the natural environment

Survey: Group or personal interviews on a series of selected topics to reveal attitudes, opinions

Case history: Report on individual participants providing a variety of detailed background information scores. Strength, endurance, power, balance, and flexibility as measured by a particular battery of tests are examples of fitness performance scores.

CONCEPT 1.7

Motor development may be studied from either a process or a product orientation.

DEVELOPMENTAL DILEMMA

Frail Old: You Have Got to Be Kidding!

In an earlier edition of this textbook we used the term "frail old" for persons aged 80 and over. Oh my! What a commotion that caused in the very office where the senior author worked. You see, one of our secretaries, Lucille, who was quite spry at age 82, in reviewing a copy of the just published text, replied somewhat indignantly: "'Frail old' at age 80 and beyond, how can that be? You have got to be kidding. Don't call me frail old! I work an eight-hour day and still have plenty of energy left to tend to my activities of daily living and to enjoy my leisure time. Furthermore, many of my friends and acquaintances of the same age or older are much like me and certainly NOT frail old."

Even though other textbooks and published articles commonly used this term at the time to describe those 80 years old and beyond, to my chagrin I could not adequately defend use of the term "frail" to Lucille. I had violated the key concept that development is age-related but not age-dependent, and had made Lucille quite displeased with me.

The dilemma facing us is that the use of chronological age is the most convenient and universal means of classification. It is, however, also the least valid means of indicating where one is developmentally. As a result, we have revised our terminology in referring to those 80 years and older. We now use the term "oldest old." Bland perhaps, but certainly not offensive.T hanky ou, Lucille.

AGE CLASSIFICATIONS OF DEVELOPMENT

Developmental levels may be classified in a variety of ways. The most popular method, but often the least accurate, is classification by chronological age. *Chronological age,* or one's age in months and/or years, enjoys universal use and represents a constant. By knowing one's birth date we can easily calculate age in years, months, and days. Table 1.2 provides a conventional chronological classification of age from conception through older adulthood. Although chronological ages are highly specific during the early years, they become increasingly more general throughout life. As you review this table keep in mind that although development is age-related, it is not age-dependent. Chronological age merely provides a rough estimate of one's developmental level, which may be more accurately determined through other means.

The **biological age** of an individual provides a record of his or her rate of progress toward maturity. It is a variable age that corresponds only roughly to chronological age and may be determined by measures of: (1) morphological age, (2) skeletal age, (3) dental age, or (4) sexual age.

Morphological age is a comparison of one's attained size (height and weight) to normative standards. Normative size was first determined by Wetzel (1948) and others through exhaustive charting of heights and weights of thousands of individuals. The Wetzel Grid was used for many years by most pediatricians as the primary means of determining the morphological age of their patients. Although not used today due to secular changes (i.e., generational changes) in height and weight, the Wetzel Grid was at one time the most popular method of determining morphological age. Today, pediatricians use the physical growth charts developed by the National Center for Health Statistics (2000). Copies of these charts are located in chapter 6 (birth to 24 months) and chapter 10 (ages 2–20) and can be found online at *cdc.gov/nchs/.*

Skeletal age provides one with a record of the biological age of the developing skeleton. Skeletal age can be accurately determined by x-ray of the carpal bones of the hand and wrist. Skeletal age

TABLE 1.2 Conventional Chronological Classifications of Age

Period		Approximate Age Range
I	PrenatalL ife	(Conception to Birth)
	A. Period of the zygote	Conception–1 week
	B. Embryonic period	2 weeks–8 weeks
	C. Fetal period	8 weeks–Birth
II	Infancy	(Birth to 24 Months)
	A. Neonatal period	Birth–1 month
	B. Early infancy	1–12 months
	C. Later infancy	12–24 months
III	Childhood	(2 Years to 10 Years)
	A. Toddler period	24–36 months
	B. Early childhood	3–5 years
	C. Middle/later childhood	6–10 years
IV	Adolescence	(10 Years to 20 Years)
	A.P repubescence	10–12 years (F)
		11–13 years (M)
	B.P ostpubescence	12–18 years (F)
		14–20 years (M)
V	Young Adulthood	(20 Years to 40 Years)
	A. Novice period	20–30 years
	B. Settling period	30–40 years
VI	Middle Adulthood	(40 Years to 60 Years)
	A. Midlife transition	40–45 years
	B. Middle age	45–60 years
VII	Older Adulthood	(60+ Years)
	A. Youngold	60–70 years
	B. Middle old	70–80 years
	C. Oldest old	80+ years

is used as a laboratory research tool and in cases where growth is either extremely delayed or accelerated. It is rarely used as a measure of biological age outside laboratory or clinical settings because of cost, inconvenience, and the accumulative effects of radiation.

Dental age is another accurate but infrequently used means of determining biological age. The sequence of tooth development from first appearance of the cusp to root closure provides a measure of calcification age. Eruption age may also be determined by charting the progressive emergence of the teeth.

Sexual age is a fourth method of determining biological age. Sexual maturation is determined by the variable attainment of primary and secondary sexual characteristics. The Tanner maturity scale (Tanner, 1962) is an accurate means of assessing sexual maturity. It is described in chapter 15. This method is used infrequently because of social and cultural constraints.

Several other methods of classifying one's age exist. They include measurements of: (1) emotional age, (2) mental age, (3) self-concept age, and (4) perceptual age. *Emotional age* is a measure of socialization and ability to function within a particular social/cultural milieu. *Mental age* is a complex measure of an individual's mental potential as a function of both learning and self-perception. It often fluctuates within one's lifetime. *Self-concept age* is a measure of an individual's personal assessment of his or her value or worth. *Perceptual age* is an assessment of the rate and extent of one's perceptual development.

CONCEPT 1.8

Although chronological age is the most commonly used means of age classification, it is frequently the least valid.

All measures of maturity are variable. They are related to chronological age but are not dependent upon it. Therefore, anyone who works with infants, children, adolescents, or adults must avoid overreliance on a chronological classification of age simply because of its ease and convenience.

TERMINOLOGY USED IN MOTOR DEVELOPMENT

Gaining a working knowledge of the terms commonly used in any area of study is important. Whether it is medicine or law, special education or economics, there is jargon typical to each field, and motor development is no exception. A variety of terms that have come into common use are presented in this section. As with the jargon in most areas of study, agreement on the meaning of each term is not universal. We must strive for greater consistency. With this concept in mind, the following definitions are presented.

INTERNATIONAL PERSPECTIVES

Are We on the Same Page?

Throughout much of the world dedicated scientists are studying various aspects of motor development, and parents, teachers, coaches, and therapists (field professionals) are trying mightily to make practical sense of their research results. At international meetings there are both scientists and field professionals in attendance.

Often, researchers and field professionals do not seem to be on the same page. Why? Simply because they sometimes neglect to be certain that the use of terminology peculiar to their area of study is universally understood. This challenge is compounded when various terms are translated into the many languages of the world.

For example, when traveling abroad and speaking to a group of Spanish or Portuguese speakers, we have found it important to carefully distinguish between the words *abilities* and *capabilities*, which are sometimes used interchangeably, but doing so can create great confusion.

In both Spanish and Portuguese, the word for *abilities* is *habilidades*. The word *abilities* or *habilidades* in all three languages refers to the skills a person has to perform a particular action; something closely linked to environmental influences but not linked directly to heredity or biological determinism.

On the other hand, the word *capabilities* or *capacidades* in Spanish and Portuguese refers to one's aptitude or inborn talent to do something; an inherited, biologically determined feature.

The confusion lies not in the word habilidades being used for the word abilities, but that it is often used interchangeably with the words capacidades and skills. This is confusing because capacidades (capabilities) are biologically based actions, whereas skills are experientially based.

Two small words, but huge differences in meaning. In fact, when lecturing in Brazil, Mexico, Cuba, and Chile the senior author encountered this very difference in international perspective. As a result, my workshops and international courses first focus on clarifications in terminology to be certain that we are all on the same page.

CONCEPT 1.9

Terms convey critical concepts essential to understanding motor development.

Growth and Development

The terms **growth** and **development** are often used interchangeably, but each implies a difference in emphasis. In its purest sense, *physical growth* refers to an increase in the size of an individual's body or its parts during maturation. In other words, physical growth is an increase in the structure of the body brought about by the multiplication or enlargement of cells. The term *growth,* however, is often used to refer to the totality of physical change, and as a result it becomes more inclusive and takes on the same meaning as development. In our discussion of growth through this text, we will adopt the former.

Development, in its purest sense, refers to changes in an individual's level of functioning over time. Keogh and Sugden (1985) defined development as "adaptive change toward competence" (p. 6). Such a definition implies that throughout the life span one is required to adjust, compensate, or change to gain or maintain competence. For example, the infant learning to walk needs to compensate for changes in his or her base of support and center of gravity. So, too, the adult needs to compensate for the diminution and regression in walking competency frequently brought about by arthritis and reduced joint flexibility. We will adopt Keogh and Sugden's definition throughout the text because it clearly and succinctly states that development is a lifelong process of change.

Although development is most frequently viewed as an emerging and broadening of one's ability to function on a higher level, we must recognize that the concept of development is much broader and that it is a lifelong process. The study of development is concerned with what occurs and how it occurs in the human organism in its journey from conception through maturity to death. Development is a continuous process encompassing all the interrelated dimensions of our existence, and care must be taken not to consider these dimensions as autonomous or limited to the growing years of childhood. Adults are as involved in the developmental process as are young children.

The interwoven elements of maturation and experience play key roles in the developmental process. **Maturation** refers to qualitative changes that enable one to progress to higher levels of functioning. Maturation, when viewed from a biological perspective, is primarily innate; that is, it is genetically determined and resistant to external or environmental influences. Maturation is characterized by a fixed order of progression in which the pace may vary but the sequence of appearance of characteristics generally does not. For example, the progression and approximate ages at which an infant learns to sit, stand, and walk are highly influenced by maturation. The sequence of appearance of these movement abilities is generally fixed and resistant to change, with only the rate of appearance being altered by the environmental influences of learning and experience.

Experience refers to factors within the environment that may alter the appearance of various developmental characteristics through the process of learning. A child's experiences may affect the rate of onset of certain patterns of behavior.

The development aspects of both maturation and experience are interwoven. Determining the separate contribution of each of these processes is impossible. A heated debate in the literature over the relative importance of the two raged for well over a century. As a result, the term *adaptation* has come into vogue and is often used to refer to the complex interplay between forces within the individual and the environment.

Domains of Behavior

The classification of human responses into *domains of behavior* was first popularized by Bloom and his associates (1956) and Krathwohl, Bloom, and Masia (1964) in their pioneering attempts to establish a taxonomy (i.e., classification scheme) of educational objectives. Unfortunately, their separation of behavior into psychomotor (motor behavior), cognitive (intellectual behavior), and affective (social-emotional behavior) domains has caused many to deal with each domain as an independent entity of human development. We must not lose sight of the interrelated nature of development and the three domains of human behavior even though we tend to separate them for convenience in our discussion and study of human development.

The *psychomotor domain* includes the processes of change, stabilization, and regression in physical structure and neuromuscular function. In the psychomotor domain, movement may be the result of cognitively mediated processes in higher brain centers (motor cortex), reflexive activity in lower brain centers, or automatic responses in the central nervous system. The psychomotor domain encompasses all physical and physiological change throughout the life span and is the topic of the next section.

The *cognitive domain* as applied to the study of movement behavior involves the functional relationship between mind and body. The reciprocal interaction of mind and body has been explored by observers ranging from Socrates and Plato to the developmental theorists of the twentieth century. Jean Piaget, known for his theory of cognitive development, is an example of a theorist who recognized the important role of movement, particularly during the early years of life. Piaget's work has done much to spread the notions that perceptual-motor development and academic concept readiness can be enhanced through the medium of movement.

The *affective domain* as related to the study of human movement involves feelings and emotions as applied to self and others through movement. Movement confidence, perceived competence, self-concept, and cultural socialization are areas of interest to students of motor development. *Movement confidence* is an individual's belief in his or her ability to satisfy the demands of various movement tasks. *Perceived competence* is one's feelings of potential for success in all areas, including movement. *Self-concept* is one's personal assessment of self-worth. It is influenced by a variety of factors, one of which is movement. *Cultural socialization* is the level of social interaction evidenced by an individual. Play behavior has a developmental base that manifests in changing peer relations and more sophisticated levels of functioning. Playfulness is also viewed by biologists as an activity vital to brain development (Fagen, 1992; Bergen & Coscia, 2000; Bergen, 2004).

CONCEPT 1.10

Human behavior may be classified into three domains: psychomotor, cognitive, and affective.

These definitions of the psychomotor, cognitive, and affective domains as they influence, and are influenced by, developmental processes permit us to clarify a variety of terms in the psychomotor domain that contain the words *motor* or *movement* (see Table 1.3). What follows is not a mere exercise in semantics. Words reflect concepts and convey ideas. It is important that we confer similar meanings on them because even subtle differences in definitions can lead to confusion and lack of clarity.

The Psychomotor Domain

In the study of human movement the term **motor** when used by itself refers to the underlying biological and mechanical factors that influence movement. The term, however, is rarely used alone but serves as a suffix or prefix in such words as: *psychomotor, perceptual-motor, sensorimotor, motor learning, motor control, motor development, motor performance,* and *motor abilities.* The terms *psychomotor, perceptual-motor,* and *sensorimotor* have gained popularity in the jargon of psychologists and educators. Kinesiologists, on the other hand, have tended to limit use of the prefixes of these words to discussions that focus on specific aspects of the motor process. In other words, the term *motor* is used as a prefix to describe specific areas of study. The following is a brief description of several of these terms as they are commonly used.

Learning is an internal process that results in consistent changes in behavior seen as evidence of its occurrence. Learning is the result of experience, education, and training interacting with biological processes. It is shaped largely by an individual's state of development and is a function of practice.

TABLE 1.3 The Interrelated Nature of Terms Commonly Used in Motor Development

Motor behavior: Change in motor learning, motor control, and motor development brought about by the interaction of learning and biological processes	
Motor control: Underlying neural and physical changes in the performance of isolated tasks	*Motor learning:* Underlying changes involved in acquiring and refining movement skills
Motor development: Progressive change in motor behavior throughout the life cycle brought about by interaction among the requirements of the movement task, the biology of the individual, and the conditions of the learning environment	
Motor: Underlying factors affecting movement	*Movement:* The observable act of moving
Motor pattern: Common underlying biological and mechanical processes	*Movement pattern:* An organized series of related movements (e.g., a sidearm pattern)
Fundamental motor pattern: Common underlying process of basic movements	*Fundamental movement pattern:* An organized series of basic movements (e.g., striking)
Motor skill: Common underlying process of gaining control in voluntary movement of the body, limbs and/or head (also called "task" or "action")	*Specialized movement skill:* Form, accuracy, and control in performance of a movement (e.g., striking an oncoming object or splitting wood)
Sport skill: The combination of a fundamental movement pattern with form, accuracy, and control in the performance of a sport-related activity (e.g., batting in baseball or softball)	

Learning is a phenomenon in which experience is prerequisite, whereas development is a process that may occur relatively independently of experience. Movement is considered to be essential to learning—"movement is an indispensable part of learning and thinking, as well as an integral part of mental processing" (Blakemore, 2003, p. 22). **Motor learning,** then, is that aspect of learning in which movement plays a major part. Motor learning is a relatively permanent change in motor behavior resulting from practice or past experience.

A **motor skill** is a learned, goal-oriented, voluntary movement task or action of one or more of the body parts. It is important to note that the definition of a motor skill as used here is that it is a *learned* action that has a specific goal and as a result is voluntary in nature and requires movement of some part or parts of the human anatomy (i.e., body, limbs, and/or head). Reflexive movements do not fit this definition and are not considered to be motor skills. Neither are movements that are genetically (i.e., maturationally) based such as creeping and crawling and what are considered to be the rudimentary movement abilities of infancy.

Motor behavior is an "umbrella" term referring to changes in motor learning control and development that embody learning factors and maturational processes associated with movement performance. Motor behavior research is concerned with the study of motor learning, motor control, and motor development.

Motor control is that aspect of motor learning and development that deals with the study of the neural and physical mechanisms that underlie human movement. Research in this area looks at the underlying processes involved in the performance of a movement act consistent from trial to trial. Much of the current research in motor development, especially that conducted from a dynamic systems perspective, approaches development from the standpoint of control mechanisms.

Motor development is continuous change in motor behavior throughout the life cycle. It is studied as a "process" and as a "product." As a process, motor development involves study of the underlying biological, environmental, and task demands that influence change in motor behavior from infancy through older adulthood. As a product, motor development may be regarded as descriptive or normative change over time and is typically viewed as age-related changes in motor behavior and motor performance.

Motor performance is the act of executing a movement skill. As such it can be directly observed and its outcome quantitatively assessed through some form of outcome measure. For example, the speed at which you run 50 meters and how far you can throw a ball are measures of your motor performance in running and throwing, respectively.

CONCEPT 1.11

Motor behavior is an umbrella term encompassing the complementary but essentially different areas of study embodied by motor learning, motor control, and motor development.

Movement Forms

The term **movement** refers to observable change in the position of any part of the body. Movement is the culminating act of the underlying motor processes. The word *movement* is often linked with others to broaden or clarify its meaning, but in general it refers to the overt act of moving. The following is a brief description of some movement terms as they are commonly used.

A **movement pattern** is an organized series of related movements. More specifically, a movement pattern represents the performance of an isolated movement that in and of itself is too restricted to be classified as a fundamental movement pattern. For example, the sidearm, underarm, or overarm patterns of movement alone do not constitute the fundamental movements of throwing or striking but merely represent an organized series of movements.

A **fundamental movement pattern** refers to the observable performance of basic locomotor, manipulative, and stabilizing movements. Fundamental movement patterns involve the combination of movement patterns of two or more body segments. Running and jumping, striking and throwing, and twisting and turning are examples of fundamental locomotor, manipulative, and stability movement patterns, respectively.

Although the terms *movement pattern* and *movement skill* are often used interchangeably, a **movement skill** is the same as a motor skill but there is a subtle difference in emphasis. Whereas a "motor" skill emphasizes the relative contributions of the underlying mechanisms (neural, muscular, biomechanical, perceptual), a "movement" skill emphasizes what can be seen through naked eye observation. In other words, the laboratory scientist tends to focus on the "motor" aspects of skill while the field professional tends to focus on the observable "movement" aspects of skill. Furthermore, in a movement skill, accuracy is stressed and extraneous movement is limited; in a fundamental movement pattern, movement is stressed but accuracy is limited and not necessarily seen as the goal.

A **sport skill** is the refinement or combination of fundamental movement patterns or movement skills to perform a sport-related activity. The fundamental movement patterns of twisting the body and striking may be developed to a high degree of precision and applied in a horizontal form to batting in the sport of baseball or in a vertical form to playing golf or serving a tennis ball. The performance of a sport skill requires making increasingly precise alterations in the basic patterns of movement to achieve higher levels of skill.

CLASSIFYING MOVEMENT SKILLS

A variety of schemes exist for classifying movement skills. Traditionally, most have been one-dimensional. That is, they have accounted for only one aspect of movement skill along a broad spectrum. Two-dimensional taxonomies are a more comprehensive means for classifying movement skills. Both are discussed in the following sections.

CONCEPT 1.12

Although there are a variety of helpful one and two-dimensional schemes for classifying movement, all fall short in fully capturing the breadth, depth, and scope of human movement.

One-Dimensional Schemes

Four ways of classifying movement skills along a single dimension have gained popularity over the years: (1) muscular, (2) temporal, (3) environmental, and (4) functional. Each is briefly discussed in the following paragraphs and visually presented in Table 1.4.

Muscular Aspects of Movement

There is not a clear delineation between the terms *gross* and *fine,* but movements are often classified as one or the other. A *gross motor movement* involves movement of the large muscles of the body. Most sport skills are classified as gross motor movements, with the exception perhaps of target shooting, archery, and a few others. A *fine motor movement* involves limited movements of parts of the body in the performance of precise movements. The manipulative movements of sewing, writing, and typing are generally thought of as fine motor movements. Physical therapists and physical education teachers are primarily concerned with the learning or relearning of gross motor skills, whereas occupational therapists and coaches are often more concerned with the fine motor aspects of skillful movement.

Temporal Aspects of Movement

On the basis of its temporal aspects, movement may also be classified as discrete, serial, or continuous. A *discrete movement* has a definite beginning and ending. Throwing, jumping, kicking, and striking a ball are examples of discrete movements. *Serial movements* involve the performance of a single, discrete movement several times in rapid succession. Rhythmical hopping, basketball dribbling, and volleying in soccer or volleyball are typical serial tasks. *Continuous movements* are movements repeated for a specified time. Running, swimming, and cycling are common continuous movements.

TABLE 1.4 Popular One-Dimensional Models for Classifying Movement

Muscular Aspects of Movement (the size/extent of the movement)	Temporal Aspects of Movement (the time series in which the movement occurs)	Environmental Aspects of Movement (the context in which the movement occurs)	Functional Aspects of Movement (the purpose of the movement)
Gross Motor Skills: Use several large muscles to perform a movement task (running, jumping, throwing, catching)	*Discrete Motor Skills:* Have a clearly defined beginning and ending (hitting a pitched ball, flipping a switch)	*Open Motor Skills:* Occur in an unpredictable and constantly changing environment (wrestling, catching a fly ball, most computer games)	*Stability Tasks:* Place emphasis on gaining or maintaining balance in either static or dynamic movement situations (sitting, standing, balancing on one foot, walking on a narrow beam)
Fine Motor Skills: Use several small muscles to perform a movement task with precision (writing, typing, knitting, portrait painting)	*Serial Motor Skills:* Series of discrete skills performed in rapid succession (dribbling a basketball, opening a locked door) *Continuous Motor Skills:* Perform repeatedly for an arbitrary length of time (peddling a bicycle, swimming, playing a violin)	*Closed Motor Skills:* Occur in a stable unchanging environment (putting in golf, word processing on a computer)	*Locomotor Tasks:* Transport the body from one point to another through space (crawling, running, performing the high jump in track) *Manipulative Tasks:* Impart force to an object or receive force from an object (striking, volleying, writing, knitting)

Environmental Aspects of Movement

Fundamental movement patterns and movement skills are often referred to as open motor tasks or closed motor tasks. An *open task* is one performed in an environment where the conditions are constantly changing. These changing conditions require the individual to make adjustments or modifications in the pattern of movement to suit the demands of the situation. Plasticity or flexibility in movement is required in the performance of an open skill. Most dual and group activities involve open skills that depend on external and internal feedback for their successful execution. For example, the child taking part in a typical game of tag, which requires running and dodging in varying directions, is never using the exact same patterns of movement during the game. The child is required to adapt to the demands of the activity through a variety of similar but different movements. Performance of an open movement task differs markedly from performance of a closed movement task.

A *closed task* is "a motor skill performed in a stable or predictable environment where the performer determines when to begin the action" (Magill, 2010, p. 9). A closed movement skill or fundamental movement pattern demands rigidity of performance. It depends on kinesthetic rather than visual and auditory feedback from the execution of the task. The child performing a headstand, throwing at a target, or doing a vertical jump is performing a closed movement task.

Intended Function of Movement

Movement skills may be classified on the basis of their intent. Although all movement tasks involve an element of balance, movements in which one's body orientation places a premium on gaining and/or maintaining a stable body orientation are called *stability tasks*. Sitting and standing, balancing on a narrow beam, body rolling, and dodging fit into this category, as do axial movements such as bending or stretching and twisting or turning. Movements for the purpose of transporting the body from one point to another such as walking, running, or performing the high jump or the hurdling event in track and field are *locomotor tasks*. Those that involve giving force to an object or receiving force from an object are *object manipulation tasks*. Throwing, catching, kicking a soccer ball, striking a baseball, and dribbling a basketball are common manipulative skills.

The reader is cautioned not to be arbitrary in the classification of movement into either one-dimensional or two-dimensional schemes. Distinct separation and classification of movements are not always possible or desirable. We are dynamic, moving beings, constantly responding to many subtle environmental factors and the demands of the movement task. The arbitrary classification of movement should serve only to focus attention on the specific aspect of movement under consideration.

Two-Dimensional Models

Two-dimensional models for classifying movement skills, although still descriptive, are somewhat more complete in recognizing the complexity of human movement. They offer a more sophisticated means for viewing movement as occurring along a continuum from simple to complex and from general to specific. The two-dimensional model proposed by Gentile (2000) is focused on the processes of motor skill learning. The one proposed by the senior author of this text in its first rendition in 1972 (Gallahue, Werner, & Luedke, 1972) and expanded upon throughout his professional career is focused on the products of motor development. Both are discussed briefly in the paragraphs that follow and ared epictedi n Tables 1.5 and 1.6, respectively.

Gentile's Two-Dimensional Model

Gentile (2000) looked beyond the one-dimensional approaches for classifying movement skills. Her two-dimensional scheme takes into account: (1) the environmental context in which the movement task is to be performed, and (2) its intended function. Although the original intent of this taxonomy was to aid physical therapists in their rehabilitation efforts, it also provides a workable framework for setting up practice sessions and training routines for anyone interested in teaching movement skills.

Table 1.5 An Adaptation of Gentile's (2000) Two-Dimensional Model for Classifying Movement with Examples Provided

Environmental Context of the Movement Task					Intended Function of the Movement Task: Stability without Manipulation	Stability with Manipulation	Locomotion without Manipulation	Locomotion with Manipulation
Stationary regulatory conditions*	+	No intertrial variability	=	Completely closed movement task	• Sitting in a chair • Standing in place	• Striking a ball off a tee • Kicking a stationary ball	• Walking on a flat surface • Jumping to a fixed height	• Walking with a suitcase • Rhythmically jumping a self-turned rope
Stationary regulatory conditions*	+	Intertrial variability	=	Moderately closed movement task	• Sitting in chairs set at varying heights • Standing up from chairs set at varying heights	• Striking a ball off tees set at varying heights • Kicking different types of stationary balls	• Walking on a treadmill • Jumping upward to varying heights	• Walking on a slippery surface with a bag of groceries • Jumping a fixed distance to catch a self-tossed ball
In motion regulatory conditions**	+	No intertrial variability	=	Moderately open movement task	• Standing on a moving escalator • Sitting on a large exercise ball	• Striking a ball tossed from a pitching machine • Kicking a slow rolling ball on a smooth, flat surface	• Walking onto an escalator • Running and jumping up to a fixed height	• Performing the shot put event in track • Throwing the javelin from a run
In motion regulatory conditions**	+	Intertrial variability	=	Completely open movement task	• Standing on a moving escalator • Sitting on a large exercise ball with both feet raised	• Striking a pitched ball • Kicking a fast-moving soccer football	• Walking across a swinging bridge • Running and then jumping up to varying heights	• Running to catch a fly ball • Jumping up to catch a rebounding ball

*The spatial aspects of the movement are controlled by the requirements of the task, but the temporal aspects of the task are controlled by the mover.

**Both the spatial and temporal aspects of the movement are controlled by the requirements of the task.

TABLE 1.6 Gallahue's Two-Dimensional Model for Classifying Movement with Examples Provided

	Intended Function of the Movement Task		
Phases of Motor Development	**Stability (emphasis is on body balance in static and dynamic movement situations)**	**Locomotion (emphasis is on body transportation from point to point)**	**Manipulation (emphasis is on imparting force to or receiving force from an object)**
Reflexive Movement Phase: Involuntary subcortically controlled movement abilities in utero and early infancy	• Labyrinthine righting reflex • Neck righting reflex • Body righting reflex	• Crawling reflex • Primary stepping reflex • Swimming reflex	• Palmar grasp reflex • Plantar grasp reflex • Pull-up reflex
Rudimentary Movement Phase: The maturationally influenced movement abilities of infancy	• Control of head and neck • Control of trunk • Unsupported sitting • Standing	• Crawling • Creeping • Upright gait	• Reaching • Grasping • Releasing
Fundamental Movement Phase: The basic movement skills of childhood	• Balancing on one foot • Walking on a low beam • Axial movements	• Walking • Running • Jumping • Hopping	• Throwing • Catching • Kicking • Striking
Specialized Movement Phase: The complex skills of later childhood and beyond	• Performing a balance beam routine in gymnastics • Defending a goal kick in soccer/football	• Running the 100-meter dash or hurdles event in track • Walking on a crowded street	• Performing a goal kick in soccer or football • Striking a pitched ball

The first dimension deals with the environmental context of the movement task to be performed. According to Gentile, the **environmental context** refers to having *regulatory conditions* that are either *stationary* or *in motion,* as well as having either *intertrial variability* or *no intertrial variability.* If the regulatory conditions during performance of a skill are stationary, then the environmental context is unchanging. There may be, however, either no intertrial variability, as in a completely closed movement task such as sitting down or standing up from a chair, or intertrial variability as in a moderately closed movement task such as sitting down or standing up from varying heights. On the other hand, if the regulatory conditions of the environment are in motion, they may also have either no intertrial variability, as in a moderately open movement skill such as sitting on a large exercise ball, or intertrial variability as in a completely open movement task such as sitting on a large exercise ball and balancing with the feet raised off the ground.

The second dimension of Gentile's two-dimensional scheme for classifying movement skills deals with the intended function of the movement task (i.e., category of movement). One's body orientation may focus on either stability or locomotion (Gentile uses the term "body transport") occurring either with or without object manipulation. Take a few minutes to study Table 1.5 and the examples provided. Note that there is a definite progression of difficulty running from left to right and from top to bottom in the movement examples provided. For example, the upper-left quadrant, the least complex, emphasizes body stability with no object manipulation and has stationary environmental regulatory conditions with no intertrial variability. Completely closed movement skills such as sitting and standing fit here. On the other hand, movement skills in the lower right-hand quadrant, the most complex, emphasize body transport (locomotion) while manipulating an object and have environmental regulatory conditions in motion as well as the presence of intertrial variability. Completely open movement skills such as leaping to catch a ball in baseball or basketball or fielding a pass on the run in a game of soccer are found in this part of the taxonomy.

Gentile's two-dimensional scheme for classifying movement skills solves many of the problems found in one-dimensional schemes. By identifying where the desired movement task is located on the sixteen-category continuum, the therapist or teacher can determine how well the learner performs the task by progressively altering the context of the environment. This then enables selection of the most appropriate learning progression based on where the learner is, rather than where she or he should be.

Multidimensional Schemes

In reality, when making application of developmental change and learning to the real world we use neither single-dimensional nor even two-dimensional schemes. Skilled instructors use, of course, multidimensional ways of dealing with the learner. In addition to considering a wide variety of important cognitive and affective factors, the instructor (parent, teacher, coach, therapist) first determines the primary skill learning objectives (is it to teach skills for the requirements of daily living, recreational participation, or sport involvement?). To do so it now becomes important to determine the following:

1. The learners' *phase of motor development* (are they at the reflexive, rudimentary, fundamental, or specialized phase?)
2. The learners' *level of movement skill learning* (are they at the novice, practice, or advanced level?)
3. The actual *type of movement task* (is the skill gross/fine, discrete/serial/continuous, locomotor/manipulative/stability; and is it to be performed under open/closed conditions?)
4. The *performance requirements of the task* (what is needed in terms of muscular strength and endurance, joint flexibility, aerobic endurance, speed, agility, power, and balance?)

With knowledge of the above four items the instructor can begin to make informed choices as to what, when, where, and most importantly how to teach a particular skill or combination of movement skills. Table 1.7 provides a visual example of a multidimensional skill instruction rubric.

TABLE 1.7 Multidimensional Skill Instruction Rubric

WhatI s Your Role?	WhatI sth e Learner's Level ofD evelopment?	WhatI st he Learner's Level of SkillL earning?	What Is Your Purpose?	What Is Required of the Movement Task?	What Is the Learner's Potential to Perform?
Parent	Reflexive	Beginning "Novice" Level	Skills for Daily Living	Functional Aspects: L/M/S	Muscular Strength and Endurance
Teacher	Rudimentary	Intermediate "Practice" Level	Skills for Recreation	Temporal Aspects: D/S/C	Aerobic Capacity
Coach	Fundamental	Advanced "Fine Tuning" Level	Skills for Sport	Muscular Aspects: G/F	Body Composition and Joint Flexibility
Therapist	Specialized	"EliteP erformance" Level	Skill Rehabilitation	Environmental Aspects: O/C	Speed, Balance, Power, Agility

SUMMARY

This chapter has focused on a variety of general topics to provide you with a brief overview of the field of motor development. The study of human development may take many forms, one form being the study of motor development. In turn, motor development may be studied in a variety of ways. The field has gone through a rather interesting history in its move from a process-oriented maturational approach, to a product-oriented normative/descriptive approach, and now back to a process approach examining underlying mechanisms of motor development.

Research designs and problems in the study of motor development were discussed as they relate to the longitudinal, mixed-longitudinal, and cross-sectional approaches to study. The advantages and limitations of each were discussed, with the caveat that only the longitudinal and mixed-longitudinal designs are true studies of development. These research designs look at change in "developmental time" rather than "real time" as in the cross-sectional study.

Various age classifications of development were examined with the intent of conveying the concept that although development is age-related, it is not age-dependent. Chronological age is the most frequently used and most convenient indicator of change, but it is the least accurate indicator of development. Age does not generate or cause development; it is merely an indicator of what has transpired because of the developmental process.

The chapter concluded with a discussion of terminology commonly used in the study of motor development and techniques for classifying movement skills. The intent of this discussion was to help you the reader, and us, the authors, proceed through the text using a common language to maximize understanding of the important topics and concepts to follow.

QUESTIONS FOR REFLECTION

1. What is motor development and why is it important for better understanding infants, children, adolescents, and adults?
2. Why is the field of motor development so young in comparison to the other biological sciences?
3. What is a developmental kinesiologist and how might you see yourself as being one?
4. Why is it important to be precise in the use of scientific terminology?
5. What are some common terms used in motor development and how can they be applied in specific teaching-learning situations?

Critical Readings

Clark, J. E., & Whitall, J. (1989). What is motor development? The lessons of history. *Quest, 41,* 183–202.

Magill, R. A. (2010). *Motor Learning and Control: Concepts and Applications* (Chapters 1 and 2). Boston, MA: McGraw-Hill.

Thomas, J. R., & Thomas, K. T. (1989). What is motor development: Where does it belong? *Quest, 41,*203–212.

Web Resources

www.webster.edu/~woolflm/mcgraw.html

This site provides background information on Myrtle McGraw and her contribution to the science and research of motor development.

www.karger.ch/journals/hde/hde_jh.htm

Human Development journal homepage. The site includes information about the journal including submission information, a subject guide, and other information resources in the field of motor development. Such other resources include a list of supplementary journals, list of authors, and indexo fb ooks.

CHAPTER 2

MODELS OF HUMAN DEVELOPMENT

KEY TERMS

Phase-staget heory
Developmentalt ask
Developmentalm ilestone
Ecologicalt heory
Dynamics ystemst heory
Affordances
Ratel imiters
Constraints
Degreeso ff reedom problem
Behaviorset tingt heory
Informationp rocessingt heory
Perception
Perceptual-motor
Adaptation
Accommodation
Assimilation
Schema

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Compare and contrast maturational, environmental, interactionist, and transactional views of causation in motor development
- Demonstrate familiarity with a variety of theoretical models of human development
- Discuss changes in cognition as a developing process
- Classify theories of development into various conceptual viewpoints
- Analyze changes in psychosocial development across the life span
- Identify the major developmental tasks across thel ifes pan

KEY CONCEPT

Human development may be studied from a variety of theoretical frameworks, each of which has implications for the motor development and movement education of infants, children, adolescents, and adults.

During the past century, several developmental theorists have closely studied the phenomenon of human development. Sigmund Freud (1856–1939), Erik Erikson (1902–1994), Arnold Gesell (1880–1947), Robert Havighurst (1900–1991), and Jean Piaget (1896–1980), among others, have made valuable contributions to our knowledge of human development. Each has constructed theoretical models that depict the developmental process and form a basis for much of today's work.

This chapter takes a brief look at the models of development proposed by these theorists. As a basis for a more detailed study of motor development, we also examine characteristic ways in which theorists view the phenomenon of human development with particular attention given to ecological theories. We finish the chapter by examining three historically popular theories of development that have stood the test of time. Cagen and Getchell (2004) contend that "for motor development teachers, the study of theories is critical to the understanding of developmental change" (p. 25).

Theoretical Models of Human Development

Austrian psychiatrist Sigmund Freud's (1927) *psychoanalytic theory* of human behavior may be viewed, in part, as one of the first models of human development, even though his work centered around personality and abnormal functioning. Freud's famous psychosexual stages of development reflected various zones of the body with which the individual seeks gratification of the *id* (the unconscious source of motives, desires, passions, and pleasure seeking) at certain general age periods. The *ego* mediates between the pleasure-seeking behavior of the id and the *superego* (common sense, reason, and conscience). Freud's *oral, anal, phallic, latency,* and *genital* stages of personality development represent the terms applied to the pleasure-seeking zones of the body that come into play at different age periods. Each stage relies heavily on physical sensations and motor activity.

Freud's psychoanalytic theory has received its share of criticism primarily due to the inability to scientifically objectify, quantify, and validate its concepts. It has, however, stimulated considerable research and study and served as the basis for the notable works of his German-born student Erik Erikson (1963).

Erik Erikson (1963, 1980) focused on the influence of society, rather than sex, on development. His *psychosocial theory* describes eight stages of the human life cycle and puts them on a continuum, emphasizing factors in the environment, not heredity, as facilitators of change. Erikson's view of human development acknowledges factors within the individual's experiential background as having a primary role in development. His view of the importance of motor development is more implicit than explicit, but he clearly points out the importance of success-oriented movement experiences as a means of reconciling the developmental crises that each individual passes through.

CONCEPT 2.1

There are numerous models of human development, each of which reflects its originator's knowledge, interests, and biases.

Arnold Gesell's (1928, 1954) *maturational theory* of growth and development emphasizes maturation of the nervous system as the principal driver of the physical and motor aspects of human behavior. Gesell documented and described general age periods for the acquisition of a wide variety of rudimentary movement abilities during infancy and viewed these maturation-based tasks as important indicators of social and emotional growth. Gesell also described various ages when children are in "nodal" periods or when they are "out of focus" with their environment. A nodal stage is a maturational period during which the child exhibits a high degree of mastery over situations in the immediate environment, is balanced in behavior, and is generally pleasant. Being out of focus is the opposite; the child exhibits a low degree of mastery over situations in the immediate environment, is unbalanced or troubled in behavior, and is generally unpleasant. Maturational theory is not widely accepted today, but it played a significant role in the evolution of child development as an area of study.

A fourth developmental model, that of Robert Havighurst (1972), views development as an interplay between biological, social, and cultural forces through which individuals are continually enhancing their abilities to function effectively in society. Havighurst's *environmental theory* views development as a series of tasks that must be achieved within a certain time frame to ensure the proper developmental progression of the individual. According to Havighurst's model, there are teachable moments when the body is ready and when society requires successful completion of a task. As with the other models discussed, the tasks described by Havighurst rely heavily on movement, play, and physical activity for their development, particularly during infancy and childhood.

CONCEPT 2.2

No one theory is complete or totally accurate in describing or explaining human development, and, as a result, all break down at some point.

A fifth developmental theory still popular among educators is that of Swiss psychologist Jean Piaget (1969). Piaget's *cognitive development theory* places primary emphasis on the acquisition of cognitive thought processes. He gained insight into the development of cognitive structures through careful observation of infants and children. The genius in Piaget's work lies in his uncanny ability to pick out subtle clues in children's behavior that give us indications of their cognitive functioning. Piaget viewed these subtle indicators as milestones in the hierarchy of cognitive development. The primary flaw in Piaget's work is that he grossly underestimated the rate of acquisition of several cognitive structures, although their sequence of acquisition is largely accepted as valid by developmentalists. Movement is emphasized as a primary agent in the acquisition of increased cognitive structures, particularly during infancy and the preschool years. Piaget used chronological age only as a broad and general indicator of cognitive functioning and relied instead on observed behaviors. These observed behaviors served for Piaget as the primary indicators of the child's ever-increasing complexity in cognitive development. Piaget identified these developmental phases as *sensorimotor* (birth to 2 years), *preoperational* (2 to 7 years), *concrete operations* (7 to 11 years), and *formal operations* (12 years and over). Piaget did not directly concern himself with development beyond about age 15 because he believed that highly sophisticated intellectual capabilities were developed by this time.

All theorists look at human development from somewhat different points of view, but close inspection reveals remarkable similarities. Each theorist emphasizes movement and play as important facilitators of enhanced functioning. Also, each tends to be more descriptive than explanatory. In other words, they tell us "what" is happening in the typical process of development, rather than "why" iti sh appening.

Conceptual Viewpoints of Development

Close inspection of the five models of development outlined, as well as the study of others, reveals a distinct tendency for each model to group around one of four conceptual frameworks. These frameworks are classified here as (1) phase-stage, (2) developmental task, (3) developmental milestone, (4) ecological, and (5) information processing theories (Table 2.1). We will take a brief look at

TABLE 2.1 Conceptual Approaches to the Study of Human Development

Conceptual Approach	Representative Theorists	Research Focus
Phase-Stage Theory	Sigmund Freud	Study of psychosexual development from birth through childhood
	Erik Erikson	Study of life span psychosocial development
	Arnold Gesell	Study of maturational processes in central nervous system development from birth through childhood ("ontogeny recapitulates phylogeny")
Developmental Task Theory	Robert Havighurst	Study of the interaction of biology and society on developmental maturity from infancy through old age
Developmental Milestone Theory	Jean Piaget	Study of cognitive development as an interactive process between biology and the environment from infancy through childhood
Ecological Theory (Dynamical Systems branch)	Nicholas Bernstein; Kugler, Kelso, and Turvey	Study of development as a discontinuous, self-organizing, transactional process among the task, individual, and environment throughout life
Ecological Theory (Behavior Setting branch)	RogerB arker; Urie Bronfenbrenner	Study of development as a function of the individual's interpretation of specific environmental settings transacting with the sociocultural and historical milieu
Information Processing Theory	Schmidt & Lee; Kephart	Study of development as a perceptual-motor process and the events occuring internally between sensory input and motor output

each, with particular attention given to the newer ecologicalt heories.

CONCEPT 2.3

Theories of development may be studied from several distinct conceptual viewpoints.

Phase-Stage Theory

The **phase-stage** approach to developmental theory is the oldest of the conceptual viewpoints. All classical developmental theorists (i.e., stage theorists), whether they are studying cognitive, moral, personality, or motor development, contend that there are universal age periods characterized by certain types of behavior. These behaviors occur in phases or stages, last for arbitrary lengths of time, and are invariant. In other words, stages are sequential and cannot be reordered, but one or more stages may be skipped. Furthermore, stage theory focuses on broad-based changes rather than narrow or isolated behaviors.

Each phase (i.e., typical behavior) generally covers a period of one year or more and may be accompanied by one or more other stages. Some theorists subdivide particular phases into smaller stages. Others prefer to look at one phase typifying one particular period. Most theorists who propose a phase-stage scheme have divided childhood, or even the entire life cycle, into ten periods or less. The phase-stage concept is probably the most popular among parents and educators and is often reflected in our thinking and speech when we say, "She is just going through a stage" or "I will be happy when he is out of that phase." Freud, Erikson, and Gesell each viewed child development as a phase-stage–related process.

Stages have been proposed for several fundamental movement tasks. The viability of a rigid stage theory of motor development is questionable. More flexible stage models based on the components of a movement rather than on the total body configuration hold greater promise. Any phase-stage theory describes only general (i.e., group or normative) developmental characteristics for a generic (average) individual postulated to be common to all people. Phase-stage theory gives us a view of the "big picture" but does not accommodate the details.

Developmental Task Theory

A second conceptual viewpoint of development is the **developmental task** approach. A developmental task is an important accomplishment that individuals must achieve by a certain time if they are to function effectively and meet the demands placed on them by society. Proponents of developmental task theory view the accomplishment of particular tasks within a certain time span as prerequisite to smooth progression to higher levels of functioning. This concept of development differs from the phase-stage view in that it is predictive of later success or failure based on the individual's performance at an earlier stage and does not merely attempt to describe typical behavior at a particular age. Havighurst's view of development uses the developmental task concept to both describe and predict behavior from infancy through adolescence (Havighurst & Levine, 1979). The hemispherical dominance theory and treatment techniques for individuals with learning disorders as proposed by Delacato (1966) also follow a developmental task approach. Although developmental task theories claim predictability, little has been done to test their assertions. Hence, there is considerable question as to their validity.

Developmental Milestone Theory

The **developmental milestone** approach is a third conceptual framework from which development is viewed. Developmental milestones are similar to developmental tasks except for their emphasis. Instead of referring to accomplishments that take place if the individual is to adapt to the environment, this approach refers to strategic indicators of how far development has progressed. The accomplishment of a developmental milestone may or may not in itself be crucial to adjustment in the world as it is with a developmental task. Milestones are merely convenient guidelines by which the rate and extent of development can be gauged. As with phase-stage theories, the developmental milestone theories are more descriptive than predictive, but unlike stage theories, they view development as a continual unfolding and intertwining of developmental processes, not as a neat transition from one stage to another. Piaget's cognitive development theory is generally considered to be a developmental milestone theory, as is the dynamical systems theory of motor development.

Recognition that most models of human development tend to fall under one of these three concepts enables us to view the phenomena of growth and development more objectively. Each concept has merit and operates to a certain degree throughout the developmental process. The years of infancy and early childhood do require the achievement of certain important tasks such as learning to walk, talk, and take solid foods by a specific age for normal functioning to be established. These years also encompass a variety of stages that children pass through at more or less the same age, in addition to a variety of milestones achieved as subtle indicators of how far development has progressed.

Ecological Theory

It is important to know about the products of development in terms of *what* people are typically like during particular phases and stages, developmental milestones, and developmental tasks (description). It is equally important, however, to know *why* these changes occur (explanation). To this end many developmentalists are looking at explanatory models in an attempt to understand more about the underlying processes that actually influence and control development.

Ecological theory attempts to be of practical benefit by being both descriptive and explanatory. **Ecological theory**, or "contextual theory" as it is sometimes called, views development occurring as a function of the environmental "context" and historical time frame in which one lives. The study of human ecology from a developmental perspective is a matter of studying the relationship of individuals to their environment and to one another. Two ecological approaches popular among motor developmentalists are dynamic systems theory and behavior setting theory.

Dynamic Systems Branch

Dynamic systems theory is popular among many developmentalists (Alexander et al., 1993; Caldwell & Clark, 1990; Kamm et al., 1990; Thelen, 1989; Thomas, 2000; Getchell & Whitall, 2004; Haywood & Getchell, 2009). It is based largely on the work of the Russian physiologist Nicholas Bernstein (1967) and has been expanded by Kugler, Kelso, and Turvey (1982). The word *dynamic* conveys the concept that developmental change is nonlinear and discontinuous. Because development is viewed as nonlinear, it is seen as a discontinuous process. That is, individual change over time is not necessarily smooth and hierarchical and does not necessarily involve moving toward ever higher levels of complexity and competence in the motor system. Individuals, particularly those with disabling impairments, may be impeded in their motor development. For example, children with spastic cerebral palsy are frequently delayed in learning to walk independently. When independent walking is achieved, their gait patterns will be individualized and achieved when appropriate for each child. Although, by definition, development is a continuous process, it is also a discontinuous process when viewed from a dynamical perspective. In other words, development is a "continuous-discontinuous" process.

The dynamics of change occur over time but in a highly individual manner influenced by a variety of critical factors within the system. These factors are termed **affordances** and **rate limiters**. *Affordances* tend to promote or encourage developmental change. *Rate limiters* are conditions that serve to impede or retard development. Affordances and rate limiters are viewed as **constraints**. Constraints either encourage or discourage movements (Newell, 1984). For children with cerebral palsy, for example, these constraints are neurological and biomechanical. Affordances may include assisted support, handholds, encouragement, and guided instruction.

The word *systems* conveys the concept that the human organism is self-organizing and composed of several subsystems. It is *self-organizing* in that humans, by nature, are inclined to strive for motor control and movement competence. Self-organization occurs when specific conditions within the biology of the individual and the environment are met that allow for a new and stable pattern of behavior to emerge. For example, as your walking speed is increased on the treadmill, you self-organize into a running pattern of movement. Conversely, when the treadmill slows down, you self-organize back to a walking pattern. Systems derived from the requirements of the movement task, the biology of the individual, and the environment operate separately and in concert to determine the rate, sequence, and extent of development. Coordination and control of movement is the result of several systems working dynamically together in a cooperative manner. No one factor is seen as more or less important than the others. All systems interact in a manner that causes motor behavior to emerge independent of any one system (Alexander et al., 1993). Children with cerebral palsy, as self-organizing systems, frequently develop individually unique gait patterns in response to their capabilities for meeting the achievement demands of the walking task. Preferred patterns of movement behavior develop in response to unique factors within the individual, the task, and the environment. These movement patterns are the result of the most efficient interaction of systems and the least amount of energy required. Although preferred patterns of movement behavior do exist, they are altered when the demands of the system dictate change.

Viewed from a systems perspective, numerous elements change over time as one grows and develops. The complexity of determining how movement skills are learned is referred to as the **degrees of freedom problem** (Bernstein, 1967). The performance of a movement task includes neuromotor as well as biomechanical degrees of freedom. The number of degrees of freedom are, however, constrained through the individual gaining motor control and movement coordination of the movement task, thereby resulting in the formation of movement patterns. The individual develops preferred patterns of movement, but these preferred patterns may be reorganized through control parameters. *Control parameters* are "those variables that provide a condition for a pattern change. Control parameters do not dictate what change will occur, but when they reach a critical value, they act as an agent for reorganization of the motor pattern" (Alexander et al., 1993, p. 3).

Transition from one pattern of movement to another is called a *phase shift*. Phase shifts are plentiful among infants when moving from one form of locomotion (crawling to creeping) to another (creeping to walking). During this time the infant is in a state of instability, shifting from one pattern to the other until a new preferred pattern is firmly established.

Dynamic systems theory attempts to answer the "why" or process questions that result in the observable product of motor development. Much of the work to date has centered on infant motor development, but an increasing amount of research is focusing on dynamical explanations of motor development among children, adolescents, and adults in populations of both typically and atypically developing individuals.

For years developmentalists have recognized the interactive role of two primary systems in the developmental process: heredity and environment. Many now, however, have taken this view one step further in recognizing that the specific demands of the movement task transact with the individual (i.e., hereditary or biological factors) and the environment (i.e., experience or learning factors) in the development of stability, locomotor, and manipulative movement skills. Such a transactional model implies that *constraints* within the task, the individual, and the environment not only interact but also have the potential for modifying and being modified by the other as one strives to gain motor control and movement competence (Figure 2.1).

Both the processes and the products of motor development should remind us of the individuality of the learner. Each individual has his or her unique timetable for the development of abilities. Although our "biological clock" is rather specific when it comes to the sequence of movement skill acquisition, the rate and extent of development are individually determined and dramatically influenced by the specific performance demands of the individual task.

For example, when performing a basketball free throw, consider all of the literally thousands of possibilities for every combination of joint actions, motor neuron responses, and muscle contractions potentially involved in performing this movement task. The complexity of the process of movement itself is truly awesome to contemplate. Moreover, these motor processes are combined with the perceptual aspects involved in the task. While attempting to make a free throw, you must execute not only the motor aspects of the task but also the perceptual aspects of judging distance, depth, and trajectory prior to taking your shot at the basket. All of these possibilities for movement must be constrained into an organized pattern that results in either making the basket (successfully negotiating the degrees of freedom problem) or missing. The degrees of freedom problem, therefore, is the scientist trying to understand and make meaning of how we control all of the potentially available degrees of freedom to provide a desired movement (Coker, 2004).

Typical age periods of development are just that: typical, and nothing more. Age periods

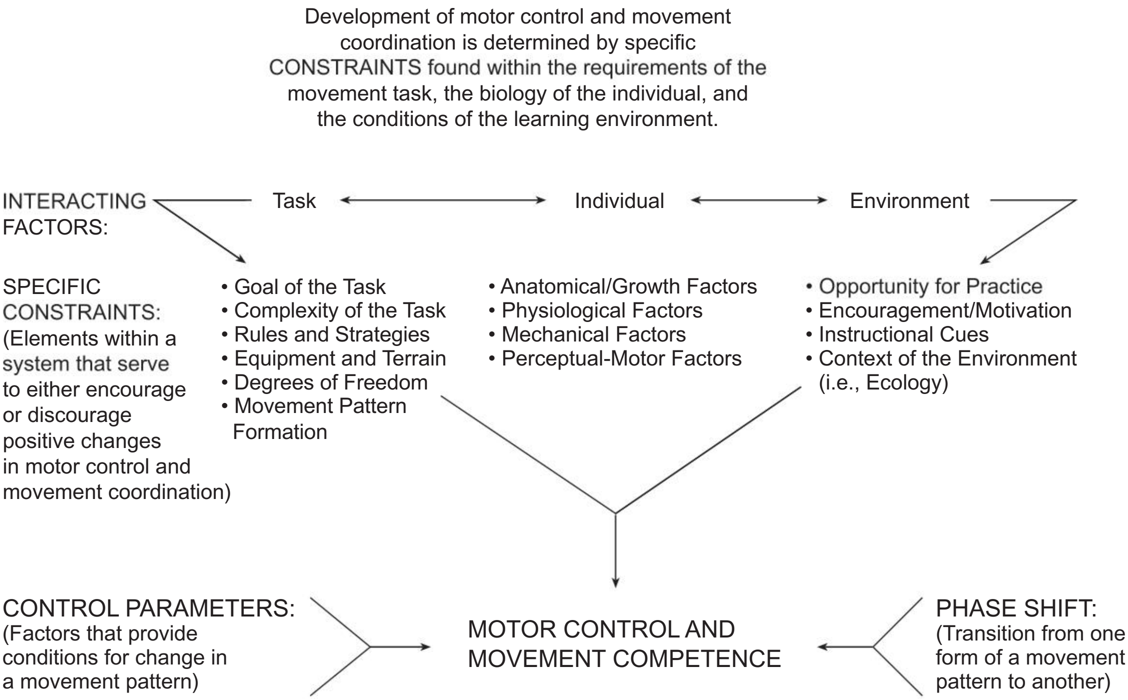

Figure 2.1

Development from a constraints perspective.

merely represent approximate time ranges during which certain behaviors may be observed for the mythical "average" individual. Overreliance on these time periods would negate the concepts of continuity, specificity, and individuality in the developmental process and are of little practical value when working with individuals from a developmentalp erspective.

Behavior Setting Branch

Behavior setting theory is a branch of ecological psychology that has its roots in the work of Kurt Lewin in the 1930s to 1940s and his colleague Roger Barker in the 1950s to 1970s (Thomas, 2000). Lewin is credited with developing a branch of Gestalt psychology known as *topological psychology,* a term taken from mathematics where "topology" is the study of geometric properties that remain unchanged even when under distortion. Lewin used the term *life space* to account for all that influences a child's behavior at a given time.

Barker (1978) extended Lewin's thinking with the notion that the *behavior setting,* that is, the specific environmental conditions of the child's life space, accounts for a large portion of the individual variation among children. His concept of *standing patterns of behavior* (i.e., typical ways in which people act) explains why different settings evoke different responses. For example, we can predict that if a typical second grader is outside for recess, her behavior will be active, energetic, and noisy. When in the classroom, however, her predicted standing pattern of behavior will be the opposite. If a teenager is hanging out at the mall, his predicted behavior is considerably different from that expected in the marching band.

Furthermore, the milieu in which these events occur, according to Barker, encompasses the expected actions of people in a specific behavior setting. To that extent Barker felt that the "physical setting" and the "time boundaries" of a behavior setting are instrumental in shaping the expected behavior. Take, for example, our abrupt change in behavior when sitting in a theater several minutes before a play begins, and when the lights dim and the first act begins. The physical setting of the brightly lit theater encourages talking and looking about the auditorium. On the other hand, when the lights dim and the actors come on stage, talk abruptly ceases and the audience settles into their seats to watch the play. If the play is relatively short, the time boundaries are acceptable to most and full attention is given to the actors on stage. But if the play is long and continues on and on, the standing patterns of behavior begin to change as a function of the time boundaries of the play. People begin to fidget, whisper, and otherwise divert their attention to something other than the play. Wise playwrights, therefore, divide their plays into two or three acts, thus allowing for a brief intermission between acts, which will restore the pattern of behavior expected from the audience.

The work of Urie Bronfenbrenner is an extension of Barker's. It places strong emphasis on factors within the environment as being key to development. Bronfenbrenner (1979) defined the ecology of human development as:

> the scientific study of the progressive, mutual accommodation between an active, growing human being and the changing properties of the immediate settings in which the developing person lives, as this process is affected by relations between those settings, and by the larger contexts in which the settings are embedded. (p. 21)

Bronfenbrenner's bioecological theory, however, is based on the premise that it is not the behavior setting that predicts behavior, but the individual's interpretation of the setting in both time and space.

INTERNATIONAL PERSPECTIVES

Theorists All

Over the years I have had the honor of hosting a wide assortment of visiting scholars who have come to study at Indiana University. They have come from every continent and have brought with them a variety of educational backgrounds and deep interests in motor development, especially among children and youth.

These scholars, both emerging and well established, also bring fresh new perspectives on a variety of child-centered developmental topics. They do so through their own personal social, cultural, economic, and political reality, a reality that in many cases is vastly different from that of an aging professor living on a horse farm in Midwest USA. As a result, no matter if the visiting scholar was from Australia, Brazil, Chile, China, Egypt, Japan, Mexico, or Turkey, we engaged in hour upon hour of spirited conversation and debate in a genuine attempt to better understand the context under which they engaged children and youth in helping them develop to their potential in body, mind, and spirit.

Although we each shared the same passion for trying to better understand the products and processes of motor development, our views were often radically different. Why? Simply because of the often wide differences in our realities. Each brought many respected theorists in support of their views, who, although sometimes little known in my reality, were respected in theirs.

Theory and reality don't often collide, but they should. They don't collide because it is a rather comfortable task to select a point of view (theory) that supports your reality. In doing so, however, we run the very real risk of not recognizing or appreciating the reality of another. Although we are much the same in our life journey, we are also much different. The reality of our daily life experience shapes who we are and what we will become. As a result no one theory, or even collection of theories, adequately describes and explains who we are.

Be aware of and attuned to the reality of others. It will shape what you believe and how you choose to make a difference.

That is, the *meaning* attached to the environment, not the environment, guides behavior. Bronfenbrenner argues that it is nonsense to try to understand behavior from the objective reality of the environment without also learning what the environment means to the individual. As a result, he places considerable importance on one's perceptions of the activities, roles, and interpersonal relations typically displayed in a behavior setting. *Activities* are what people are doing. *Roles* are the expected behaviors in that setting for a given position in society—parent, teacher, adolescent, coach, and so forth. *Interpersonal relations* are the ways in which people treat each other by what they say and what they do, in that setting (Bronfenbrenner, 2005).

Development occurs within a broad range of environmental contexts. Bronfenbrenner terms these settings the *microsystem* (one's family, school, neighborhood, and peers), the *mesosystem* (the interaction among various settings within the microsystems), the *exosystem* (social settings in which the individual does not play an active role but is affected by its decisions), the *macrosystem* (the culture in which one exists), and the *chronosystem* (the sociohistorical events of one's lifetime). Figure 2.2 illustrates the microsystems of the family, school,

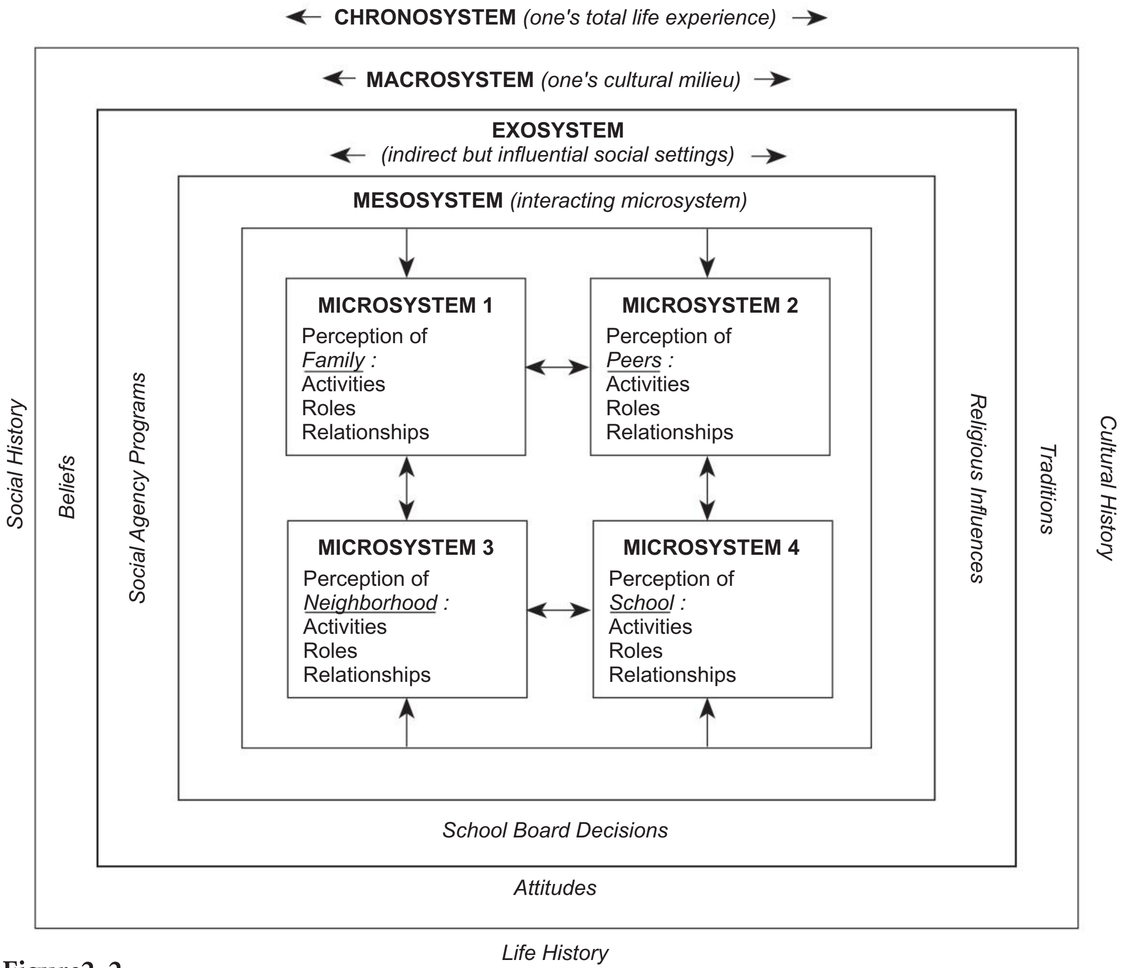

Figure2 .2

A conceptualization of Bronfenbrenner's ecological theory of development as influenced by one's perceptions of his or her behavior settings.

neighborhood, and peer group influencing an individual based on his or her perceived notion of appropriate activities, roles, and interpersonal relations within the context of each. In our example, the mesosystem is composed of the interaction patterns among these four microsystems. The exosystems in our hypothetical example are settings that do not directly involve the individual but affect, or are affected by, what happens in a behavior setting. The macrosystem is the cultural milieu in which the individual exists and is composed of such things as beliefs, traditions, attitudes, and practices shared throughout one's immediate culture. Finally, the chronosystem involves the pattern of events over one's life span.

Information Processing

Information processing perspectives on motor skill learning first appeared in the 1960s and are associated with the process by which one attaches meaning to information, namely perception. Our sensory modalities (i.e., visual, auditory, gustatory, tactile, and kinesthetic) provide for input into the brain, which from an information processing perspective is sometimes characterized as a "computer" (Haywood & Getchell, 2009) or "black box" (Schmidt & Lee, 2005). This computer or black box heuristic begins with input into the process and ends with output from the process. What happens between input-output is critical to understanding this perspective that has been so dominant in studying the motor learning and control of human motor behavior.

Kephart (1960, p. 63) contends that: "The input-output system is a closed system, and we cannot stop activities in one area while we investigate the effect of changes in the other. Therefore, we can not speak of, or think of, input and output as two separate entities; we must think of the hyphenated term *input-output.* In like manner, we cannot think of perceptual activities and motor activities as two different activities; we must think of the hyphenated term *perceptual-motor*." Furthermore, Kephart goes on to say that: "The total perceptual-motor process should be considered in every learning activity which we set up for the child" (p. 63): And from our perspective, for adolescents and adults as well.

The word **perception**, which means to know or to interpret information, is the process of organizing and synthesizing information that we gather through the various sense organs with stored information or past data, which leads to a modified response pattern. When we consider the term **perceptual-motor**, then, we know that the first part of the term signifies the dependency of voluntary movement activity on some form of sensory information. All voluntary movement involves an element of perceptual awareness resulting from sensory stimulation. The second part of the term *perceptual-motor* indicates that the development of one's perceptual skills are influenced, in part, by movement. Perceptual skills are learned and, as such, use movement as an important medium for this learning to occur. The reciprocal relationship between sensory input and motor output enables both perceptual and motor skills to develop in harmony.

It has long been recognized that the quality of one's movement performance depends on the accuracy of perception and the ability to interpret these perceptions into a series of coordinated movement acts. The terms *eye-hand coordination* and *eye-foot coordination* have been used for years to express the dependency of efficient movement on the accuracy of one's sensory information. The individual in the process of shooting a basketball free throw has numerous forms of sensory input that must be sorted out and expressed in the final act of shooting the ball. If the perceptions are accurate and if they are expressed in a coordinated sequence, the basket is made. If not, the shot misses. All voluntary movement involves the use of one or more sensory modalities to a greater or lesser degree, depending on the movement act to be performed.

As multisensory learners, we constantly use our senses to learn about the spatial and temporal aspects of our environment. Therefore, information-processing theories include the following steps:

1. *Sensory input:* Receiving various forms of stimulation by way of specialized sensory receptors (visual, auditory, tactile, and

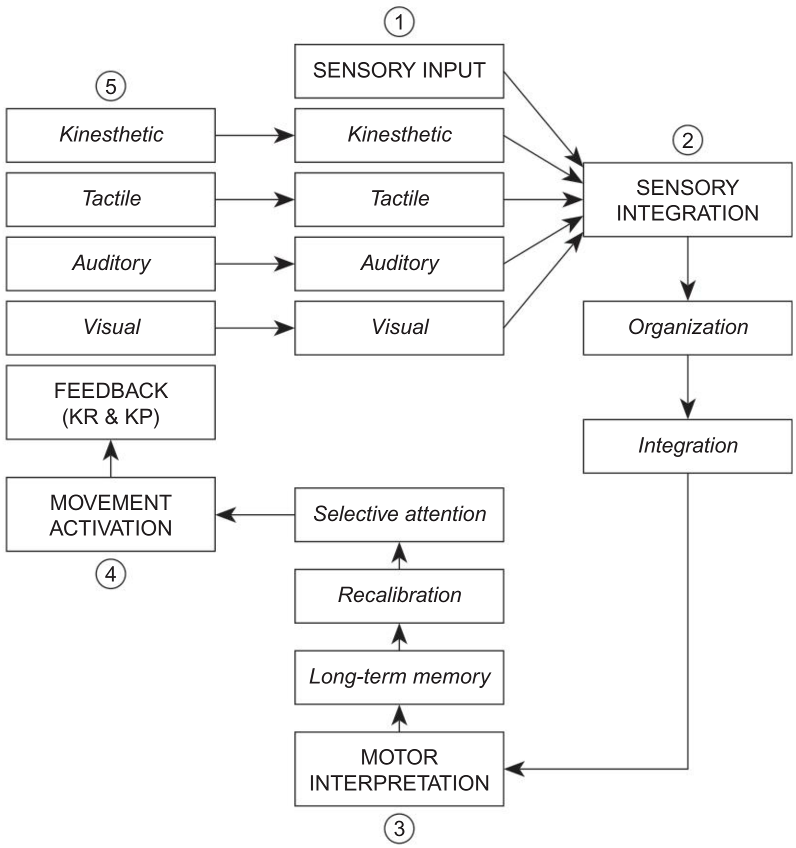

Figure2 .3
An information processing perspective of the perceptual-motor process.

kinesthetic) and transmitting this stimulation to the brain in the form of neural energy.
2. *Sensory integration:* Organizing incoming sensory stimuli and integrating it with past or stored information (memory).
3. *Motor interpretation:* Making internal motor decisions (recalibration) based on the combinations of sensory (present) and long-term memory (past) information.
4. *Movement activation:* Executing the actual movement (observable act) itself.
5. *Feedback:* Evaluating the movement act using various sensory modalities that feed back information into the sensory input aspect of the process, thus beginning the cycle again (KR = knowledge of results; and KP = knowledgeo fp erformance).

Figure 2.3 illustrates an information processing perspective of the perceptual-motor process. Take a few minutes to review this figure to fully appreciate the importance of perception in the process of movement.

THREE LEADING THEORIES OF HUMAN DEVELOPMENT

In this section, summaries of three theories, each representing a different conceptual point of view, are presented. The phase-stage theory of Erik Erikson, the developmental milestone theory of Jean Piaget, and the developmental task theory of Robert Havighurst have been selected because of their thoroughness, popularity, and important implications for motor development. Ecological theories were discussed in the preceding paragraphs.

Erik Erikson

The psychosocial theory of Erik Erikson (1963, 1980) adheres to the phase-stage approach to studying human development. It is an experience-based theory widely acclaimed by educators and psychologists. The following overview of Erikson's stage theory is presented for clarity and ease of understanding. See Table 2.2 for an outline of Erikson's stages and the approximate age periods when they appear. Note the numerous implications for movementt hroughoutt het heory.

CONCEPT 2.4

Individuals' psychosocial development is influenced by their motor development and movement education throughout the life span.

A. Acquiringa S enseo fB asic Trust Versus Mistrust (Infancy)

According to Erikson, bodily experiences provide the basis for a psychological state of *trust versus mistrust*. The infant learns to trust "mother," oneself, and the environment through mother's perception of the infant's needs and demands. Mutual trust and a willingness to face situations together are established between mother and child. For the

DEVELOPMENTAL DILEMMA

Al: A Story of Success

Several years ago the senior author and his wife faced a very personal developmental dilemma. Our 17-year-old nephew, Alan, was in serious trouble with the law. Since the untimely death of his father when Alan was only 22 months of age his life had gone steadily downhill. A grieving mother, an inconsistent home life, and unreliable father figures coupled with rejection, difficulty making friends, school failure, truancy, uncontrolled rage, and total disregard for authority finally culminated in several encounters with the police, the result being that the judge was prepared to send him to a prison for juveniles. Upon learning of this, we hastily convened a family meeting and discussed the possibility of bringing Alan from the East out to Indiana to live with us. The court agreed to permit us to serve as his "parole officers" and if he remained out of trouble for the next three years, his record as a juvenile would be expunged.

Thus began a three-year effort in tough love but with a definite frame of reference: Erik Erikson's theory of psychosocial development. We focused on the first six stages in Erikson's model, using them as the basis for restructuring Alan's life in the quest to help him become a responsible, law-abiding, contributing member of society.

Through a series of family-focused activities and living on a rural horse farm in southern Indiana we were able to help Al (we never referred to him as Alan, but called him Al in a complete attempt for him to adopt a new identity). He learned to *trust*. He developed a sense of *autonomy, initiative, industry*, and personal *identity*. He even, for the first time, experienced what it was like to have a girlfriend and decent male friends who contributed to his emerging sense of *intimacy*.

Was it worth the time and effort? Absolutely. Al graduated from high school as the "Most Improved Student," did a stint in the Army, and now works as a graphic artist for a well-known company that advertises nationally.

With the help of Erik Erikson we are able to tell the story of Al as a success story, rather than that of a life that went wrong from the very beginning and never recovered. Way to go, Al!

TABLE 2.2 Erik Erikson's Stages of Psychosocial Development

Stage		Characteristics	Approximate Age Period	Defining Event
I	Trustv s. Mistrust	Trust during infancy is achieved by having basic needs met by responsive, sensitive caregivers. Mistrust is developed through uncertainty about the future and inconsistent meeting of basic needs.	Infancy	Mutual affirmation
II	Autonomy vs. Doubt and Shame	Autonomy is developed as a toddler by being permitted to assert one's will and establish a rudimentary sense of independence. Doubt and shame develop out of overly harsh and inconsistent discipline and "smothering" behaviors by caregivers.	Toddler	"Terrible two's"
III	Initiativev s. Guilt	Initiative is established during the early childhood years when children are challenged to engage in more purposeful and responsible socialized behaviors. Guilt feelings develop from excessive anxiety arising out of irresponsible behavior.	Preschool	Play age
IV	Industry vs. Inferiority	Industry is maximized during the exuberant years of childhood when children direct their energies to mastering the new cognitive and physical skills of their rapidly expanding world. Inferiority develops from feelings of incompetence and failure to achieve expectation levels.	School Age	Learning new skills
V	Identity vs. Role Confusion	Identity is achieved by adolescents finding out who they are and what they are about and exploring alternative solutions to life's problems. Role confusion is likely among those stifled in this quest.	Early Adolescence	Fidelity and devotion to friends and causes
VI	Intimacyv s. Isolation	Intimacy is achieved during young adulthood by forming long-term, close, personal ties with significant others. Isolation occurs among those unable to reveal themselves in intimate relationships.	Late Adolescence	Mutually satisfying love and affiliation
VII	Generativity vs. Self-Absorption	The mature adult who has achieved generativity is genuinely interested in helping others, especially the younger generation, lead productive lives. Those more concerned about their own wants and needs than those of others are self-absorbed.	Adulthood	Resolves "midlife crisis"
VIII	Integrityv s. Despair	Older adults who look back over their life and positively evaluate what they have done with it are individuals with integrity. Those who lament the past and the decisions of a lifetime do so with despair.	Old Age	Wisdom, reflection, and a sense of fulfillment

neonate, trust requires a feeling of physical comfort and a minimum of fear and uncertainty. A sense of basic trust helps an individual to be receptive to new experiences willingly.

Movement is an essential ingredient of the reciprocal relationship between parent and child. The rhythmical rocking, bathing, and general play behaviors between parent and baby provide a natural means, through movement, for establishing a sense of trust. Mistrust arises out of uncertainty; insecurity; and failure to respond to baby's needs for comfort, attention, and mutual play dialogue.

B. Acquiringa S enseo f Autonomy VersusD oubt and Shame (Toddler)

During the stage in which the toddler is establishing a sense of *autonomy versus doubt and shame,* Erikson believed that continued dependency creates a sense of doubt and shame about one's capabilities. It is therefore critical that the young child assert autonomy as a normal stage of psychosocial development. Children are bombarded by the conflicting pulls of asserting their autonomy and of denying themselves the right and capacity to make this assertion. During this period they need guidance and support as they strive for autonomy, lest they find themselves at a loss and are forced to turn against themselves with shame and doubt. At this stage of development, children are typically eager to explore and accomplish new feats. During this period it is essential that proper development of the ego occurs, thereby permitting awareness of oneself as an autonomous whole.

Active play is particularly important during this stage because it allows children to develop autonomy within their own boundaries. A child's autonomy emerges from the realization that the environment and the self can be controlled. During this stage children frequently violate the mutual trust established with others in order to establish autonomy in distinct areas.

C. Acquiring a Sense of Initiative Versus Guilt (Preschool)

During this stage in which the child establishes a sense of *initiative versus guilt,* avid curiosity and enthusiasm or feelings of guilt and anxiety develop. According to Erikson, the conscience is established during this stage. Specific tasks are mastered, and children assume responsibility for themselves and their world. They realize that life has a purpose. Children discover that with their greater mobility they are not unlike the adults in their environment. They begin to incorporate into their consciences who their parents are as people, and not merely what their parents try to teach them. With improvements in their use of language, children can expand their fields of activity and imagination. Awareness of sex differences also develops at this stage.

During this period children find pleasurable accomplishment in manipulating meaningful toys. Fundamental movement skills are being mastered, influencing children's success in the game activities of their culture. Successful play and game experiences contribute to a sense of initiative. Unsuccessful experiences promote feelings of doubt and shame. In the normal scheme of things a sense of accomplishment in other areas quickly compensates for most guilt and failure. For the child, the future tends to absolve the past.

D. Acquiring aS enseo fI ndustry Versus Inferiority (School Age)

Acquiring a sense of *industry versus inferiority* is marked by the development of the skills necessary for life in general and preparation for adulthood. During this phase Erikson believed that children should be finding places among their peers instead of among adults. They need to work on mastering social skills and becoming competent and self-striving. They need feelings of accomplishment for having done well. Failure during this stage is difficult to accept, and the child has a distinct tendency to ward off failure at any price. During this period children begin to recognize that they must eventually break with accustomed family life. Dependence on parents begins to shift to reliance on social institutions such as the school, the team, or the gang.

Play activities during this phase tend to reflect competition through organized games and sports. Boys and girls generally play separately. Play for its own sake begins to lose importance at the end of this stage. In conjunction with puberty, involvement in play merges into semiplayful and, eventually, real involvement in work.

E. Acquiring a Sense of Identity Versus Role Confusion (Early Adolescence)

When acquiring a sense of *identity versus role confusion* there is rapid body growth and sexual maturation. Masculine or feminine identity develops. Feelings of acceptance or rejection by peers are important. Conflicts frequently arise when peers say one thing and society says another. Identity is essential for making adult decisions about vocation and family life. Youth select people who mean the most to them as significant adults. These role models may be family members, friends, sports heroes, or other accomplished individuals in their lives. During this stage of development, the individual slowly moves into society as an interdependent and contributing member. A sense of identity assures the individual a definite place within his or her corner of society.

Organized sports help many youth acquire a sense of identity. Skill proficiency, team membership, and competitive victories contribute to a sense of identity. Failure and unsuccessful experiences, on the other hand, contribute to a sense of rolec onfusion.

F. Acquiringa S enseo fI ntimacy Versus Isolation (Late Adolescence)

Erikson believed that in acquiring a sense of *intimacy versus isolation* an individual accepts himself or herself and goes on to accept others by fusing his or her personality with others. Childhood and youth are at an end. The individual settles down to the task of full participation in the community and begins to enjoy life with adult responsibilities as well as adult liberties. At this stage the individual shows readiness and ability to share mutual trust and to regulate cycles of work, procreation, and recreation.

Play through the games, sports, and recreational activities of adulthood serves as one important medium for fostering a sense of intimacy with same-sex and opposite-sex teammates. Efforts on behalf of a team, whether in a competitive or recreational setting, reflect a level of intimacy due to the need for cooperative behaviors and teamwork. Failure to develop and refine game and sport skills, to at least a recreational level, can lead to a sense of isolation from a team or social group.

G. Acquiring a Sense of Generativity Versus Self-Absorption (Adulthood)

Generativity versus self-absorption, according to Erikson, refers to the course an individual pursues in society to provide the next generation with the hope, virtues, and wisdom he or she has accumulated. It also includes parental responsibility to uphold society's interests in child care, education, the arts and sciences, and cultural traditions. This stage is manifested when an individual shows more interest in the next generation than in his or her problems.

In a movement sense, generativity may be viewed as wanting to pass on the joys and values of play, games, and sport activities to the next generation for their enjoyment and self-fulfillment. Failure during this stage involves self-absorbed disappointment and the inability to accept one's waning capabilities as middle age approaches.

H. Acquiring a Sense of Integrity Versus Despair (Mature Adult and Old Age)

During this final stage, in which the mature adult acquires a sense of *integrity versus despair,* Erikson believed that the individual accomplishes the fullest sense of trust as the assured reliance on the integrity of significant others. A different love of one's parents is established. Parents are seen as individuals with weaknesses as well as strengths, and deserving of love for who they are and not what they are. Integrity provides a successful solution to an opposing sense of despair. Fulfillment of this stage involves a sense of wisdom and a philosophy of life that often extends beyond the life cycle of the individual and relates directly to the future of new developmental cycles. Successfully meeting the challenge of this stage enables one to look back on his or her life with all of its successes and failures, good times and bad times, and to do so with integrity. Failure to meet the challenges of this stage causes one to look back with remorse, and to look forward in despair.

Movement in the form of active play, games, recreational sport, and general mobility is of real importance during this stage. During this period, successful movement, whether it involves walking, driving a car, or swimming laps, means independence. Movement at this stage means freedom and life. Looking back upon one's movement accomplishments, and forward at declining capabilities, does not cause despair in the individual who meets the challenges of this stage. Instead, movement helps one to maintain competence and accept physicalc hanges.

Jean Piaget

The developmental milestone theory of Jean Piaget (1952, 1954, 1969, 1974) is among the most popular of the theories postulated by experts in the field of child development because of its clarity and insight into and understanding of the development of cognition. Table 2.3 outlines Piaget's phases of cognitive development. Cognitive development, according to Piaget, occurs through the process of adaptation. **Adaptation** requires one to make adjustments to environmental conditions and intellectualize these adjustments through the complementary processes of accommodation and assimilation (Figure 2.4).

Accommodation is adaptation that the child must make to the environment when new and incongruent information is added to his or her repertoire of possible responses. The individual adjusts the response to meet the demands of the specific challenge. Accommodation is a process that reaches outward toward reality and results in a visible change in behavior. For example, when playing in the shallow water of a bathtub or wading pool, a child learns to take into account many of the physical properties and realities of the water. However, when trying to swim in deep water, the child will have to go through a series of new actions (e.g., not being able to touch the bottom, letting go, floating, and breath holding) to accommodate to the new reality of deep water.

Assimilation, on the other hand, is Piaget's term for the interpretation of new information based on present interpretations. Assimilation involves taking in information from the environment

TABLE 2.3 Jean Piaget's Phases of Cognitive Development

Phase	Characteristics	Approximate Age-Period	Defining Event
I Sensorimotor	The infant constructs meaning of her world by coordinating sensory experiences with movement.	Birth to 2 years	Basic assimilation and schema formation through movement
II Preoperational Thought	The young child displays increased symbolic thinking by linking his world with words and images.	2 to 7 years	Advanced assimilation by using physical activity to perform cognitive processes
III Concrete Operations	The child reasons logically about concrete events and can classify objects in her world into various sets.	7 to 11 years	Reversibility with intellectual experimentation through active play
IV Formal Operations	The adolescent is capable of reasoning more logically and in abstract and idealistic ways.	11 years onward	Deductive reasoning through abstract hypothesis formulation

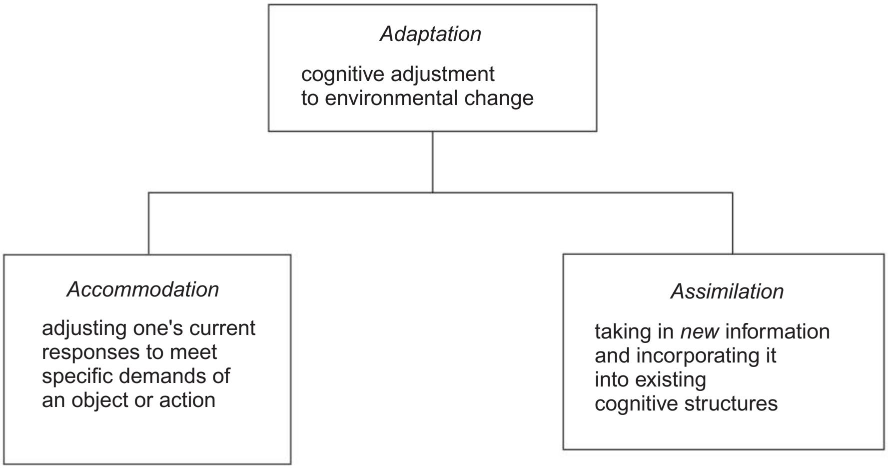

Figure2 .4
Piaget's view was that adaptation occurs through the complementary processes of accommodation and assimilation.

and incorporating it into the individual's existing cognitive structures. If this information cannot be incorporated into existing structures because of small variations, accommodation will occur. However, if the information is too different from the existing structures, it will not be assimilated or accommodated. For example, giving a toddler a ball to toss may be a new experience, but after a series of accommodations (i.e., adjustments), the child may attempt to play catch. You would not, however, expect the child to challenge you to a game of basketball. Although basketball playing involves various forms of ball tossing, it is too different from playing toss and catch to be assimilated (i.e., incorporated) by the child.

A summary of Piaget's theory follows. Note the numerous implications for movement throughout Piaget's phases of cognitive development.

CONCEPT 2.5

Higher cognitive structures are formulated through the processes of accommodation and assimilation, both of which rely on self-discovery through play and movement activity.

A. Sensorimotor Phase (Birth to 2 Years)

The *sensorimotor phase* is the period during which children learn to differentiate themselves from objects and others. Motor activity is critical because the child learns through his or her physical interactions with the world. During the sensorimotor phase of development, the major developmental tasks of infancy are coordination of the infant's actions or movement activities and his or her perceptions into a tenuous whole. The sensorimotor phase is composed of several overlapping stages.

1. *Use of reflexes* (birth to 1 month): Piaget believed that there is a continuation of prenatal reflexes for the purpose of enabling the infant to gain additional information about his or her world. Reflexes are spontaneous repetitions caused by internal and external stimulation. Through reflexes and stereotypical behaviors, rhythm is established through practice, and habits are formed that later emerge as voluntary movements.
2. *Primary circular reactions* (1 to 3 months): Primary circular reactions refer to the assimilation of a previous experience and the recognition of the stimulus that triggered the

reaction required to generate the experience. At this point in the infant's development, new or past experiences have no meaning unless they become part of the infant's primary circular reaction pattern. During this period, reflexive movement is gradually replaced with voluntary movement, but neurological maturity must be reached before sensations can be understood. What previously had been automatic behavior for the infant is now repeated voluntarily, and more than one sensory modality can be used at a time. Accidentally acquired responses become new sensorimotorh abits.

3. *Secondary circular reactions* (3 to 9 months): During this stage, the infant tries to make events last and tries to make them occur. Secondary circular reactions mean that the focus of the infant is on retention, not repetition, as in the previous stage. The infant now tries to create a state of permanency by repeating and prolonging primary circular reactions with secondary reactions. During this stage, two or more sensorimotor experiences are related to one experiential sequence or schema. **Schema**, as used here, is Piaget's term for a pattern of physical or motor action occurring in early infancy. It should not be confused with Schmidt and Lee's (2005) use of the word "schema," in which they are referring to later motor skills. For the infant at the secondary circular reactions stage, vision is the prime coordinator of behavior. The other sensory modalities are used to a lesser degree. This is the stage, according to Piaget, where imagination, play, and emotion begin to appear.
4. *Application of the secondary schemata to new situations* (8 to 12 months): Piaget viewed this stage as being characterized by the child's ability to distinguish means from ends; that is, being able to produce the same result in more than one way. During this period, children use previous behavioral achievements primarily as the basis for adding new achievements to their expanding repertoire. As a result, there is increased exploration in which ends and means are differentiated through experimentation. Accommodation occurs as the result of experimentation, and the infant can now experience action by observation.
5. *Tertiary circular reactions* (12 to 18 months): Tertiary circular reactions is Piaget's term for the infant's discovery of new means through active experimentation. During this period, curiosity and novelty-seeking behavior are developing. Fundamental reasoning comes into play and is developed. As a result, failure to remember is seen as failure to understand. The infant begins to develop spatial relationships upon discovering objects as objects. Imitation develops and play is important because the child repeats the action phase, linking cognitive processes to movementp rocesses.
6. *Invention of new means through mental combinations* (12 to 24 months): During this stage, Piaget recognized a shift from sensorimotor experiences to increased reflection about these experiences. This represents the stepping-stone to the next phase, a more advanced level of intellectual behavior. Children at this stage are capable of discerning themselves as one object among many. Therefore, they tend to perceive and use objects for their intrinsic qualities. Additionally, they begin to relate objects to new actions without perceiving all of the actions. Sensorimotor patterns are slowly replaced by semimental functioning. Imitation copies the action or the symbol of the action. Parallel play appears, and identification, as a mental process, becomes evident by the end of this phase, depending on the level of the child's intellectual development. Furthermore, this period is characterized by the creation of means and not merely the discovery of means. The rudiments of insight begin to develop.

B. Preoperational Thought Phase (2 to 7 Years)

During the *preoperational thought phase,* the first real beginnings of cognition occur. It is "preoperational" because the child is not yet capable of mentally manipulating objects and must rely on physical activity to do so. Additionally, the preoperational thought phase is a period of transition from self-satisfying behavior to rudimentary socialized behavior in young children. As a result, children attempt to adjust new experiences to previous patterns of thinking. Continuous investigation of one's world develops, but the child knows the world only as he or she sees it. Assimilation (i.e., interpreting new information based on present interpretations) is the paramount task of the child. During this phase, emphasis on "why" and "how" becomes a primary tool for adaptation to occur. Conservation of quantity, involving such things as object permanence and conservation of volume, must be mastered before a concept of numbers can be developed.

Language begins to replace sensorimotor activity as a primary facilitator of learning and as the preferred mode of expressing thoughts. Additionally, events are judged by outward appearance regardless of their objective logic. The child responds to either the qualitative aspects of an event or its quantitative aspects, but not both simultaneously. As a result, the child is unable to merge concepts of objects, space, and causality into interrelationships with a concept of time. Time is a nebulous concept that eludes the child in this phase of development.

The child, according to Piaget, is egocentric (i.e., self-centered) in his or her relationship to the world rather than autistic (i.e., nonrelating) as in the sensorimotor phase. Play serves as an important means of assimilation and occupies most of the child's waking hours. Imaginary play and parallel play are important tools for learning. Play also serves to enact the rules and values of one's elders. Characteristic of the preoperational thought phase is the child's widening of social interest in his or her world. As a result, egocentricity is reduced and social participation increases. The child begins to exhibit interest in relationships between people. Understanding the social roles of "mother," "father," "sister," and "brother" and their relationship to one another is important to the child at this phase.

C. Concrete Operations Phase (7 to 11 Years)

During the *concrete operations phase* of development, the child becomes aware of alternative solutions, uses rules in thinking, and is able to differentiate between appearance and reality. It is called "concrete" because the child's mental actions (i.e., "operations") are still tied to concrete objects.

The concept of reversibility becomes established during this phase. Reversibility refers to the capacity of the child to understand that any change of shape, order, position, number, and so forth can be mentally reversed and returned to its original shape, order, position, or number. Reversibility enables the child to relate an event or thought to a total system of interrelated parts and to consider the event or thought from beginning to end or from end to beginning. This form of operational thought enhances the child's mental capacity to order and relate experiences to an organized whole.

The concrete operational thought level presupposes that mental experimentation still depends on perception. At this phase perceptions are more accurate, and the child applies his or her interpretation of these environmental perceptions knowingly. The child examines the parts to gain knowledge of the whole and establishes means of classification for organizing parts into a hierarchical system.

The child uses play during this phase to understand his or her physical and social world. Rules and regulations are of interest to the child when applied to play. Play, however, loses its assimilative characteristics and becomes a balanced subordinate process of cognitive thought. As a result, curiosity finds expression in intellectual experimentation instead of active play alone.

D. FormalO perations Phase (11O nward)

During the *formal operations phase,* childhood ends and youth begins as the individual enters the world of ideas. In this fourth and final phase of cognitive development, a systematic approach to problem solving appears. Logical deduction by implication develops, and the individual is capable of thinking vertically; that is, beyond the present. At this level the individual can dream and does not need concrete reality. Deduction by hypothesis and judgment by implication enable one to reason beyond cause and effect.

Robert Havighurst

The theory of Robert Havighurst (1953, 1972; Havighurst & Levine, 1979) is based on the concept that successful achievement of developmental tasks leads to happiness and success with later tasks, whereas failure leads to unhappiness, social disapproval, and difficulty with later tasks. Havighurst disagreed with any theory that proposes an innate basis of growth and development. He believed that living is learning and growing is learning. Development, then, according to Havighurst, is the process of learning one's way through life. Havighurst conceived of successful development as requiring mastery of a series of tasks. At each level of development the child encounters new social demands. These demands, or tasks, arise out of three sources. First, tasks arise from physical maturation. Such tasks as learning to walk, talk, and get along with one's age-mates are maturation-based. Second, tasks arise out of the cultural pressures of society, such as learning how to read and learning to be a responsible citizen. The third source of tasks is oneself. Tasks arise out of the maturing personality and the individual's values and unique aspirations.

Havighurst's theory has implications for all age levels. His theory is of particular importance to educators because it describes teachable moments in which a person's body and self are ready to achieve a certain task. Educators can better time their efforts at teaching by identifying the tasks suitable for a particular level of development, being fully aware that a child's level of readiness is influenced by biological, cultural, and self factors interacting with one another.

CONCEPT 2.6

Numerous developmental tasks must be achieved for the normal process of development to proceed unencumbered.

Havighurst has suggested six major periods of development: infancy and early childhood (birth through 5 years), middle childhood (6 through 12 years), adolescence (13 through 18 years), early adulthood (19 through 29 years), middle adulthood (30 through 60 years), and later maturity (60 years and up). A summary of Havighurst's developmental tasks in outline form follows. The reader is cautioned to be flexible in the interpretation of these tasks with respect to age. Ages are only convenient approximations and should not be viewed as rigid time frames. However, significant delay beyond these age boundaries would, according to Havighurst, represent failure in a developmental task, with resulting unhappiness and great difficulty with future tasks.

A. Infancy and early childhood (birth to 5 years)
   1. Learningt o walk.
   2. Learningt ot akes olidf oods.
   3. Learningt o talk.
   4. Learning to control the elimination of bodilyw astes.
   5. Learning sexd ifferencesa nds exual modesty.
   6. Acquiringc onceptsa ndl anguage to describe social and physical reality.
   7. Readinessf orr eading.
   8. Learning to distinguish right from wrong andd evelopinga conscience.

B. Middle childhood (6 to 12 years)
   1. Learningp hysicals kills necessaryf or ordinaryg ames.
   2. Buildinga wh olesomea ttitudet oward oneself.
   3. Learningt og eta longw itha ge-mates.
   4. Learninga n appropriate sexr ole.
   5. Developing fundamentalsk illsi n reading, writing, and calculating.
   6. Developing concepts necessaryf or everydayl iving.
   7. Developing a conscience, morality, and a scale of values.

8. Achievingp ersonali ndependence.
9. Developinga cceptablea ttitudest oward society.

C. Adolescence(13t o1 8y ears)
1. Achievingm aturer elationsw ithb oth sexes.
2. Achieving a masculine or feminine social role.
3. Acceptingo ne'sp hysique.
4. Achievinge motionali ndependence of adults.
5. Preparingf orm arriagea ndf amilyl ife.
6. Preparing for an economic career.
7. Acquiring values and an ethical system to guideb ehavior.
8. Desiringa nda chievings ocially responsibleb ehavior.

D. Early adulthood (19 to 29 years)
1. Selectinga m ate.
2. Learningt ol ivew itha p artner.
3. Startinga fa mily.
4. Rearingc hildren.
5. Managinga h ome.
6. Startinga no ccupation.
7. Assuming civic responsibility.

E. Middle adulthood (30 to 60 years)
1. Helpingt eenagec hildren tob ecome happy and responsible adults.
2. Achievinga dult sociala ndc ivic responsibility.
3. Satisfactory career achievement.
4. Developing adultl eisure-timea ctivities.
5. Relating to one's spouse as a person.
6. Acceptingt hep hysiological changeso f middlea ge.
7. Adjustingt oa gingp arents.

F. Later maturity (60 years and up)
1. Adjustingt od ecreasing strengtha nd health.
2. Adjustingt or etirement and reduced income.
3. Adjusting to death of spouse.
4. Establishingr elations witho ne's age group.
5. Meetings ociala ndc ivic obligations.
6. Establishingsa tisfactoryli ving quarters.

SUMMARY

The process of development is commonly viewed as hierarchical. That is, the individual proceeds from general to specific, and from simple to complex, in gaining mastery and control over his or her environment. Erik Erikson's phase-stage theory, Jean Piaget's developmental milestone theory, and Robert Havighurst's developmental task theory make it obvious that the human organism throughout all aspects of its development is moving from comparatively simple forms of existence to more complex and sophisticated levels of development. Until recently, these levels of development have been expressed primarily in terms of the cognitive and affective behaviors of the individual, with only indirect attention given to motor development. Ecological theories, particularly dynamic systems theory and behavior setting theory, offer newer perspectives on development and are particularly relevant to the study of motor behavior.

Although the theoretical formulations of Erikson, Piaget, and Havighurst are of value, none adequately address motor development. It is appropriate, therefore, that a theoretical model of motor development that integrates elements from each, plus a dynamic systems and behavior setting perspective, be put forth in order that we may describe and explain this important aspect of human development. Chapter 3, "Motor Development: A Theoretical Model," is dedicated to this end.

QUESTIONS FOR REFLECTION

1. For some, unfortunately, theoretical models are viewed as "boring" or just an "ivory tower" exercise. Why do you think this is so and why are theoretical models of human development indeed important?
2. After looking briefly at the various conceptual viewpoints of human development, what ones are you most attracted to and why?

3. If developmental theories have real utility, how might they be practically applied in real teaching-learnings ituations?
4. What are your thoughts at this point about dynamic systems theory and phase-stage theory, which will both be applied throughout this text and are utilized in the next chapter in the form of a Triangulated Hourglass Model for motor development?
5. Which of the theoretical models reviewed in this chapter makes the most sense to you? Why?

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Schmidt, R. A., & Lee, T. D. (2005). *Motor Control and Learning: A Behavioral Emphasis* (Chapter 1). Champaign, IL: Human Kinetics.

WEB RESOURCES

www.people.cornell.edu/pages/ub11/

This site provides background information on Urie Bronfenbrenner, the Jacob Gould Sherman Professor of Human Development and Family Studies, and of Psychology at Cornell University. The site includes Professor Bronfenbrenner's work as well as his curriculum vitae.

www.unige.ch/piaget/

The Jean Piaget Archives homepage, a foundation that collects the works of Jean Piaget, psychologist and genetic epistemologist. The site includes a bibliography of work, monographs, theses, articles from periodicals, critical reviews, etc.

www.piaget.org

Homepage for the Jean Piaget Society. Information about Jean Piaget, the society, and publications described. Resources for students, Web links, and membership information included.

http://facultyweb.cortland.edu/~ANDERSMD/ERIK/welcome.HTML

Site provides background information on Erik Erikson and his eight stages of psychological development. Includes summary, biography, and references,a sw ella s otherl inks.

CHAPTER 3

Motor Development: A Theoretical Model

KEY TERMS

Descriptivet heory
Explanatoryt heory
Phaseso fm otord evelopment
Inductivem ethod
Deductivem ethod
Categoryo fm ovement
Reflexes
Rudimentarym ovementa bilities
Fundamentalm ovementsk ills
Specializedm ovements kills
Heuristic
Algorithm
Triangulated Hourglass Model of motor development

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Define life span motor development
- View an individual's motor behavior as "more" or "less" advanced on a developmental continuum rather than as "good" or "bad"
- Demonstrate an understanding of neural, physiological, perceptual, and cognitive changes across the life span
- Distinguish between inductive and deductive theory formulation
- Describe the phases of motor development
- List and describe the stages within the phases of motor development
- Explain how the requirements of the movement task, the biology of the individual, and conditions of the learning environment interact with the Triangulated Hourglass Model of motor development
- Demonstrate knowledge of both how and why using a heuristic device as a metaphor for understanding is helpful in conceptualizing the products and processes of motor development

KEY CONCEPT

The processes and products of motor development across the lifespan may be conceptualized through use of a triangulated hourglass heuristic.

A major function of theory is to integrate existing facts, to organize them in such a way as to give them meaning. Theories of development take existing facts about the human organism and provide a developmental model congruent with these facts. Therefore, theory formulation serves as a basis for fact testing and vice versa. Facts are important, but they alone do not constitute a science. The development of a science depends on the advancement of theory as well as on the accumulation of facts. In the study of human behavior, especially in the areas of cognitive and affective development, theory formulation has gained increased importance over the past several years. Theory has played a critical dual role in both of these areas; namely, it has served and continues to serve as an integrator of existing facts and as a basis for the derivation of new facts (Bigge & Shermis, 2004; Lerner, 2007).

Describing and Explaining Motor Development

Until the 1980s, interest in motor development had been concerned primarily with describing and cataloging data, with little interest in developmental models leading to theoretical explanations of behavior across the life span. This research was necessary and important to our knowledge base. But it did little to help us answer the critically important questions of what lies underneath the process of motor development and how the process occurs. Only a limited number of comprehensive models of motor development exist, and there are still few comprehensive theories of motor development. Now, however, scholars in motor development are reexamining their work with a view toward more carefully thought out research grounded in sound theoretical frameworks. The intent of this chapter is to present a comprehensive model of motor development, based on two specific theoretical viewpoints: *descriptive* phase-stage theory and *explanatory* dynamic systems theory. We will present this model in the form of an hourglass accompanied by an overlapping inverted triangle. Our intent here is to use this visual representation as a way to conceptualize both the descriptive products (hourglass) and explanatory processes (inverted triangle) of motor development as it typically unfolds across the life span. As with all theoretical models ours too will fall short. It has, however, served as a plinth (basis) by many for better understanding *what* is occurring and *why* it is occurring in this amazing process that we call motor development.

CONCEPT 3.1

Few comprehensive theoretical models of motor development exist.

The first function of a theoretical model of motor development should be to integrate the existing facts encompassed by the area of study. The second function should be to serve as a basis for the generation of new facts. One might argue that the facts could be interpreted in more than one way, that is, from different theoretical perspectives. This is entirely possible and desirable. Different viewpoints generate theoretical arguments and debates, the spark for research to shed new light on differing theoretical interpretations. Even if theoretical differences do not exist, research should be undertaken to determine whether the hypotheses derived from the theory can be both experimentally and ecologically supported.

Theory should undergird all research and science, and the study of motor development is no exception. It is our view that developmental theory must be both **descriptive** and **explanatory.** In other words, the developmentalist should be interested in what people are typically like at particular age periods (description) and why these characteristics occur (explanation). Without a theoretical construct, research in motor development, or any other area, tends to yield little more than isolated facts. However, without an existing body of knowledge (facts), we cannot formulate theory, and without the formulation and constant testing of theory, we cannot hope for a higher level of understanding and awareness of the phenomenon that we call motor development.

CONCEPT 3.2

Theoretical models attempt to describe and explain behavior and may be inductive or deductive.

A theory is a group of statements, concepts, or principles that integrate existing facts and lead to the generation of new facts. The **phases of motor development** presented in this chapter are not based solely on the accumulation of facts. Such a model would result from using an **inductive method** of theory formulation. In the inductive method the investigator first starts with a set of facts and then tries to find a conceptual framework around which to organize and explain them. The **deductive method** of theory formulation, as used here, is based on inference and has three primary qualifications. First, the theory should integrate existing facts and account for existing empirical evidence that bears on the content of the theory. Second, the theory should lend itself to the formulation of testable hypotheses in the form of: If ______, then ______ statements. Third, the theory should meet the empirical test; that is, experimentally tested hypotheses should yield results that lend further support to the theory.

The use of a deductive, rather than an inductive, model enables us to see how well-accumulated facts fit together into a cohesive, understandable whole. It also enables us to identify the information needed to fill in gaps in the theory or to clarify or refine it. The phases of motor development outlined here are deductively based and serve as a model for theory formulation. In subsequent sections of the text each phase will be explored in greater detail.

THE PHASES OF MOTOR DEVELOPMENT

The process of motor development reveals itself primarily through changes in movement behavior over time. All of us, infants, children, adolescents, and adults, are involved in the lifelong process of learning how to move with control and competence in response to challenges we face daily in our constantly changing environment. We are able to observe developmental differences in movement behavior. We can do this through observation of changes in process (form) and product (performance). A primary means by which motor development may be observed is through studying changes in movement behavior throughout the life cycle. In other words, a "window" to the process of motor development is provided through an individual's observable movement behavior, which provides us with clues to underlying motor processes.

CONCEPT 3.3

The process of motor development may be viewed as phase-like and stage-like.

Observable movement may be grouped into three functional categories according to their purpose and across all of the phases of motor development: stabilizing movement tasks, locomotor movement tasks, and manipulative movement tasks, or combinations of the three. In the broadest sense, a stability movement is any movement in which some degree of balance or posture is required (i.e., virtually all gross motor activity). In a narrower sense, a stability movement is one that is both nonlocomotor and nonmanipulative. The category conveniently encompasses movements such as twisting, turning, pushing, and pulling that cannot be classified as locomotor or manipulative. In this book, stability, as a **category of movement,** is viewed as more than a convenient catchall term, but as less than a global term applicable to all movement. The *stability movement* category refers to any movement that places a premium on gaining and maintaining one's equilibrium in relation to the force of gravity. Thus, axial movements (another term sometimes used for nonlocomotor movements) as well as inverted and body rolling postures are considered here as stability movements. So too are standing on one foot or remaining upright while sitting in a chair.

The *locomotor movement* category refers to movements that involve a change in location of the body relative to a fixed point on the surface. To transport oneself from point A to point B by walking, running, hopping, jumping, or skipping is to perform a locomotor task. In our use of the term, such activities as the forward roll and backward roll may be considered both locomotor and stability movements—locomotor because the body is moving from point to point, stability because of the premium placed on maintaining equilibrium in an unusual balancing situation.

The *manipulative movement* category refers to both gross and fine motor manipulation. Gross motor manipulation involves imparting force to, or receiving force from, objects. The tasks of throwing, catching, kicking, and striking an object, as well as trapping and volleying, are gross motor manipulative movements. Fine motor manipulation involves intricate use of the muscles of the hand and wrist. Sewing, cutting with scissors, and typing are fine motor manipulative movements. A large number of movements involve a combination of stability, locomotor, and/or manipulative movements. For example, jumping rope involves locomotion (jumping), manipulation (turning the rope), and stability (maintaining balance). Likewise, playing soccer involves locomotor skills (running and jumping), manipulative skills (dribbling, passing, kicking, and heading), and stability skills (dodging, reaching, turning, and twisting).

In summary, if movement serves as a window to the process of motor development, then one way of studying this process is through examining the sequential progression of movement skills throughout the entire life span. The following phases of motor development and the developmental stages within each phase are designed to serve as a model for this study. (See Figure 3.1 for a visual representation of the four phases and their correspondings tages.)

Reflexive Movement Phase

The first movements the fetus makes are reflexive. **Reflexes** are involuntary, subcortically controlled movements that form the basis for the phases of motor development. Through reflex activity the infant gains information about the immediate environment. The infant's reactions to touch, light, sounds, and changes in pressure trigger involuntary movement activity. These involuntary movements, coupled with increasing cortical sophistication in the early months of postnatal life, play an important role in helping the child learn more about his or her body and the outside world.

Primitive reflexes may be classified as information-gathering, nourishment-seeking, and protective responses. They are information-gathering in that they help stimulate cortical activity and development. They are nourishment-seeking and protective because there is considerable evidence that they are phylogenetic in nature. Primitive reflexes such as the rooting and sucking reflexes are thought to be primitive survival mechanisms. Without them, the newborn would be unable to obtain nourishment.

Postural reflexes are the second form of involuntary movement. They are remarkably similar in appearance to later voluntary behaviors but are entirely involuntary. These reflexes seem to serve as neuromotor testing devices for stability, locomotor, and manipulative mechanisms that will be used later with conscious control. The primary stepping reflex and the crawling reflex, for example, closely resemble later voluntary walking and crawling behaviors. The palmar grasping reflex is closely related to later voluntary grasping and releasing behaviors. The labyrinthine righting reflex and the propping reflexes are related to later balancing abilities. The reflexive phase of motor development may be divided into two overlapping stages.

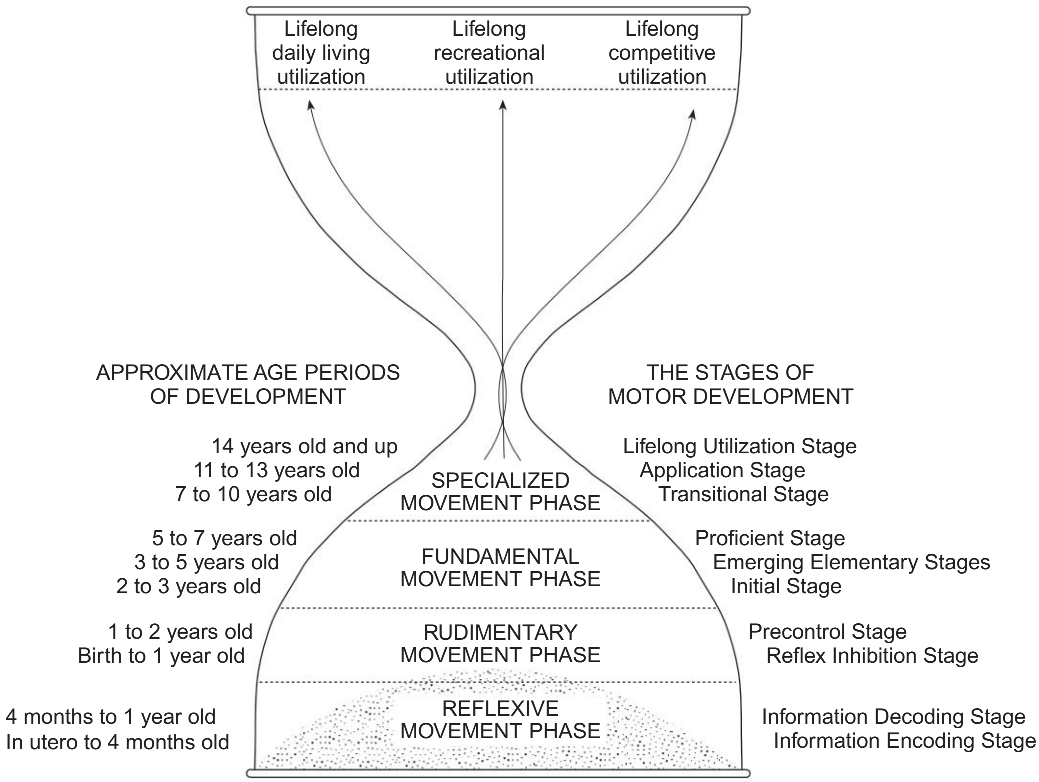

Figure3 .1

The phases and stages of motor development.

CONCEPT 3.4

Reflexes are the first forms of human movement and, because they are not learned, are considered to be "abilities" rather than "skills."

Information Encoding Stage

The information encoding (gathering) stage of the reflexive movement phase is characterized by observable involuntary movement activity during the fetal period until about the fourth month of infancy. During this stage lower brain centers are more highly developed than the motor cortex and are essentially in command of fetal and neonatal movement. These brain centers are capable of causing involuntary reactions to a variety of stimuli of varying intensity and duration. Reflexes now serve as the primary means by which the infant is able to gather information, seek nourishment, and find protection through movement.

Information Decoding Stage

The information decoding (processing) stage of the reflex phase begins around the fourth month. During this time there is a gradual inhibition of many reflexes as higher brain centers continue to develop. Lower brain centers gradually relinquish control over skeletal movements and are replaced by voluntary movement activity mediated by the motor area of the cerebral cortex. The decoding stage replaces sensorimotor activity with perceptual-motor ability. That is, the infant's development of voluntary control of skeletal movements involves processing sensory stimuli with stored information, not merely reacting to stimuli.

Chapter 7 focuses on the primitive and postural reflexes of infancy as they relate to the information encoding and decoding stages. Special attention is given to the relationship between the reflexive phase of development and voluntary movement.

Rudimentary Movement Phase

The first forms of voluntary movement are rudimentary movements. They are seen in the infant beginning at birth to about age 2. Rudimentary movements are maturationally determined and are characterized by a highly predictable sequence of appearance. This sequence is resistant to change under normal conditions. The rate at which these abilities appear will vary from child to child, however, and depends on biological, environmental, and task factors. The **rudimentary movement abilities** of the infant represent the basic forms of maturationally dependent voluntary movement required for survival. They involve stability movements such as gaining control of the head, neck, and trunk muscles; the manipulative tasks of reaching, grasping, and releasing; and the locomotor movements of creeping, crawling, and walking. The rudimentary movement phase of development may be subdivided into two stages that represent progressively higher orders of motor control.

CONCEPT 3.5

The sequence of movement skill acquisition during the rudimentary movement phase is generally fixed, but the rate is variable.

Reflex Inhibition Stage

The reflex inhibition stage of the rudimentary movement phase may be thought of as beginning at birth. At birth, reflexes dominate the infant's movement repertoire. From then on, however, the infant's movements are increasingly influenced by the developing cortex. Development of the cortex, and lessening of certain environmental constraints, causes several reflexes to be inhibited and gradually disappear. Primitive and postural reflexes are replaced by voluntary movement behaviors. At the reflex inhibition level, voluntary movement is poorly differentiated and integrated because the neuromotor apparatus of the infant is still at a rudimentary stage of development. Movements, though purposeful, appear uncontrolled and unrefined. If the infant wishes to make contact with an object, there will be global activity of the entire hand, wrist, arm, shoulder, and even trunk. The process of moving the hand into contact with the object, although voluntary, lacks control.

Precontrol Stage

Around 1 year of age, children begin to bring greater precision and control to their movements. The process of differentiating between sensory and motor systems and integrating perceptual and motor information into a more meaningful and congruent whole takes place. The rapid development of higher cognitive processes and motor processes encourages rapid gains in rudimentary movement abilities during this stage. During the precontrol stage, children learn to gain and maintain their equilibrium, to manipulate objects, and to locomote throughout the environment with an amazing degree of proficiency and control considering the short time they have had to develop these abilities. The maturational process may partially explain the rapidity and extent of development of movement control during this phase, but the growth of motor proficiency is no less amazing.

Chapter 8 provides a detailed explanation of the development of rudimentary movement abilities. Particular attention is paid to the interrelationship between the stages within this phase and the stages within the reflexive phase of development. Attention is also focused on the critical function that the rudimentary movement phase serves in preparing the child for the development of fundamental movement skills.

INTERNATIONAL PERSPECTIVES

The Royal Academy of Dance

The Royal Academy of Dance, located in London, has produced superb *Pre-Primary in Dance* and *Primary in Dance* syllabi and instructional DVDs. They deftly achieve the goals of helping young children become more skillful movers, knowledgeable movers, and expressive movers in a teaching and learning environment that is age-appropriate, developmentally appropriate, and fun. Each of the themed lessons is well presented and pedagogically sound. A diverse group of children depict the joy of moving with skill, efficiency, and purpose. The focus is on a wide variety of the fundamental locomotor, manipulative, and stability skills of early childhood. These skills are important because they form the basis for the more complex and specialized movement, sport, and dance skills of later childhood and beyond. In each of the many lessons children are encouraged to experiment with an endless variety of movement variations and to self-discover ways of moving that increase their movement vocabulary as well as skillfulness. The children are delightful to observe and interaction with the on-camera instructor is joyful. The instructor is a master teacher who, lesson after lesson, demonstrates how to make curricular material personally meaningful and developmentally appropriate for young learners.

In a world often more interested in specializing in movement skill development at an early age, the Royal Academy of Dance has taken a bold step in a different direction: a direction that is focused on the developmental needs, interests, and unique abilities of children as they begin the lifelong quest of being skillful, knowledgeable, and expressive movers. Check out the Royal Academy of Dance website for more information: http://www.radenterprises.co.uk

Fundamental Movement Phase

The **fundamental movement skills** of early childhood are an outgrowth of the rudimentary movement phase of infancy. This phase of motor development represents a time in which young children are actively involved in exploring and experimenting with the movement potential of their bodies. It is a time for discovering how to perform a variety of stabilizing, locomotor, and manipulative movements, first in isolation and then in combination with one another. Children developing fundamental patterns of movement are learning how to respond with motor control and movement competence to a variety of stimuli. They are gaining increased control in the performance of discrete, serial, and continuous movements as evidenced by their ability to accept changes in the task requirements. Fundamental movement patterns are basic observable patterns of behavior. Locomotor activities such as running and jumping, manipulative activities such as throwing and catching, and stability activities such as the beam walk and one-foot balance are examples of fundamental movements that should be developed during the early childhood years.

A major misconception about the developmental concept of the fundamental movement phase is the notion that these skills are maturationally determined and are little influenced by task demands and environmental factors. Some child development experts (not in the motor development area) have written repeatedly about the "natural" unfolding of the child's movement and play skills and the idea that children develop these abilities merely by growing older (maturation). Although maturation does play a role in the development of fundamental movement patterns, it should not be viewed as the only influence. The conditions of the environment—namely, opportunities for practice, encouragement, instruction, and the ecology (context) of the environment—play important roles in the degree to which fundamental movement skills develop.

Fundamental movement skills have utility throughout life and are important components of daily living for adults as well as children. The daily tasks of walking to the store, climbing stairs, and balancing in static and dynamic positions are important basic skills across the life span. Using the forward roll as the independent variable, Haynes (2009) looked at 117 participants across three age cohorts (children: mean age 9.7; young adults: mean age 18.9; older adults: mean age 35.9). Haynes found that the observable components for the forward roll were essentially the same for each group, a finding that lends support to similar sequences of fundamental movement skills as being age-independent.

CONCEPT 3.6

Constraints contained within the requirements of the movement task, the biology of the individual, and the conditions of the learning environment have profound effects on the acquisition of movement skills at each phase of development.

Several researchers and assessment instrument developers have attempted to subdivide fundamental movements into a series of identifiable sequential stages. For the purposes of our model we will view the entire fundamental movement phase as having separate but often overlapping stages: the initial stage, the emerging elementary stages, and the proficient stage. These stages are described briefly here and in greater detail in chapters 11 and 12.

Initial Stage

The initial stage of a fundamental movement phase represents the child's first goal-oriented attempts at performing a fundamental skill. Movement is characterized by missing or improperly sequenced parts, markedly restricted or exaggerated use of the body, and poor rhythmical flow and coordination. The spatial and temporal integration of movement is poor. Typically, the locomotor, manipulative, and stability movements of the 2–3-year-old are at the initial level. Some children may be beyond this level in the performance of some patterns of movement, but most are at the initial stage.

Emerging Elementary Stages

The emerging elementary stages, of which there may be several, involve gaining greater motor control and rhythmical coordination of fundamental movement skills. The synchronization of the temporal and spatial elements of movement is improved, but patterns of movement during these stages are still generally restricted or exaggerated, although better coordinated. Children of normal intelligence and physical functioning tend to advance to the emerging elementary stages primarily through the process of maturation. Observation of the typically developing 3 to 5 year-old child reveals a variety of fundamental movement skills that are emerging in a series of sometimes distinct and sometimes overlapping elementary stages. Many individuals, adults as well as children, fail to get beyond these emerging elementary stages in one or more fundamental movement skills.

Proficient Stage

The proficient stage within the fundamental movement phase is characterized by mechanically efficient, coordinated, and controlled performances. Proficient fundamental movement skills are mature in these three process aspects. With continued opportunities for practice, encouragement, and instruction they will, however, continue to improve in terms of the product components of how far, how fast, how many, and how accurately.

The majority of available data on the acquisition of fundamental movement skills suggests that children can and should be at the proficient stage by age 5 or 6 in most fundamental skills. Manipulative skills that require visually tracking and intercepting moving objects (catching, striking, volleying) tend to develop somewhat later because of the sophisticated visual-motor requirements of these tasks. Even a casual glance at the movements of children and adults reveals that a great many have not developed their fundamental movement skills to a proficient level. Although some children may reach this stage primarily through maturation and with a minimum of environmental influences, the vast majority require some combination of opportunities for practice, encouragement, and instruction in an environment that fosters learning. Failure to offer such opportunities makes it exceedingly difficult for an individual to achieve proficiency in fundamental movement skills and will inhibit further application and development in the specialized movement phase that follows (O'Keeffe, 2001; Stodden et al., 2008). Seefeldt (1982) was the first to appropriately refer to this as a "proficiency barrier" between fundamental movement skills and their companion specialized sport skills. More recently Clark & Metcalfe (2002) suggested that fundamental motor skills provided the "base camp" to the mountain of motor development leading to motor skillfulness.

Specialized Movement Phase

Specialized movement skills are an outgrowth of the fundamental movement phase. During the specialized phase, movement becomes a tool applied to a variety of complex movement activities for daily living, recreation, and sport pursuits. This is a period when fundamental stability, locomotor, and manipulative skills are progressively refined, combined, and elaborated upon for use in increasingly demanding situations. The fundamental movements of hopping and jumping, for example, may now be applied to rope-jumping activities, to performing folk dances, and to performing the triple jump (hop-step-jump) in track and field. O'Keeffe studied the relationship between fundamental movement skills and sport-specific skills in a test of the Triangulated Hourglass Model of motor development. The results of his investigation led him to conclude that "this study provides empirical evidence in support of Gallahue's theoretical model with respect to the relationship between fundamental skill and sport-specific skill phases and also for dynamical systems theory to explain the learning process" (O'Keeffe, 2001, abstract). In other words, the patterns of movement contained within a fundamental movement skill are the same movement patterns upon which sport-specific skills are based. Therefore, it can be concluded that mastering fundamental skills leads to easier learning of specific skills.

The onset and extent of skill development within the specialized movement phase depends on a variety of task, individual, and environmental factors. Reaction time and movement speed, coordination, body type, height and weight, customs, culture, peer pressure, and emotional makeup are but a few of these constraining factors. The specialized movement phase has three stages.

Concept 3.7

Progress through the specialized movement skill phase depends on mature fundamental movement skill development.

Transitional Stage

Somewhere around their seventh or eighth year, children commonly enter a transitional movement skill stage (Haubenstricker & Seefeldt, 1986). During the transitional period, the individual begins to combine and apply fundamental movement skills to the performance of specialized skills in sport and recreational settings. Walking on a rope bridge, jumping rope, and playing kickball are examples of common transitional skills. Transitional movement skills contain the same elements as fundamental movements with greater form, accuracy, and control. Fundamental movement skills developed and refined during the previous stage are applied to play, game, and daily living situations. Transitional skills are applications of fundamental movement patterns in somewhat more complex and specific forms.

The transitional stage is an exciting time for the parent and the teacher as well as for the child. Children are actively involved in discovering and combining numerous movement patterns and are often elated by their rapidly expanding movement abilities. The goal of concerned parents, teachers, and youth sport coaches during this stage should be to help children increase their motor control and movement competence in a wide variety of activities. Care must be taken not to cause the child to specialize or restrict his or her activity involvement. A narrow focus on skills during this stage is likely to have undesirable effects on the last two stages of the specialized movement phase.

Application Stage

From about age 11 to age 13 (the middle school years) interesting changes take place in the skill development of the individual. During the previous stage, the child's limited cognitive abilities, affective abilities, and experiences, combined with a natural eagerness to be active, caused the normal focus (without adult interference) on movement to be broad and generalized to "all" activity. In the application stage, increased cognitive sophistication and a broadened experience base enable the individual to make numerous learning and participation decisions based on a variety of task, individual, and environmental factors. For example, the 5-foot, 10-inch (179 cm) 12-year-old who likes team activities and applying strategy to games, who has reasonably good coordination and agility, and who lives in Indiana, may choose to specialize in the development of his or her basketball playing abilities. A similarly built child who does not really enjoy team efforts may choose to specialize in a variety of track and field activities. The individual begins to make conscious decisions for or against participation in certain activities. These decisions are based, in large measure, on how he or she perceives the extent to which factors within the task, himself or herself, and the environment either enhance or inhibit chances for enjoyment and success. This self-examination of strengths and weaknesses, opportunities and restrictions, narrows the choices.

During the application stage, individuals begin to seek out or to avoid participation in specific activities. Increased emphasis is placed on form, skill, accuracy, and the quantitative aspects of movement performance. This is a time for more complex skills to be refined and used in advanced games, lead-up activities, and selected sports.

Lifelong Utilization Stage

The lifelong utilization stage of the specialized phase of motor development begins around age 14 and continues through adulthood. The lifelong utilization stage represents the pinnacle of the process of motor development and is characterized by the use of one's acquired movement repertoire throughout life. The interests, competencies, and choices made during the previous stage are carried over, further refined, and applied to a lifetime of daily living, recreational, and sports-related activities. Factors such as available time and money, equipment and facilities, and physical and mental limitations affect this stage. Among other things, one's level of activity participation will depend on talent, opportunities, physical condition, and personal motivation. An individual's lifetime performance level may range anywhere from professional status and the Olympics; to intercollegiate and interscholastic competition; to participation in organized or unorganized, competitive or cooperative, recreational sports and simple daily living skills.

In essence, the lifelong utilization stage represents a culmination of all preceding stages and phases. It should, however, be viewed as a continuation of a lifetime process. Specialized skill development can and should play a role in our lives, but it is unfair to require children to specialize in one or two skill areas at the expense of developing their movement repertoire in and appreciation for many other areas (Landers, Carson, & Tjeerdsma-Blankenship, 2010).

CONCEPT 3.8

The primary goal of a person's motor development and movement education is to accept the challenge of change in the continuous process of gaining and maintaining motor control and movement competence throughout a lifetime.

THE TRIANGULATED HOURGLASS: A LIFE SPAN MODEL

The age ranges for each phase of motor development should be viewed as general guidelines, illustrative only of the broad concept of age appropriateness. Individuals often function at different phases depending on their experiential backgrounds and genetic makeups. For example, it is entirely possible for a 10-year-old to function in the specialized movement phase at the lifelong utilization stage in stability activities involving gymnastic movements, but only at the elementary stage of the fundamental movement phase in manipulative and locomotor skills such as throwing, catching, or running. Although we should encourage this precocious behavior in gymnastics, we should also help the child catch up to his or her age-mates in the other areas and develop acceptable levels of proficiency in them as well.

It is important to gather facts about the process of developing motor skills. Throughout this text we discuss study after study, but if we fail to provide you with a theoretical framework and a conceptual grasp of the process of motor development, we will have presented isolated facts that tell you little about their implications for successful developmental teaching, coaching, therapy, and parenting. Therefore, we would like to propose a theoretical model for the process of motor development and work through this model with you. This model as presented is not a comprehensive theory of motor development. It is a **heuristic** device, that is, a conceptual metaphor, or model, of motor development, that provides us with general guidelines for describing and explaining motor behavior. Heuristics differ from algorithms in one important way. Whereas an **algorithm** is a procedure or set of rules guaranteed, if followed, to lead to solution of a given kind of problem, heuristics are rules of thumb giving one clues for how to search for answers to given problems. In the study of development, many theories use heuristic devices that researchers hope will eventually lead to algorithms.

The intent of all heuristic devices (which may be likened to metaphors) is to be helpful in characterization of particular phenomena. As such, they can only be viewed as more or less helpful, not as being right or wrong. Heuristic devices provide a broad framework for better understanding a particular phenomenon. Our hope, therefore, is that the Triangulated Hourglass heuristic will be of genuine help to you in better understanding the phenomena of motor development.

CONCEPT 3.9

The triangulated hourglass model is a helpful heuristic device for conceptualizing, describing, and explaining the process of motor development.

To understand this model, picture yourself as an hourglass (Figure 3.2). Into your hourglass we need to place the stuff of life: "sand." Sand gets into your hourglass from two different containers. One is your hereditary container and the other your environmental container. The hereditary container has a lid. At conception our genetic makeup is determined and the amount of sand in the container is fixed. However, the environmental container has no lid. Sand may be added to the container and to your hourglass. We could reach down into the "sand pile" (i.e., the environment) and get more sand to put into your hourglass.

The two buckets of sand signify that both the environment and heredity influence the process of development. The relative contributions of each have been a volatile topic of debate for years. Arguing the importance of each is a meaningless exercise because sand is funneled from *both* containers into your hourglass. In the final analysis it does not really matter if your hourglass is filled with hereditary sand or environmental sand. What is important is that somehow sand gets into your hourglass and that this stuff of life is the product of *both* heredity and the environment.

Now, what do we know about motor development during the early phases of life? When we look at the reflexive and rudimentary phases of motor development, we know that sand pours into the hourglass primarily, but not exclusively, from the hereditary container. The sequential progression of motor development during the first few years of life is rigid and resistant to change except under environmental extremes. Therefore, we know in the first two phases of motor development that the developmental sequence is highly predictable.

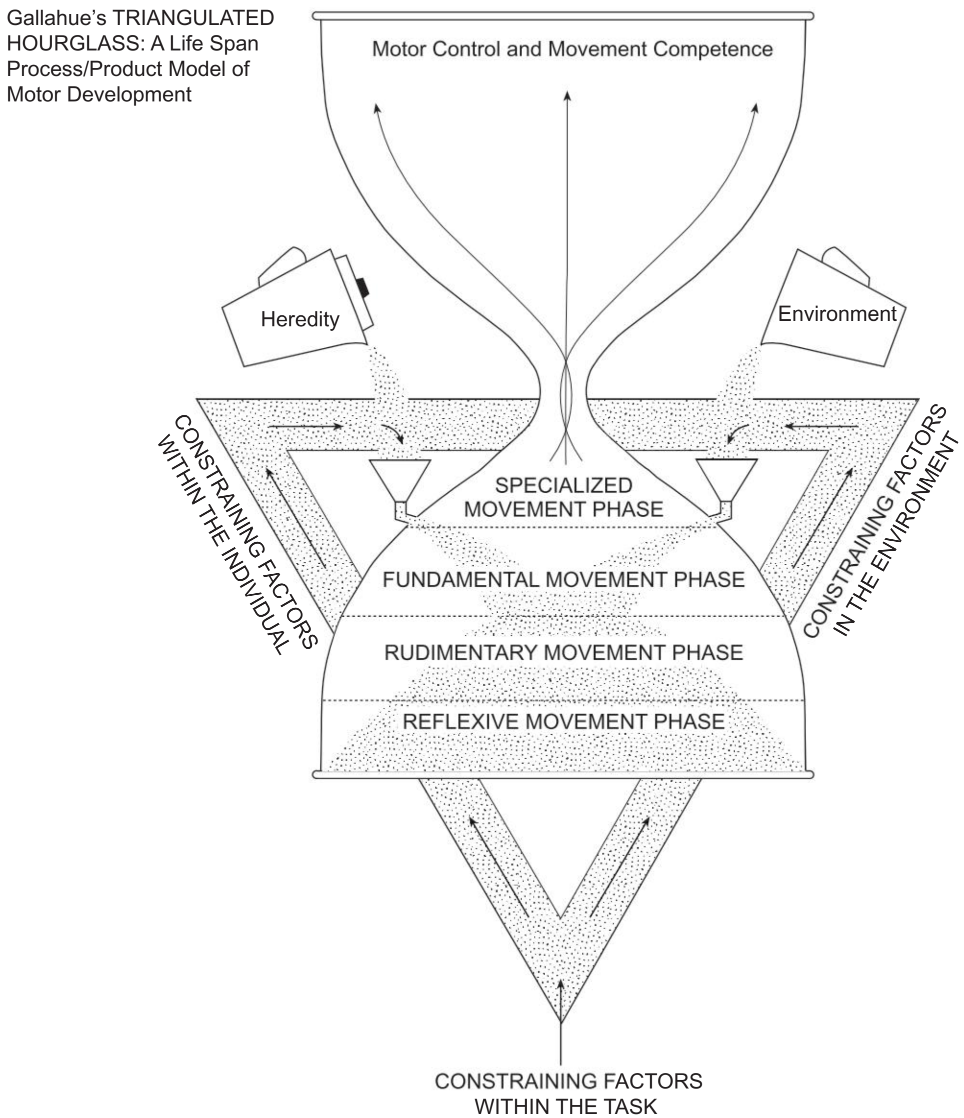

Figure 3.2

Filling an individual's hourglass with "sand" (i.e., the stuff of life). The hourglass represents a descriptive (product) view of development. The inverted triangle represents an explanatory (process) view of development. Both are helpful in understanding motor development as one continually adapts to change in the lifelong quest for gaining and maintaining motor control and movement competence.

For example, children all over the world learn how to sit before they stand, how to stand before they walk, and how to walk before they run. However, we do see considerable variability in the rates at which the very young acquire their rudimentary movement abilities. This is something in which researchers and program developers have become increasingly interested. We have seen a rapid rise in the number of infant stimulation programs and infant-toddler movement programs. Some make elaborate claims about the worth of these programs and their ultimate importance to the child. Unfortunately, we have little hard evidence at this juncture to either support or refute these claims. The rate of movement skill acquisition is variable from infancy throughout life. If an infant, child, adolescent, or adult receives additional opportunities for practice, encouragement, and instruction in an environment conducive to learning, movement skill acquisition will be promoted. The absence of these

DEVELOPMENTAL DILEMMA

The Mountain of Motor Development

Clark and Metcalfe (2002) published an interesting paper entitled "The Mountain of Motor Development: A Metaphor." In it they deftly discuss the intent and purpose of heuristic devices, or metaphors, in the study of human development. The authors provide an interesting discussion of how to select appropriate metaphors for motor development as well as means for assessing its validity and usefulness. Next, they carefully look at metaphors as descriptors of human behavior, focusing on motor development. They even take time to succinctly describe the triangulated hourglass model prior to presenting their own (see Figure 3.3).

The mountain metaphor is intriguing in that it envisions humankind collectively. Clark and Metcalfe rightfully contend that we each climb our own mountain. Interestingly, however, our own individual mountains vary. Some are high and rugged, others are shorter and more rounded, and still others are only small foothills. In this range of mountains the individual, as the "mountaineer," who is seen as a nonlinear self-organizing adaptive organism, "climbs" as high as possible. How high she or he climbs (the goal of the task) is dependent on the interaction between the biology of the individual and the conditions of the environment. In other words, constraints.

Serving as a framework for understanding, the mountain heuristic device, much like the Triangulated Hourglass, attempts to broadly describe both the products and the processes of motor development. The two appear to differ, however, from the collective framework of each person having his or her own personal mountain to climb (or hourglass to fill). The mountain may

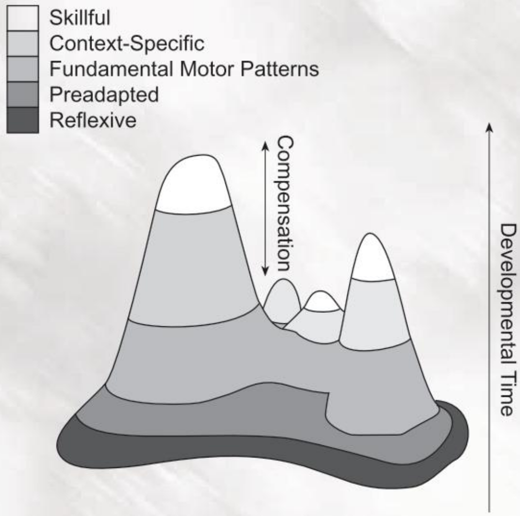

Figure 3.3

The Mountain of Motor Development

Clark, J.E., & Metcalfe, J.S. (2002). The mountain of motor development: A metaphor. In J.E. Clark & J. Humphrey (Eds.). Motor Development: Research and Reviews (pp. 163–190). Reston VA: NASPE Publications.

be seen as an open system that is dynamic in terms of shape, size, number, and complexity, whereas the hourglass could be viewed (inappropriately, we believe) as a closed and static system that has a "one size/shape fits all" view of development.

Do we have a developmental dilemma here? Is motor development a "mountain" or is it an "hourglass"? Is one view of development right and the other wrong? Better yet, given your personal reality (i.e., where you are and with whom you interact on a regular basis), what is your metaphor/heuristic for better understanding the processes and products of motor development?

environmental affordances (i.e., enabling factors) will constrain movement skill acquisition. Furthermore, the acquisition rate will vary depending on the mechanical and physical requirements of each task. For example, if an infant does not have sufficient handholds (an environmental constraint) in her environment to enable her to pull herself up to a stand, she will have to wait until sufficient balance (a biomechanical constraint) and strength in the legs (a physical constraint) have developed, before she is able to bring herself to a standing position unaided. "Contemporary theory explains motor development as a dynamic process in which a motor behavior emerges from the many constraints that surround that behavior" (Clark, 1994, p. 247).

In the fundamental movement phase, boys and girls are beginning to develop a whole host of basic movement skills—running, hopping, jumping, throwing, catching, kicking, and trapping. Unfortunately, many still have the notion that children somehow "automatically" learn how to perform these fundamental movements. Many naively think that children at this phase of development will, through the process of maturation, develop proficient fundamental movement skills. This is not true for the vast majority of children. Most children must have some combination of opportunities for practice, encouragement, and instruction in an ecologically sound environment. These conditions are crucial to helping them through each of the stages within the fundamental movement phase. Furthermore, as the task requirements of a fundamental movement skill change, so too will the process and the product. For example, the perceptual requirements of hitting a pitched ball are considerably more sophisticated than those required to strike a stationary ball or to perform a striking pattern without making contact with another object. Teachers of individuals at the fundamental movement phase must learn to recognize and analyze the task requirements of movement skills to maximize learner success. Teachers who overlook these duties erect proficiency barriers at the specialized movement skill phase.

At the specialized movement skill phase, successful performance of the mechanics of movement depends on mature fundamental movements. After the transitional stage we progress to the final stages in which specialized movement skills are applied to daily living, recreational, and sport experiences.

At some point, the hourglass turns over (Figure 3.4). The timing of this occurrence is variable and often depends more on social and cultural factors than on physical and mechanical factors. For most individuals, the hourglass turns over and the "sand" begins to pour out during the late teens and early 20s. This is a time in which many individuals enter the adult world of work, car payments, mortgages, family responsibilities, and a host of other time-consuming tasks. Time restrictions limit the pursuit of new movement skills and the maintenance of skills mastered during childhood and adolescence.

There are several interesting features in the overturned hourglass that we need to consider. The sand falls through two different filters. One is the *hereditary filter* with which we can do very little. For example, an individual may have inherited a predisposition toward longevity or coronary heart disease. The hereditary filter is going to be either dense, causing the sand to filter through slowly, or easy to penetrate, allowing the sand to flow through more rapidly. Sand that has fallen through the hereditary filter cannot be recovered, but it must pass through a second, or final, filter called the lifestyle filter.

The density of the *lifestyle filter* is determined by such things as physical fitness, nutritional status, diet, exercise, the ability to handle stress, and social and spiritual well-being. The lifestyle filter is environmentally based, and we have a good deal of control over the rate at which sand falls through this filter. Although we can never stop sand from flowing to the bottom of the hourglass, we can slow down the rate at which it falls. A former surgeon general of the United States, Dr. C. Everett Koop, once stated that although we cannot stop the aging process, we can control it by up to 40%. We can directly influence how fast sand falls through our hourglasses. As teachers, coaches, therapists, and parents we have the wonderful opportunity to shovel "sand" into many "hourglasses." We also have the privilege and the obligation to help others develop "lifestyle filters" that will slow the rates at

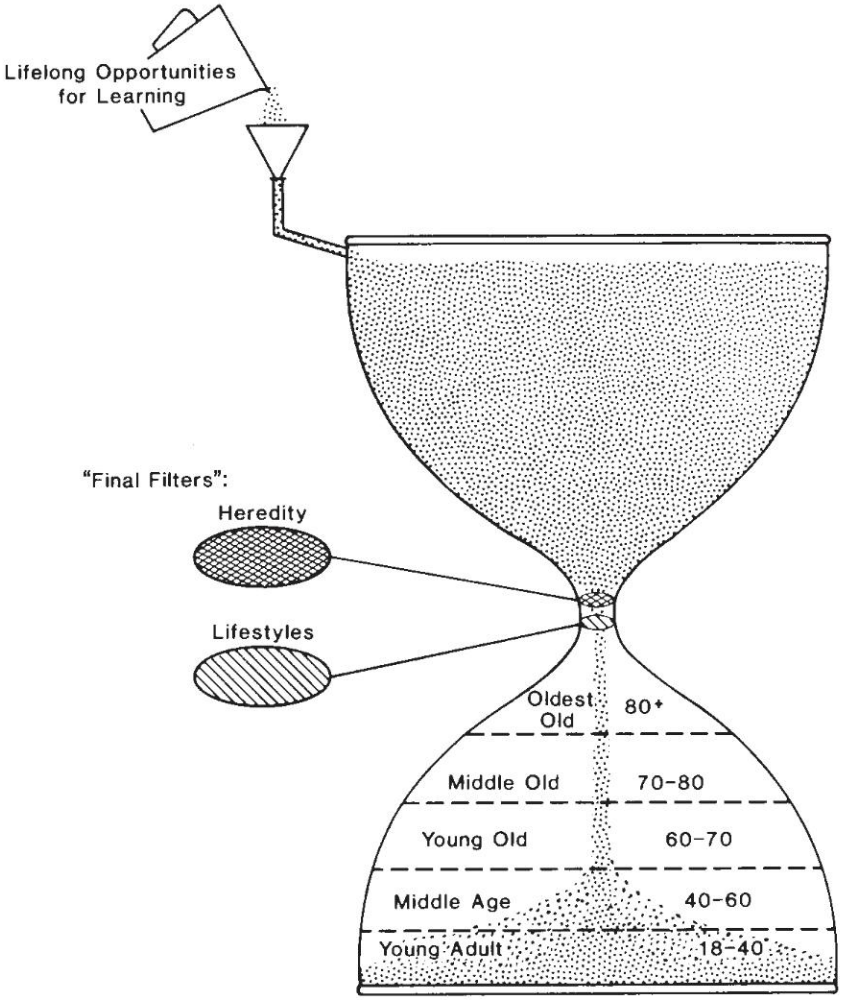

Figure3 .4
Emptying the overturned hourglass of life. Development as seen here is a continuous discontinuous process throughout the life span.

which sand falls in their hourglasses. Sand can still be added even when hourglasses are overturned and the sand is falling to the bottom. Each of us has *lifelong opportunities for learning.* By taking advantage of the numerous opportunities for continued development and physical activity, we can add more sand. We cannot add sand faster than it is falling and claim immortality. We can, however, extend and improve the quality of life.

The **hourglass heuristic** device as described to this point gives the impression that development is an orderly and continuous process. Note, however, that the sand at the bottom of the hourglass in both Figures 3.2 and 3.4 is distributed in a bell-shaped curve. The shape of this curve implies that there is a distribution of movement skills among the categories of movement (locomotion, manipulation, and stability), and within the various movement tasks. For example, one may be at the elementary stages in some skills, the proficient stage in others, and at a sport skill level in still others. Additionally, one may be at different stages of development within the same skill. For example, when children and adults perform the overhand throw, they are often at the initial stage in their trunk action, an emerging elementary stage in their arm action, and a proficient stage in their leg action. Motor development in the hourglass model, therefore, is a *discontinuous process,* that is, a process that, although phaselike and stagelike in a general sense, is highly variable in a specific sense. Motor development when viewed as discontinuous is in effect a *dynamic* (i.e., nonlinear) process occurring within a self-organizing system (i.e., the "hourglass").

CONCEPT 3.10

Motor development is a discontinuous process occurring within a self-organizing system.

Although depicted as being unidimensional in Figures 3.1, 3.2 and 3.4, the Triangulated Hourglass Model should not be viewed as such. "Real" hourglasses occur in both time and space. They are multidimensional and as such contain, along with the motor domain, both cognitive and affective domains as well. As a result, real hourglasses have height, width, and depth and must be supported if they are to remain upright. Visualize, if you will, an individual's hourglass as being supported by a cognitive pillar, an affective pillar, and a motor pillar. The hourglass is multidimensional; thus, there is a triple interaction among the cognitive, affective, and motor domains. In other words, the Triangulated Hourglass Model is more than a motor model. It is a model of motor development that influences, and is influenced by, a wide variety of cognitive and affective factors operating within both the individual and the environment.

You may find it helpful to visualize the hourglass heuristic device as you proceed through the following sections dealing with motor development during infancy, childhood, adolescence, and adulthood. Remember, however, that it is not important that you accept this model as proposed. Theoretical models are just that—"models." As such they are incomplete, inexact, and subject to verification and further refinement. What is important is that you visualize how the process of motor development occurs. Remember, understanding motor development helps to explain how learning occurs. Both are crucial to the creation of effective, developmentally appropriate instruction.

CONCEPT 3.11

Understanding the process of motor development helps explain how movement skill learning occurs, which is crucial to developmentally appropriate instruction.

SUMMARY

The acquisition of competency in movement is an extensive process beginning with the early reflexive movements of the newborn and continuing throughout life. The process by which an individual progresses from the reflexive movement phase, through the rudimentary and fundamental movement phases, and finally to the specialized movements skill phase of development is influenced by factors within tasks, the individual, and the environment.

Reflexes and rudimentary movement abilities are largely based on maturation. Reflexes appear and disappear in a fairly rigid sequence. Rudimentary movements form the important base upon which fundamental movement skills are developed.

Fundamental movement skills are basic movement patterns that begin developing around the same time that a child is able to walk independently and move freely through his or her environment. These basic locomotor, manipulative, and stability skills go through a definite, observable process from immaturity to maturity. Stages within this phase include the initial, emerging elementary, and proficient stages. Attainment of the mature stage is influenced greatly by opportunities for practice, encouragement, and instruction in an environment that fosters learning. Under the proper circumstances, children are capable of performing at the mature stage in the vast majority of fundamental movement patterns by age 6. The fundamental movement skills of children entering school are too often incompletely developed. Therefore, the primary grades offer an excellent opportunity to develop fundamental movement skills to their proficient levels. These same fundamental skills will be enhanced and refined to form the specialized movement skills so highly valued for recreational, competitive, and daily living tasks.

The specialized movement skill phase of development is in essence an elaboration of the fundamental phase. Specialized skills are more precise than fundamental skills. They often involve a combination of fundamental movement skills and require a greater degree of precision. Specialized skills involve three related stages. The transitional stage is typically the level of the child in grades three through five. At this level, children are involved in their first real applications of fundamental movements to sport. If the fundamental skills used in a particular sport activity are not at the mature level, the child will resort to less proficient or elementary patterns of movement. Involving children in sport skill refinement before they reach proficient levels of ability in prerequisite fundamentals is unwise. When this happens, the less proficient movements found in the basic patterns are carried over to the related sport skills. The child will regress to his or her characteristic pattern. It is important that sensitive teaching and coaching be incorporated at this point.

When we look at the process of motor development, we need to look at it first from a theoretical perspective. Each of us needs to have a theoretical framework to use as the basis for our actions. It is not important that you agree with the theoretical framework presented here. The Triangulated Hourglass Model is our way of viewing the process of motor development and its implications for life. What is your theoretical framework? How does it influence your teaching, coaching, therapy, or parenting, and how does it influence you personally?

Questions for Reflection

1. The Triangulated Hourglass Model borrows from two differing but complementary views of human development. What are they and in which ways are they both similar and different? How might they be viewed as complementary?
2. Using a heuristic different from the Triangulated Hourglass Model, can you use a metaphor to help yourself and others visualize the processes and products of motor development?
3. If motor development can be viewed as a Triangulated Hourglass or as a mountain metaphor, can it also be viewed, perhaps, as a tree, a train, or even a river or ocean? Select one of the above or choose another metaphor and build your own theoretical model.
4. The Tom Hanks character Forrest Gump in the movie of the same name said, "Life is like a box of chocolates." What did he mean? How could a box of chocolates be used as a metaphor for better understanding human development?
5. Why are theory building and theory testing important?

Critical Readings

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WEB RESOURCES

www.nia.nih.gov

Homepage for the National Institute on Aging. The site provides health and research information as well as press releases, a calendar of events, and general information on the NIA in regard to mission and programs.

www.elsevier.com/wps/find/journaldescription.cws_home

Journal of Adolescence Web page. Page includes journal information including description, editorial board, and a guide for authors, online submission, online reviewer form, and abstracting/indexing. Site also contains subscription information and journal-related information.

www.isisweb.org/main.htm

Homepage for the International Society on Infant Studies. ISIS is an organization "devoted to the promotion and dissemination of research on the development of infants." Site contains a description of the society, latest news, and newsletter.

www.srcd.org

Society for Research in Child Development homepage. The society is an international professional association focused on human development. The site includes news for members, job opportunities, suggested publications, summaries of journal articles, and information on becominga m embero ft hes ociety.

CHAPTER

4 SELECTED FACTORS AFFECTING MOTOR DEVELOPMENT

KEY TERMS

Developmentald irection
Growthr ate
Reciprocal interweaving
Readiness
Sensitivep eriod
Phylogenetics kills
Ontogenetics kills
Bonding
Premature
Very low birth weight (VLBW)
Lowb irthw eight(LBW)
Young-for-date
Obesity
Bingee atingd isorder
Anorexian ervosa
Bulimian ervosa
Physicalfi tness
Force
Lawo fi nertia
Lawo fa cceleration
Lawo fa ctiona ndr eaction

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Identifyg enetica nde nvironmentalf actors influencing growth and biological maturation
- Derivep rincipleso fm otord evelopment and apply these principles to teaching/learning situations at various points in the life span
- Describe "catch-up" growth andt hef actors affecting this phenomenon
- Analyze relationshipsa mongg rowth, biological maturation, and physiological changes in motor skill development
- Discusst hee ffectso f environmental deprivation on life span motor development
- Discusst heeffec tsof enrichment,spec ial practice, and teaching on life span motor development
- Define and discuss the concepts of critical and sensitive periods, phylogenetic and ontogenetic skills, and co-twin control
- Identify and order from simple to complex the environmental variables that may influence developmental levels
- Explaint hes imilarities andd ifferences between bonding and imprinting
- Hypothesizea boutt hei mpact of temperament on the interactive process of development
- Described ifferences ands imilaritiesi mplied by the terms "low birth weight" and "young-for-date"

KEY CONCEPT

Both the process and products of motor development are influenced by a wide variety of factors operating in isolation and in conjunction with one another.

The development and refinement of movement patterns and movement skills are influenced in complex ways. Both the process and products of movement are rooted in one's unique heredity and background of experiences, coupled with the specific demands of the movement task. Any study of motor development would be incomplete without a discussion of several of these influencing factors. This chapter focuses on factors within the individual, the environment, and the task that influence the process of development throughout the life cycle.

FACTORS WITHIN THE INDIVIDUAL

The unique genetic inheritance that accounts for our individuality can also account for our similarity in many ways. One similarity is the trend for human development to proceed in an orderly, predictable fashion. A number of biological factors affecting motor development seem to emerge from this predictable pattern.

Developmental Direction

The concept of **developmental direction**, namely that change is cumulative and directional, was first formulated by Gesell (1954) as a means of explaining increased coordination and motor control as a function of the maturing nervous system. Through observations, Gesell noted that an orderly, predictable sequence of physical development proceeds from the head to the feet (cephalocaudal) and from the center of the body to its periphery (proximodistal). The concept of developmental direction has encountered recent criticism and should not be viewed as operational at all levels of development or in all individuals. It may be that the observation of tendencies toward distinct developmental directions is not exclusively a function of the maturing nervous system, as originally hypothesized by Gesell, but is due, in part, to the demands of the specific task. For example, the task demands of independent walking are considerably greater than those for crawling or creeping. There is less margin for error in independent walking than there is in creeping and, in turn, crawling. In other words, it is mechanically easier to crawl than it is to creep and to creep than it is to walk. Therefore, the apparent cephalocaudal progression in development may be due not only to maturation of the nervous system, but also to the performance demands of the task. Care, therefore, should be taken when interpreting the concept of developmental direction, particularly during the period of infancy.

CONCEPT 4.1

Neuromotor maturation may be used to account for, in part, both the sequence and rate of motor development throughout the life cycle.

The *cephalocaudal* aspect of developmental direction refers specifically to the gradual progression of increased control over the musculature, moving from the head to the feet. It may be witnessed in the prenatal stages of fetal development as well as in later postnatal development. In the developing fetus, for example, the head forms first, and the arms form prior to the legs. Likewise, infants exhibit sequential control over the musculature of the head, neck, and trunk, prior to gaining control over the legs and feet. Young children are often clumsy and exhibit poor motor control over their lower extremities. This may be due to incomplete cephalocaudal development and to the complexity of the task demands of independent walking.

The second aspect of developmental direction, known as *proximodistal* development, refers specifically to the child's progression in control of the musculature from the center of the body to its most distant parts. As with cephalocaudal development, the proximodistal concept applies to both growth processes and the acquisition of movement skills. For example, with regard to growth, the trunk and shoulder girdle grow prior to arms and legs, which grow prior to the fingers and toes. In skill acquisition, the young child is able to control the muscles of the trunk and shoulder girdle prior to the muscles of the wrist, hand, and fingers. This principle of development is frequently used in the primary grades when children are taught the less refined elements of manuscript writing before they learn the more complex and refined movements of cursive writing.

The cephalocaudal and proximodistal process is operational throughout life and has a tendency to reverse itself as one ages. Actions of the lower body and extremities are the first to regress. Certainly, however, older individuals can forestall and reduce such regression by staying active throughout life.

Rate of Growth

One's **growth rate** follows a characteristic pattern universal for all and resistant to external influence. A minor interruption of the normal pace of growth is compensated for by a still unexplained process of *self-regulatory fluctuation* (Gesell, 1954) that enables a child to catch up to his or her age-mates. This *developmental plasticity* occurs, for example, when a severe illness limits a child's normal gains in height, weight, and movement ability, but upon recovery the child tends to catch up. The same phenomenon is seen with low-birth-weight infants. Despite low weights at birth, most of these babies catch up to the characteristic growth rates of their age-mates in a few years. Conditions surrounding the causes of low birth weight, such as inadequate nutrition, must not persist. Appropriate intervention must occur early on for this developmental plasticity process to fully manifest in the growing infant. Measures of height, weight, and motor development taken prior to age 2 are generally meaningless for predicting later growth and development.

The self-regulatory process of growth will compensate for relatively minor deviations in the growth pattern, but it is frequently unable to make up for major deviations, especially during infancy and childhood. For example, low-birth-weight infants under three pounds, and children experiencing severe and prolonged nutritional deficiencies, frequently suffer permanent deficits in height and weight, as well as in their cognitive and motor development.

CONCEPT 4.2

The permanency of growth retardation is particularly devastating during the first two years of life.

Severe and prolonged restricted opportunities for movement and deprivation of experience have been shown repeatedly to interfere with children's abilities to perform movement tasks characteristic of their age levels. The effects of sensory and motor experience deprivation can sometimes be overcome when nearly optimal conditions are established for a child. The extent to which the child will be able to catch up to his or her peers, however, depends on the duration and severity of deprivation, the age of the child, and the child's genetic growth potential.

Reciprocal Interweaving

The coordinated and progressive intricate interweaving of neural mechanisms of opposing muscle systems into an increasingly mature relationship, termed **reciprocal interweaving** by Gesell (1954), is characteristic of the developing child's motor behavior. Developmental change is therefore seen as generally qualitatively differentiated and sequential in nature. Two different but related processes are associated with this increase of functional complexity: differentiation and integration.

CONCEPT 4.3

Neuromotor maturation is evidenced through increased ability to differentiate and integrate motor and sensory mechanisms.

Differentiation is associated with the gradual progression from the gross globular (overall) movement patterns of infants to the more refined and functional movements of children and adolescents. For example, the manipulative behaviors of the newborn for reaching, grasping, and releasing objects is poor; there is little control of movement. But as the child develops, the control improves. The child is able to differentiate among various muscle groups and begins to establish control. Control continues to improve with practice until we see the precise movements of block building, cutting with scissors, cursive writing, and violin playing.

Integration refers to bringing various opposing muscle and sensory systems into coordinated interaction with one another. For example, the young child gradually progresses from ill-defined corralling movements when attempting to grasp an object to more mature and visually guided reaching and grasping behaviors. The differentiation of movements of the arms, hands, and fingers, followed by the integration of the use of the eyes with the movements of the hand to perform eye-hand coordination tasks, is crucial to normal development.

Differentiation and integration tend to be reversible with aging. As one ages and movement abilities begin to regress, the coordinated interaction of sensory and motor mechanisms frequently becomes inhibited. The extent to which one's coordinated movement abilities regress is not merely a function of age, but is influenced greatly by activity levels and attitude.

There is little doubt that the processes of differentiation and integration operate simultaneously. The complex abilities of the adult cannot be explained merely as a process of integration of simpler responses. What occurs, instead, is a constant interlacing of both processes.

Readiness

E. L. Thorndike (1913), the "grandfather" of learning theory, first proposed the concept of readiness primarily in reference to emotional responses to actions or expected actions. According to his concept, readiness depended on the biological maturation model, which was popular at the turn of the century. Today's concept of readiness, however, is much broader and refers to readiness for learning. **Readiness** may be defined as convergence of the requirements of the task, the biology of the individual, and the conditions of the environment that make mastery of a particular skill appropriate. The concept of readiness, as used today, extends beyond biological maturation and includes consideration of factors that can be modified or manipulated to encourage or promote learning. Several related factors combine to promote readiness. Physical and mental maturation, interacting with motivation, prerequisite learning, and an enriching environment all influence readiness. At this juncture we do not know how to pinpoint exactly when someone is ready to learn a new movement skill. However, research suggests that early experience in a movement activity before the individual is ready is likely to have minimal benefits.

CONCEPT 4.4

Readiness for learning depends on convergence of biological, environmental, and physical factors.

In recent years a great deal of attention has been focused on developing reading readiness through appropriate types of preschool and primary grade experiences. Entire educational programs have been built around the notion that children must achieve a certain level of development before they are ready to pursue intellectual tasks such as reading and writing (Bergen et al., 2001; Bredenkamp and Rosengrant, 1995), and mathematics (Kamii and Housman, 2000), as well as movement tasks involving locomotion, manipulation, and stability (Gallahue and Cleland-Donnelly, 2003; California Department of Education, 2010). Readiness training is a part of most preschool and primary grade educational programs. An integral part of these readiness programs has been the use of movement as a means of enhancing basic perceptual-motor qualities. Although it has not been conclusively documented that perceptual-motor experiences have a direct effect on the attainment of specific cognitive readiness skills, it is safe to assume that they have at least an indirect influence because they encourage a child's self-esteem and a positive "Yes I can" approach to learning.

The concept of readiness, whether for the learning of cognitive skills or motor skills, is probably best summed up in Bruner's (1965) statement that "the foundation of any subject may be taught to anybody at any age in some form" (p. 12). In other words, the burden of being "ready" is as much the instructor's responsibility in recognizing it, as it is the student's. Readiness, a combination of maturational "ripeness," environmental openness, and caregiver sensitivity, has numerous implications for lifelong learning opportunities.

Critical and Sensitive Learning Periods

The concept of *critical* and *sensitive learning periods* is closely aligned to readiness and revolves around the observation that an individual is more sensitive to certain kinds of stimulation at certain times. Normal development in later periods may be hindered if a child fails to receive the proper stimulation during a critical period. For example, inadequate nutrition, prolonged stress, inconsistent nurturing, or a lack of appropriate learning experiences may have a more negative impact on development if they occur early in life rather than at a later age. The concept of critical periods also has a positive side. It suggests that appropriate intervention during a specific period tends to facilitate more positive forms of development at later stages than if the same intervention occurs at another time.

One should recognize that the tendency of a child to follow a critical period pattern is closely linked to the theory of developmental tasks and to a lesser degree linked to the milestone and phase-stage views. Robert Havighurst's theoretical framework of development (as reviewed in chapter 2) is a critical period hypothesis, applied from the perspective of education.

The notion of critical periods of development has been so pervasive in education that an entire federally funded educational program was established on this premise. Operation Head Start, begun in the 1960s and continued today throughout the United States, viewed the age period of 3 to 5 years as critical to children's intellectual development. It was hypothesized that if given a "head start" through a carefully structured environment designed to develop school-oriented skills, deprived children would be able to begin school on nearly the same level as their nondeprived counterparts. The results of Head Start programs did not entirely bear out the critical period hypothesis. This was probably due to the existence of more than one critical period for intellectual development. In addition, the age period of 3 to 5 years may not be as pivotal as originally assumed. Current views of the critical period hypothesis reject the notion that one must develop movement skills within highly specific time frames.

CONCEPT 4.5

There are broadly defined sensitive periods during which individuals can learn new tasks most efficiently and effectively.

It is safe to assume, however, that there are **sensitive periods,** or broad time frames, for development. Critical or sensitive periods should not be too narrowly defined. Failure to account for individual differences and for special environmental circumstances will lead one to conclude that a sensitive period is a universal point in time. Instead, a notion of sensitive periods as broad, general guidelines susceptible to modification should be adopted. Learning is a phenomenon that continues throughout life. As scientists learn more about the aging brain and the aging motor system, they continually demonstrate this important concept (Hinton, 1992; Selkoe, 1992; Ward & Frackowiak, 2003). Learning can be a lifelong process, and the effects of aging can be slowed and reduced through continual use of the brain and motor system.

Individual Differences

Change is variable between children. The tendency to exhibit *individual differences* is crucial. Each person is unique with his or her timetable for development. This timetable is a combination of an individual's heredity and environmental influences. Although the sequence of appearance of developmental characteristics is predictable, the rate of appearance may be variable. Therefore, strict adherence to a chronological classification of development by age is without support or justification.

> **CONCEPT 4.6**
>
> Interindividual and intraindividual variation are the key concepts upon which developmental education is based.

The "average" ages for the acquisition of all sorts of developmental tasks, ranging from learning how to walk (the major developmental task of infancy) to gaining bowel and bladder control (often the first restrictions of a civilized society on the child) have been bandied about in the professional literature and the daily conversation of parents and teachers for years. It must be remembered that these average ages are just that and nothing more—mere approximations that serve as convenient indicators of developmentally appropriate behaviors. It is common to see deviations from the mean of as much as six months to one year in the appearance of numerous movement skills. The tendency to exhibit individual differences is closely linked to the concept of readiness and helps to explain why some individuals are ready to learn new skills when others are not.

Phylogeny and Ontogeny

Many of the rudimentary abilities of the infant and the fundamental movement skills of the young child, when viewed from the maturation perspective proposed by Gesell (1954), are considered to be phylogenetic; that is, they tend to appear automatically and in a predictable sequence within the maturing child. **Phylogenetic skills** are resistant to external environmental influences. Movement skills such as the rudimentary manipulative tasks of reaching, grasping, and releasing objects; the stability tasks of gaining control of the gross musculature of the body; and the fundamental locomotor abilities of walking, jumping, and running are examples of what may be viewed as phylogenetic skills. **Ontogenetic skills,** on the other hand, depend primarily on learning and environmental opportunities. Such skills as swimming, bicycling, and ice skating are considered ontogenetic because they do not appear automatically within individuals but require a period of practice and experience and are influenced by one's culture. The entire concept of phylogeny and ontogeny needs to be reevaluated in that many skills heretofore considered phylogenetic can be influenced by environmental interaction.

> **CONCEPT 4.7**
>
> Several types of movement patterns may have their basis in phylogeny (biology), but ontogenetic (environmental) conditions shape the rate and extent to which the patterns are acquired.

Although there may be a biological tendency for the development of certain abilities due to phylogenetic processes, it is simplistic to assume that maturation alone will account for motor development. The extent or level to which any voluntary movement skill is mastered depends, in part, on ontogeny, or the environment. In other words, opportunities for practice, encouragement, and instruction, and the ecology, or conditions, of the environment contribute significantly to movement skill development throughout life. Little solid support exists for Gesell's notion that "ontogeny recapitulates phylogeny," although some phylogenetic behaviors may be present in humankind.

FACTORS IN THE ENVIRONMENT

Over the past several years considerable speculation and research have focused on the effects of parenting behaviors during infancy and early childhood as they influence the subsequent functioning of children. Because of the extreme dependence of human infants on their caregivers and because of the length of this period of dependence, a variety of parental care factors influence later development. Among the most crucial are the effects of environmental stimulation and deprivation, and the bonding that occurs between parent and child during the early months following birth.

Bonding

The study of parent-to-infant attachment, or **bonding,** has its roots in the early imprinting (i.e., attachment) studies conducted by Lorenz (1966), Hess (1959), and others on birds, ducks, and other animals. These experiments with animals revealed that the degree to which the newborn imprinted on its mother was directly related to their contact time. Human infants do not imprint in the narrow sense of the word as animals do, but it is commonly believed by many that there is a broad "sensitive" period in which parent-to-infant attachment occurs during the early months of postnatal life. Popular culture has speculated that if this sensitive period is missed, the parent and child may fail to bond. Compelling evidence places the validity of this belief in jeopardy (Eyer, 1994; Lewis, 1998). Experiences such as the death of a family member, divorce, accidents, and severe and prolonged disease are far more important to the long-term development of children and youth than the early maternal bond.

Developmental Dilemma

Infant Bonding: Is the Critical Period Hypothesis Valid?

Early attachment between parent and child may influence some aspects of development, but it is fair to question whether bonding is essential to the welfare of the child. Generations of adopted children will attest to the success of their development even though bonding with "mother" was delayed by weeks, months, or even years. The reciprocal interaction between parent and child creates a mutually satisfying and rewarding relationship, the importance of which cannot be minimized. Care must be taken, however, not to define the concept of bonding too narrowly or to overemphasize its importance. Further research is necessary to clearly establish its link to the process of development and to clear up this developmental dilemma.

Concept 4.8

The reciprocal interaction between parent and child influences both the rate and extent of development.

Bonding is a strong emotional attachment that endures over time, distance, hardship, and desirability. This emotional bond begins developing at birth and may be incompletely established with early separation. The leading factors contributing to initial separation are prematurity and low birth weight, which result in the incubation of the newborn and mild or severe neonatal problems at birth.

Concept 4.9

Bonding plays a yet undetermined role in the process of human development.

Stimulation and Deprivation

A great deal of study has been done over the years to determine the relative effects of *stimulation* and *deprivation* on the learning of a variety of skills. There has been considerable controversy among hereditarians and environmentalists over the issue during the past 100 years. Numerous textbooks have recorded the nature versus nurture debates, but little has been settled in the attempt to categorize the effects of each on development. The current trend has been to respect the individual importance of both nature and nurture and to recognize the complexly intertwined influences of maturation and experience.

CONCEPT 4.10

Both stimulation and deprivation of experiences have potential for influencing the rate of development.

Students of motor development have recognized the futility of debating the separate merits of maturation and experience and have instead concentrated their research on three major questions. The first of these questions deals with the approximate ages at which various skills can be learned most effectively. The research of Bayley (1935), Shirley (1931), and Wellman (1937) represented the first serious attempts to describe the age at which many of the rudimentary and fundamental movement abilities appear. Each of these researchers reported a somewhat different timetable for the rate of appearance of numerous rudimentary movement skills acquired during infancy. They did, however, show amazing consistency in the sequential order of appearance of these abilities. This factor illustrates the combined effects of both intrinsic, or maturationally determined, influences on the sequence of development and extrinsic, or environmentally influenced, behaviors on the rate of development.

Until recently, little has been done to more clearly ascertain the ages at which fundamental movement skills can be learned most effectively. The principle of readiness has been viewed as a cornerstone of our educational system, but little more than lip service has been paid to its importance, particularly with regard to developing fundamental movement skills. We know now that children can learn many movement skills early in life and that they have the developmental potential to be at the mature stage in most fundamental movements by age 6 or 7.

The second question deals with the effects of special training on the learning of motor skills. A number of co-twin control studies have been conducted to ascertain the influence of special practice on early learning. The use of identical twins enables the researcher to ensure identical hereditary backgrounds and characteristics of the research participants. One twin is given advanced opportunities for practice while the other is restricted from practicing the same skills over a prescribed time. The famous studies of Gesell and Thompson (1929), Hilgard (1932), and McGraw (1935, 1939) demonstrated the inability of early training to hasten development to an appreciable degree. However, follow-up studies of the co-twin control experiments of both Gesell and McGraw showed that the trained participants exhibited greater confidence and assurance in the activities in which they had received special training. In other words, special attention and training may not influence the quantitative aspects of the movement skills learned as much as the qualitative aspects. Again, we see the complex interrelationship between maturation and experience.

With the advent of neonatal and infant intensive care units in the 1970s, the survival rate for preterm and low-birth-weight infants has risen dramatically. Parents, physicians, and researchers have wondered about the effects of infant stimulation programs on the subsequent development of these high-risk infants. Ulrich (1984), in her comprehensive review of the research, concluded: "Despite difficulties in comparing studies due to the variability of subjects used, and type, intensity, and duration of treatment, the overwhelming evidence indicates beneficial effects" (p. 68). Such a conclusion is encouraging and leads one to consider the timing and duration of special training or stimulation. Is there a "sensitive period" beyond which the benefits of stimulation are minimally beneficial?

From the 1980s until the present, there has been a tremendous surge of interest in stimulation programs for infants, toddlers, and preschoolers. Structured swim and gym programs have sprung up all across North America and beyond. There have been considerable claims and counterclaims about the supposed benefits of these programs.

The third question concerns the effect of limited or restricted opportunities for practice on the acquisition of motor skills. Studies of this nature have centered generally on experimentally induced environmental deprivation in animals. Only a few studies have been reported in which children have been observed in environments where unusual restrictions of movement or experience have existed.

An investigation conducted by Dennis (1960) examined infants reared at three separate institutions in Iran. The infants in two of the institutions were found to be severely retarded in their motor development. In the third there was little motor retardation. The discrepancy led Dennis to investigate the lifestyles of the children in each institution. The results of his investigation led to the conclusion that lack of handling, blandness of surroundings, and general absence of movement opportunity or experience were causes of motor retardation in the first two institutions. Another investigation, by Dennis and Najarian (1957), revealed similar findings in a smaller number of creche infants reared in Beirut, Lebanon. Both investigations lend support to the hypothesis that behavioral development cannot be fully attributed to the maturation hypothesis.

Due to cultural mores, the humanitarian virtues of most investigators, and concerned parents, there are few experiments in which the environmental circumstances of infants or young children have been intentionally altered to determine whether serious malfunctioning or atypical behavior will result. The general consensus of the research that does exist is that severe restrictions and lack of experience can delay normal development.

To understand the influence of experience on development, we need only to look as far as the school playground and observe many girls jumping rope expertly and many boys throwing and catching balls with great skill. When asked to reverse the activities, however, each group tends to revert to less mature patterns of movement. Factors within our culture, unfortunately, often predetermine the types of movement experiences in which boys and girls engage (Gallahue et al., 1994). Additionally, the gross motor development of blind children, as well as children confined in their early weeks and months of postnatal life to the neonatal intensive care unit, have repeatedly been shown to be behind their age-mates on standardized measures of gross motor behavior as well as classroom behavior (Hack et al., 1994). Furthermore, very low birth weight babies (<1500 g), as well as blind children, have been shown to acquire some rudimentary movement skills out of the normally expected sequence.

CONCEPT 4.11

Extreme conditions of environmental deprivation may disrupt both the sequence and rate of movement skill acquisition.

In summary, both maturation and learning play important roles in the acquisition of movement skills. Although experience seems to have little influence on the sequence of their emergence, it does affect the time of appearance of certain movements and the extent of their development. One of the greatest needs of children is to practice skills at a time when they are developmentally ready to benefit the most from such skills. Special practice prior to maturational readiness is of dubious benefit. The key is to be able to accurately judge the time at which each individual is "ripe" for learning and then to provide a series of educationally sound and effective movement experiences. However, all indications are that young children are generally capable of more than we have suspected, and many of the traditional readiness signposts that we have used may be incorrect.

CONCEPT 4.12

The extent to which environmental stimulation may affect development is as yet unknown.

PHYSICAL TASK FACTORS

A number of additional factors affect motor development. The influence of ethnicity and social class (Malina, Bouchard, & Bar-Or, 2004), gender (Branta et al., 1987), and ethnic and cultural background (Bril, 1985; Gallahue et al., 1996; Malina, Bouchard, & Bar-Or, 2004) all have an impact on growth and motor development. Motor development is not a static process. It not only is the product of biological factors but also is influenced by environmental conditions and physical laws. The interaction of both environmental and biological factors modifies the course of motor development during infancy, childhood, adolescence, and adulthood. Premature birth, eating disorders, fitness levels, and biomechanical factors, as well as the physiological changes associated with aging and lifestyle choice, all influence the lifelong process of motor development in important ways.

Prematurity

The typical average birth weight of an infant is about 3,300 grams (about 7 pounds). Formerly, any infant weighing under 2,500 grams (about 5.5 pounds) was classified as **premature.** Today, however, 1,500–2,500 grams (about 3.35 pounds to 5.56 pounds) is used as the standard, unless there is evidence that the gestation period was less than 37 weeks. Infants born under 1,500 grams are considered to be **very low birth weight** (VLBW) babies (D'Agostino and Clifford, 1998). Infants born above 1,500 grams but under 2,500 grams are considered to be **low birth weight** (LBW) babies (WHO, 2008). The practice of labeling a newborn as premature based on gestation period or weight alone is no longer used for two reasons. First, it is often difficult to accurately determine the gestational age of the infant, and, second, the highest mortality and morbidity rates are present for infants of the very lowest birth weights. As a result, the terms *low birth weight* and *young-for-date* have emerged as more accurate indicators of prematurity in the true sense of the word. Prematurity is of major concern because it is closely associated with physical and mental retardation, hyperactivity, and infant death. Prevention is considered to be the most important factor in improving infant health and survival rates.

CONCEPT 4.13

Prematurity puts the newborn at risk and frequently undermines the process of motor development.

Low Birth Weight

Low-birth-weight (LBW) infants weigh less than expected for their gestational age. In the United States approximately 8.2% of live births are considered to be LBW (Martin et al., 2010). Two standard deviations below the mean for a given gestational age is the generally accepted criterion for low birth weight. Therefore, an LBW infant may be one born at term (40 weeks) or preterm (37 weeks or under). Low-birth-weight infants have experienced "intrauterine growth retardation" and are generally called "small-for-date." A variety of prenatal maternal factors have been implicated, including diet, drugs, smoking, infections, and disease (Kopp & Kaler, 1989; Malina, Bouchard, & Bar-Or, 2004). Other factors such as social class, multiple births, and geographic locale have been shown to influence birth weight (Mason, 1991). The long-term effects of low birth weight are directly related to the degree of intrauterine growth retardation and gestational age of the child. An encouraging finding in outcome studies of LBW infants is that the majority survive with little or no disability. However, babies classified as VLBW experience a much higher incidence of major disability (D'Agostino and Clifford, 1998; Lemans et al., 2001). In the United States, the incidence of VLBW is approximately 1.5% of live births (Martin et al., 2010).

Young-for-Date

Children born at the expected birth weight (less than two standard deviations below the mean) for their gestational age but before full term (37 weeks or less) are called **young-for-date,** or *preterm infants.* In the United States approximately 13% of live births are considered to be preterm (Martin et al., 2010). There is little agreement on the exact causes of preterm birth, but a number of factors have been shown to contribute, including drug use, smoking, maternal age, excessive weight gain, and adverse social and economic conditions. Until recent years the prognosis for young-for-date infants who were either small-for-date or normal-weight-for-date was bleak. Their morbidity and mortality rates were abnormally high when compared with normal-term infants. Bennett (1997) reported that the lower the gestational age, the higher the incidence of major disability.

The preterm infant is still likely to have more learning difficulties, language and social interaction disadvantages, and motor coordination problems than his or her full-term counterpart. For some unknown reason, boys seem to be more severely affected than girls. The usual treatment of hospital-born premature infants is to put them in a sterile isolette, where temperature, humidity, and oxygen can be precisely controlled. It has been suggested that the absence of normal stimulation from the mother and the surrounding environment contributes to these deficits.

Long-Term Effects of Prematurity

The data are clear that VLBW babies are more likely to die in the first few weeks following birth than are normal-weight babies. Preterm LBW ranks second behind congenital anomalies as the leading cause of infant death in the United States. In the United States infant mortality is approximately 6.7% per 1,000 live births, making the United States number 30 in the number of infant deaths among developed countries. At 1.8 infant deaths per 1,000 live births, Hong Kong ranks as the lowest in infant mortality (MacDorman & Matthews, 2009). Figure 4.1 depicts the estimated mortality risk for females and for males based on birth weight and gestational age. Note that as both gestational age and weight increase, mortality correspondingly decreases.

The long-term effects of premature birth are not as clear as are the short-term consequences. In recent years, neonatal intensive care units have been implicated in long-term developmental problems of some premature babies. The effects of

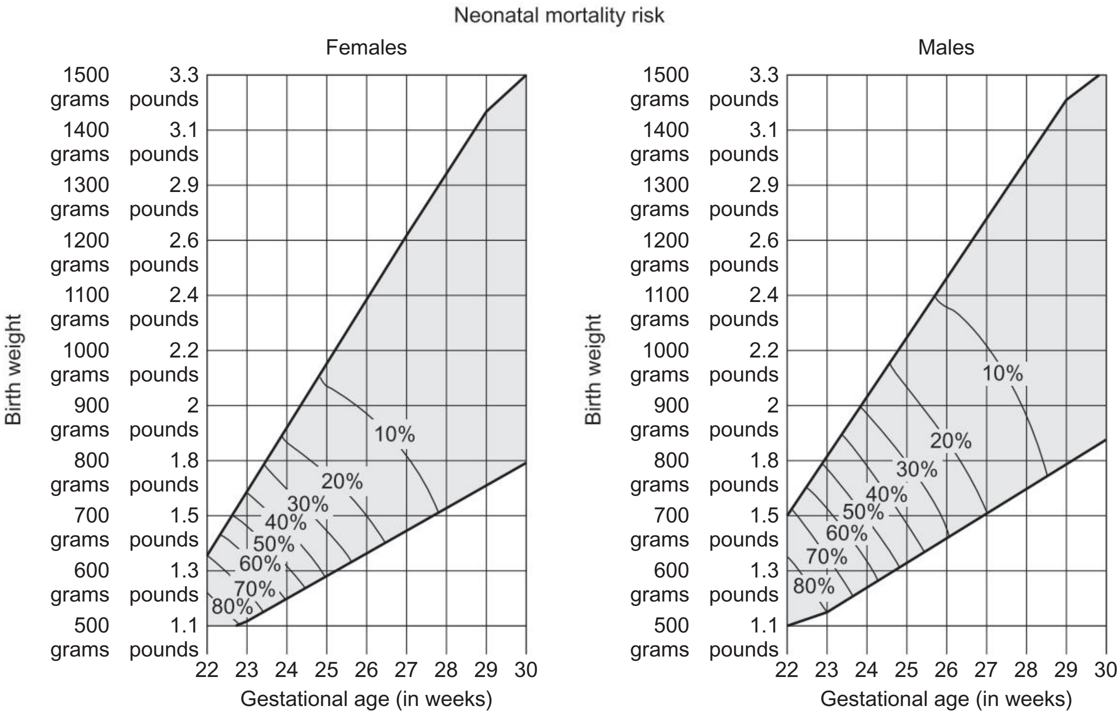

Figure 4.1

Estimated mortality risk for females and males based on birth weight and gestational age.

Adapted from: Lemons et al. (2001). Very low birth weight outcomes of the Neonatal Institute of Child Health and Human Development Neonatal Research Network. *Pediatrics, 107(1).* Online: www.pediatrics.org/cgi/content/full/107/1/e1 noise, light, and the absence of pleasurable touch on the developing neurologic system have been studied. The encouraging news is that the majority survive with little or no disability. But as the age of viability (i.e., the lowest gestational age possible for survival) continues to decrease with medical advances, and the survival rate of VLBW babies increases, there has been a greater incidence of both minor and major developmental disabilities (Lemans et al., 2001; Tommiska et al., 2001).

Eating Disorders

North Americans live in a world far different from that of their ancestors. Vigorous physical exertion is not a necessary part of the daily life pattern of most people. Today, most exercise, if it occurs, is planned and is not an integral part of one's existence. In addition, many, for the present, have an abundance of food. It is possible for an individual to consume a large amount of food and use up little of the energy contained in that food. The maintenance of body weight is relatively simple. It requires maintaining a balance between caloric intake and caloric expenditure. If more calories are consumed than are burned over a time, obesity is the eventual result. On the other hand, if fewer calories are consumed than expended, weight loss will result over time. Weight loss caused by a long-term aversion to food (anorexia nervosa) or repeated binging and purging (bulimia) is of growing concern and must be considered in any discussion of eating disorders.

CONCEPT 4.14

Eating disorders among children, adolescents, and adults dramatically affect their growth and motor development.

Obesity

Obesity, or any excessive increase in the amount of stored body fat, is considered to be the most prevalent chronic nutritional disease in North America. The combination of obesity (BMI >30) and overweight (BMI 25–29.9) occur in over 33% of children (NASPE/AHA, 2010) and 68% of adults in the United States (NIDDK, 2010). Today, obesity is considered to be the second leading cause of unnecessary death (smoking is first with an estimated 435,000 deaths per year) of over 400,000 Americans each year (USDHHS, 2004). The dramatic increase in obesity is a global problem, affecting children and adults in many developed and developing countries (Vincent et al., 2003; Stettler, 2004).

Fat has a number of constructive functions. It is a reserve source of energy; it is a vehicle for fat-soluble vitamins; it provides protection and support to the body parts, insulating the body from the cold; and in proper proportion, it enhances the appearance of the body. However, to serve these functions, the proportion of fat desired in adults is about 15 to 18% for males and 20 to 25% for females.

The full-term infant has about 12 to 16% fat, much of which develops during the last two months of the gestation period. By the sixth month following birth body fat percentages have increased to about 25%, declining thereafter through childhood to about 15 to 18%. During the preadolescent period, fat deposits increase in girls, but not in boys. There is a small but significant decrease in the percentage of body fat among males (Fomon et al., 1982). Ideally, the percentage of body fat in proportion to total body weight changes little from late adolescence through adulthood. However, the percentage of body fat may range from a low of about 8% (typical of the long-distance, ectomorphic runner) to as high as 50% (characteristic of the very obese).

Millions of Americans are obese. In the United States, the prevalence of obesity in adults age 20 and over is now estimated to range from a low of 18.6% in Colorado to a high of 34.4% in Mississippi. Moreover, in 2009 nine states had a reported percentage of adult obesity of over 30% as compared to no states at this level in the year 2000. Additionally, no state met the Healthy People 2010 goal of less than 15% obesity (CDC/MMWR 2010. Online at: http://www.cdc.gov/mmwr/pdf/wk/mm59e0803.pdf). Similarly, childhood obesity in individuals age 2–19 years has shown a steady increase since 1971 when it averaged a mere 5%, to an estimated 16.9% in 2008 (NCHS, 2009. Online at: www.cdc.gov/nchs/data/hestat/obesity_child_07_08/obesity_child_07_08.htm). It is estimated that obese children who have not slimmed down by age 14 have a 70% risk of remaining obese as adults (AOA, 2000).

In North America the percentage of lean body mass tends to decrease with age. The percentage of body fat is the most important determiner of obesity. A person's weight is less crucial than the ratio of fat to lean tissue. Body composition is a valid criterion for determining obesity. Body composition is determined by calculating one's body mass index (BMI). To calculate your BMI use the following formula: weight (in pounds)____ ÷ height (in inches)^2 × 704.5 = BMI. Worldwide, a BMI of 30 or greater is considered obese. A BMI from 25.0 to 29.9 is considered overweight. Go to Table 4.1 to get an estimate of your BMI.

The evidence is clear; there has been a substantial increase in the incidence of obesity in the United States across all segments of the population. Using stratified random sampling techniques, the National Health and Nutrition Examination Survey (NHANES) has been conducted since the 1970s. Tables 4.2 and 4.3 provide a revealing look at the steady increase in the percentage of obesity in the United States among children and adults, respectively, particularly in the last decade. A growing body of evidence has implicated obesity as a major contributing factor in a wide variety of negative health outcomes, several of which are depicted in Table 4.4. Obesity places additional stress on the circulatory, respiratory, and metabolic systems and

TABLE 4.1 Body Mass Index Chart

Height (inches)	Body Weight (pounds)																
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35*
58	91	96	100	105	110	115	119	124	129	134	138	143	148	153	158	162	167
59	94	99	104	109	114	119	124	128	133	138	143	148	153	158	163	168	173
60	97	102	107	112	118	123	128	133	138	143	148	153	158	163	168	174	179
61	100	106	111	116	122	127	132	137	143	148	153	158	164	169	174	180	185
62	104	109	115	120	126	131	136	142	147	153	158	164	169	175	180	186	191
63	107	113	118	124	130	135	141	146	152	158	163	169	175	180	186	191	197
64	110	116	122	128	134	140	145	151	157	163	169	174	180	186	192	197	204
65	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210
66	118	124	130	136	142	148	155	161	167	173	179	186	192	198	204	210	216
67	121	127	134	140	146	153	159	166	172	178	185	191	198	204	211	217	223
68	125	131	138	144	151	158	164	171	177	184	190	197	203	210	216	223	230
69	128	135	142	149	155	162	169	176	182	189	196	203	209	216	223	230	236
70	132	139	146	153	160	167	174	181	188	195	202	209	216	222	229	236	243
71	136	143	150	157	165	172	179	186	193	200	208	215	222	229	236	243	250
72	140	147	154	162	169	177	184	191	199	206	213	221	228	235	242	250	258
73	144	151	159	166	174	182	189	197	204	212	219	227	235	242	250	257	265
74	148	155	163	171	179	186	194	202	210	218	225	233	241	249	256	264	272
75	152	160	168	176	184	192	200	208	216	224	232	240	248	256	264	272	279
76	156	164	172	180	189	197	205	213	221	230	238	246	254	263	271	279	287

Data from: *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults,* National Institutes of Health, National Heart, Lung, and Blood Institute.
*BMI

TABLE 4.2 Prevalence of Obesity (Defined as a Body Mass Index [BMI] Greater Than or Equal to the Sex- and Age-Specific 95th Percentile from the 2000 CDC Growth Charts) Among U.S. Children and Adolescents Aged 2–19, from 1971–1974 Through 2007–2008

Age (in years)	NHANES 1971–1974	NHANES 1976–1980	NHANES 1988–1994	NHANES 1999–2000	NHANES 2001–2002	NHANES 2003–2004	NHANES 2005–2006	NHANES 2007–2008
Total	5.0%	5.5%	10.0%	13.9%	15.4%	17.1%	15.5%	16.9%
2–5	5.0%	5.0%	7.2%	10.3%	10.6%	13.9%	11.0%	10.4%
6–11	4.0%	6.5%	11.3%	15.1%	16.3%	18.8%	15.1%	19.6%
12–19	6.1%	5.0%	10.5%	14.8%	16.7%	17.4%	17.8%	18.1%

Source: Adapted from: Ogden, C., & Carroll, M. (2010). Prevalence of obesity among children and adolescents: United States, trends 1963–1965 through 2007–2008. *NCHS Health E-stat*. Online at: www.cdc.gov/nchs/data/hestat/obesity_child_07_08/obesity_child_07_08.htm.

TABLE 4.3 Prevalence of Obesity Among Age-Adjusted Groups of U.S. Adults Aged 20 and over, by Sex and Race/Ethnicity, Using Selected Years 1988–1994 Through 2007–2008 NHANES (National Health and Nutrition Examination Survey) Age-Adjusted Data to Year 2000 U.S. Census Bureau Estimates

Characteristic	NHANES 1988–1994	NHANES 1999–2000	NHANES 2001–2002	NHANES 2003–2004	NHANES 2005–2006	NHANES 2007–2008
Men, All	**20.2%**	**27.5%**	**27.8%**	**31.1%**	**33.3%**	**32.2%**
Men,N on-Hispanic white	20.3%	27.3%	29.1%	31.1%	33.1%	31.9%
Men,N on-Hispanicb lack	21.1%	28.1%	27.9%	34.0%	37.2%	37.3%
Men,M exican American	23.9%	28.9%	25.9%	31.6%	27.0%	35.9%
Women,[1] All	**25.4%**	**33.4%**	**33.3%**	**33.2%**	**35.3%**	**35.5%**
Women[1],N on-Hispanicw hite	22.9%	30.1%	31.3%	30.2%	32.9%	33.0%
Women[1],N on-Hispanic black	38.2%	49.7%	48.3%	53.9%	52.9%	49.6%
Women[1],M exican American	35.3%	39.7%	37.0%	42.3%	42.1%	45.1%

[1]Excludes pregnant females.

Source: Adapted from: Ogden, C. L., & Carroll, M. D. Prevalence of Overweight, Obesity, and Extreme Obesity among Adults: United States, Trends 1976–1980 through 2007–2008. *NCHS Health E-Stat*. Online at: www.cdc.gov/nchs/data/hestat/obesity_adult_07_08/obesity_adult_07_08.htm.

may cause, or intensify, disorders in these systems. Obese adults have a well-established increased risk of cardiovascular morbidity and mortality independent of age, cholesterol level, blood pressure, smoking, and glucose intolerance. In addition, obese children and adults frequently suffer ridicule from their peers, poor academic performance, poor self-image, and persistent concern with dieting.

The primary environmentally based causes of obesity in individuals with normal hormonal balances are excessive eating and lack of exercise, or a combination of both. Poor eating and exercise habits are formed in childhood and carried on into adult life. The child urged to clean the plate at every meal but not encouraged to exercise regularly has the potential for a serious weight problem.

An area of interest to many who study obesity is the activity levels of obese children (Treuth, Butte, Adolph, & Puyau, 2004). Physical inactivity appears to contribute to obesity, as indicated by studies linking television watching to the prevalence of childhood obesity. Bar-Or and Baranowski (1994)

TABLE 4.4 Overweight and Obesity Increase the Risk of Several Diseases and Are Associated with Numerous Negative Health Conditions

Overweighta ndO besity AreK nown Risk Factors for:	Overweight and Obesity Are Associated with:
Type2 D iabetes	Elevated Cholesterol
HeartD isease	Complications During Pregnancy
Stroke	Menstrual Irregularities
Hypertension	Excessive Body and Facial Hair
Rheumatoid Arthritis	Birth Defects (neural tube defects)
Osteoarthritis (especially of the knees, hips, back, and hands)	Carpal Tunnel Syndrome
Sleep Apnea	Daytime Sleepiness
Some Forms of Cancer (breast, uterine, colorectal, kidney, and gallbladder)	Gout
Gallbladder Disease	Impaired Immune Response
HeatD isorders	Impaired Respiratory Function

Source: CDC (2009). The health effects of obesity. Online at: www.cdc.gov/healthyweight/effects/index.html.
National Heart Lung and Blood Institute (2009). What are the health risks of overweight and obesity? Online at: www.nhlbi.nih.gov/health/dci/Diseases/obe/obe_risks.html.

INTERNATIONAL PERSPECTIVES

We Are Not Alone

Over the past 20 years the United States has witnessed a secular trend (generational shift) in the percentage of Americans who are considered to be overweight or obese. Today, over two-thirds of all adults and one-third of all children are either overweight or obese. The statistics are startling because of the negative health consequences associated with obesity. But we are not alone. The obesity epidemic is now a worldwide phenomenon. Yes, the United States is a dubious number 1 in the percentage of overweight and obesity among its citizens, but our neighbors, Mexico and Canada, are not far behind. So too are Brazil, Germany, France, and the United Kingdom. Additionally, a large number of countries are reporting still relatively small, but heretofore unheard of, increases in their nations' obesity rates, including Australia, China, and Japan (Stettler, 2004).

It appears that a fundamental shift has occurred in the lifestyles of not only those living in North America, but in much of the rest of the world also. Welcome to the global community.

noted in a review paper of physical activity and obesity among adolescents several studies that clearly indicate that the intensity of physical activity is significantly lower in obese children and adolescents. Although increased levels of physical activity coupled with moderation in caloric intake may be the keys to reducing the trend toward increased fatness, Bar-Or and Baranowski concluded that of the many physical intervention programs studied there was only a small (1 to 3% body fat) reduction in adiposity among adolescents. Dieting does not appear to be the complete, or the best, solution to behaviorally based obesity in children. Their food intake may be normal, so dieting may cause serious deficiencies in the nutrients required for proper growth and health. A major cause of obesity in children is lack of activity, therefore long-term increases in this area may be the best and most healthful solution (USDHHS, 2001; Dietz, 2004).

CONCEPT 4.15

Both genetic and environmental factors contribute to the onset and extent of obesity.

The etiology of obesity in most children is unknown, but genetic as well as environmental factors appear to be involved. Obesity appears to be highly familial with either a hereditary or environmental basis or a combination of both. Obesity occurs at higher rates in African Americans and Mexican Americans than their white counterparts (see Table 4.3). Twin studies support the concept that genetic factors play a major role in obesity (Stunkard et al., 1986, 1990). Additionally, obesity among children after 10 years of age appears to be strongly genetic with about two-thirds of the variability in body weight attributable to genetic factors (Malina, Bouchard, & Bar-Or, 2004). Although both hereditary and environmental factors play a role, regular, vigorous physical activity may be the most important variable in preventing obesity.

Binge Eating Disorder

Binge eating disorder is probably the most common eating disorder, occurring in about 3% of the adult population in the United States. It is more common in women than men and in obese individuals than those who are not obese (NIDDK, 2008). Although the causes are yet unknown, binge eating disorder includes up to 50% with a history of depression. Negative emotions such as anger, anxiety, sadness, and boredom may trigger episodes of binge eating. Individuals with a binge eating disorder consume large amounts of food in binges but do not engage in the purging or fasting behaviors typical of individuals with bulimia or anorexia. An individual with **binge eating disorder** is characterized as having reoccurring episodes of binge eating (without purging) within any two-hour period, at least two days per week for a period of at least six months. Furthermore, binge eaters typically eat much more rapidly than usual; eat until feeling uncomfortably full; eat large quantities of food when not feeling hungry; eat alone because of embarrassment about how much they eat; and feel guilty, depressed, or disgusted with themselves after overeating (NIDDK, 2008; Spitzer et al., 1993).

Anorexia Nervosa/Bulimia Nervosa

A problem as perplexing and potentially as dangerous as obesity is **anorexia nervosa,** characterized by an aversion to the consumption of food and an obsession with being "too fat," even when the person is clearly underweight. These self-starvers can lose 25 to 50% of their normal body weights in the pursuit of thinness. They start dieting and, although emaciated, continue to refuse food because they see themselves as fat. **Bulimia nervosa,** another severe eating disorder, is similar to anorexia in terms of results. Persons with bulimia have the same "need" for thinness but use a binge-purge process. Individuals with bulimia often eat large quantities of food and then force themselves to vomit. It is estimated that anorexia and bulimia occur in 3 to 4% of the female population, with 90% of all cases being female (NIMH, 2000, 2010). Both disorders have major long-term health consequences and are related to amenorrhea during the childbearing years and osteoporosis during the postmenopausal years.

Characteristically, in both anorexia nervosa and bulimia, there is no true loss of appetite or awareness of hunger pains corresponding to the body's need for food. Some individuals brainwash themselves into believing that the pain feels good. In about 25% of the cases, food refusal alternates with eating binges followed by forced vomiting and/or the use of laxatives, enemas, and diuretics (bulimia).

CONCEPT 4.16

Anorexia nervosa and bulimia nervosa are emotional disorders that culminate in an aversion to food and self-starvation that results in developmental delays and even death.

Individuals with anorexia or bulimia often pursue their goal of thinness not only through food restriction but also through exhausting exercise.

TABLE 4.5 Early Warning Signs of Eating Disorders

BingeE atingD isorder	AnorexiaN ervosa	Bulimia Nervosa
1. Eating binges without purging	1. Overidentification with a doctor-prescribed weight-control program	1. Eating binges followed by purging
2. Irregularw eightloss	2. Obsession with dieting and talk of food	2. Irregular weight loss
3. Frequentlyo bese	3. Sociali solation accompanying slimness (loner)	3. Long periods in the bathroom after meals
4. Difficulty losing weight and keeping it off	4. Nop articipation in the courting behavior of classmates	4. Variable performance
5. Obsessedw ithf ood	5. Sudden increased involvement in athletics, usually of a solitary nature	5. Loss of tooth enamel
6. Frequenta mong people on a medically supervised weight-controlp rogram	6. Exaggerated concern with achieving high academic grades	6. Fear of gaining weight
7. Disgustedw ith self after a binging episode	7. Overconcern with weight	7. Prolonged/extreme exercise
8. Frequent historyo f depression	8. Failure to consume food	8. Emotional instability and impulsivity
9. Eatingb ingest riggered by extremen egativee motions	9. Denialo f hunger	9. Depression and frequent mood swings
	10. Obsession with exercise	10. Throat, esophagus, stomach, or colon problems

Exercise becomes a way to burn off calories. Despite their weakness due to extreme loss of weight, many with anorexia display incredible energy. The longer it is left undiagnosed, the more difficult it is to treat. To help those with eating disorders and the underlying emotional issues, psychotherapy is generally recommended. Antidepressant medication is frequently prescribed. Some early warning signals of binge eating disorder, anorexia nervosa, and bulimia nervosa are listed in Table 4.5.

Society is partly to blame for the increase in eating disorders in North America. The lean, slender form is glorified by society, which propagates the idea that being thin symbolizes beauty, desirability, and self-control and is a magic key to a happier life. Educators may be among the first to recognize eating disorders. They should be able to recognize the early stages of either illness while it is still relatively easy to reverse.

Fitness Levels

A wide variety of factors from all three domains of human behavior (cognitive, affective, and psychomotor) influence development, as well as factors within the individual, the environment, and the task. Task factors within the psychomotor domain are termed *physical* and *mechanical* factors. These factors have a profound impact on the acquisition, maintenance, and diminution of our movement abilities throughout life. Our level of physical fitness coupled with the mechanical requirements of a task greatly influence our ability to move with control, skill, and confidence. Figure 4.2 illustrates this important concept.

The interaction among physical activity, genetics, and nutrition suggests the upper and lower limits of physical fitness that can be reasonably expected of an individual. Nutritional status can greatly inhibit or enhance one's level of physical functioning (Meredith & Dwyer, 1991; Rickard et al., 1996), and genetic structure determines the ultimate level of fitness that can be attained (Malina, Bouchard, & Bar-Or, 2004). Therefore, for the purposes of this text, **physical fitness** is defined as a set of attributes that one possesses related to the ability to perform physical activity, coupled with one's genetic makeup, and the maintenance of nutritional adequacy. Physical fitness may be subdivided into health-related and performance-related components.

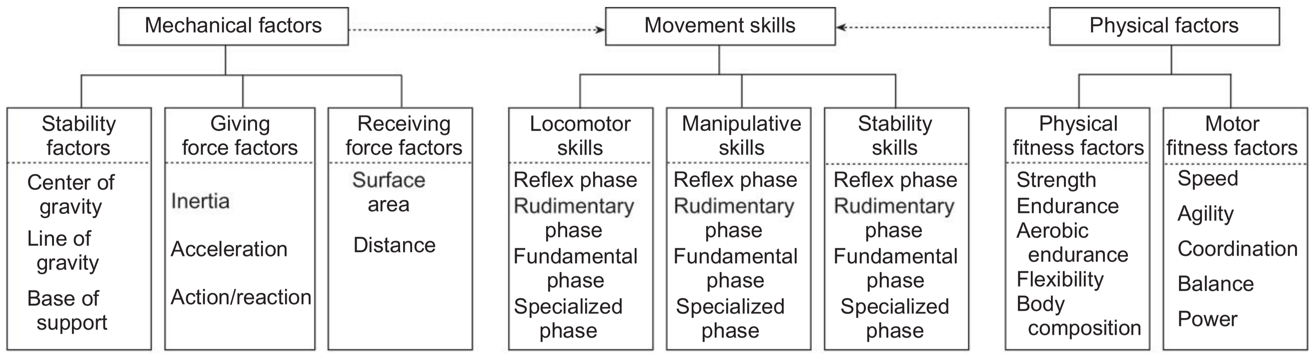

Figure 4.2
Physical and mechanical factors affect the development of movement potential at all phases of motor development.

Health-Related Fitness

Muscular strength, muscular endurance, aerobic endurance, joint flexibility, and body composition are usually considered the components of health-related fitness. The extent to which each of these factors is possessed will influence an individual's performance capabilities in movement. For example, how far a person can run or ride a bicycle is related to his or her level of muscular strength, muscular endurance, and aerobic endurance.

CONCEPT 4.17

One's personal level of health-related and performance-related fitness influences motor development in many ways.

Performance-Related Fitness

Performance-related fitness, also widely known as motor fitness, is the performance aspect of physical fitness. *Motor fitness* is generally thought of as one's current performance level as influenced by factors such as movement, speed, agility, balance, coordination, and power. One's motor fitness has a definite effect on the performance of any movement activity that requires quick reactions, speed of movement, agility and coordination of movement, explosive power, and balance.

Biomechanics

Before embarking on a detailed discussion of motor development, it will be useful to review some mechanical principles of movement as they relate to stability, locomotion, and manipulation. The human body is capable of moving in numerous ways. Learning all of the skills involved in the performance of children's game, sport, and dance activities may appear to be an impossible task. Closer inspection of the total spectrum of movement will reveal, however, that fundamental mechanical laws affect all human movement. Selected mechanical principles are considered here to serve as basic preparation for the chapters that follow.

CONCEPT 4.18

All movement is governed by fundamental mechanical laws.

Balance

All masses within the gravitational pull of the earth are subjected to the force of gravity. The three primary factors of concern in the study of balance principles are (1) center of gravity, (2) line of gravity, and (3) base of support.

A *center of gravity* exists within all objects. In geometric shapes, it is located in the exact center of the object. In asymmetrical objects (e.g., human bodies), it is constantly changing during movement. The center of gravity of our bodies always shifts in the direction of the movement or the additional weight (Figure 4.3). The center of gravity of a child standing in an erect position is approximately at the top of the hips between the front and the back of the trunk. Activities in which the center of gravity remains in a stable position, such as standing on one foot or performing a headstand, are known as static balance activities. If the center of gravity is constantly shifting, as in jumping rope, walking, or doing a forward roll, the activities are dynamic balance movements.

The *line of gravity* is an imaginary line that extends vertically through the center of gravity to the center of the earth. The interrelationship of the center of gravity and the line of gravity to the base of support determines the degree of stability of the body(Figure 4.4).

The *base of support* is the part of the body that comes into contact with the supporting surface. If the line of gravity falls within the base of support, the body will be in balance. If it falls outside the base, it is out of balance. The wider the base of support, the greater the stability, as can be seen when one balances on two feet rather than on one foot. The nearer the base of support to the center of gravity, the greater the stability. Someone standing erect may be pushed off balance more easily than someone in a lineman's stance with the feet spread

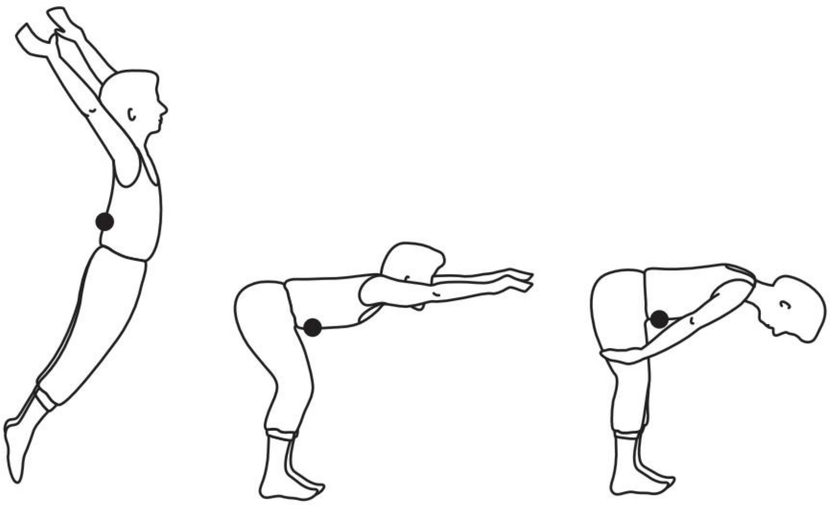

Figure4 .3
The center of gravity shifts as the body changes position.

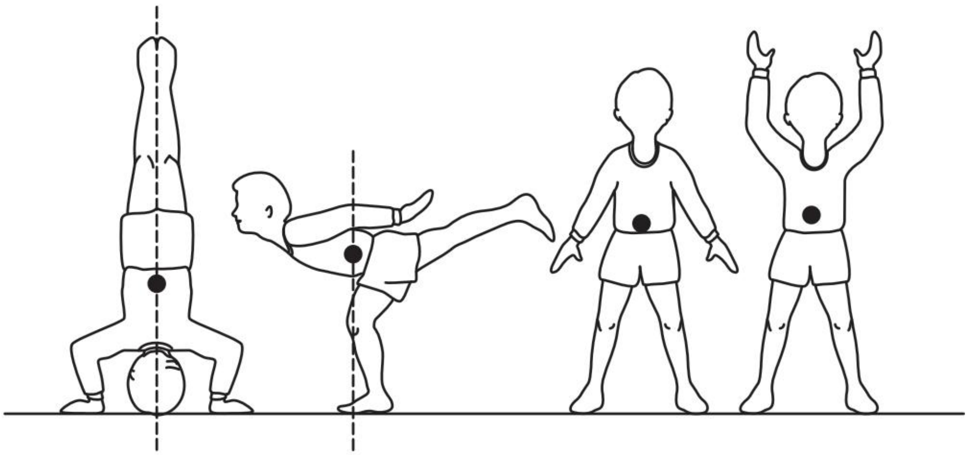

Figure4 .4
The body remains in balance when the center of gravity and line of gravity fall within the base of support.

and the body slightly forward. The nearer the center of gravity to the center of the base of support, the greater the stability. A foot position that allows for a larger base of support in the direction of the movement gives additional stability. This principle is illustrated by the foot position of a runner attempting to stop or of a catcher trying to receive and control a heavy object.

Giving Force

Force is one of the basic concepts of movement and body mechanics. **Force** is the instigator of all movement and may be defined as the effort that one mass exerts on another. The result may be (1) movement, (2) cessation of movement, or (3) resistance of one body against another. There may be force without motion, as is seen in isometric activities, but motion is impossible without the application of some form of force. Three forces relative to the human body are of concern to us: (1) force produced by muscles, (2) force produced by the gravitational pull of the earth, and (3) momentum. The entire science of force is based on Newton's three laws of motion, namely, the law of inertia, the law of acceleration, and the law of action and reaction.

The **law of inertia** states that a body at rest will remain at rest and a body in motion will remain in motion at the same speed in a straight line unless acted upon by an outside force. For movement to occur, a force must act upon a body sufficiently to overcome that object's inertia. If the applied force is less than the resistance offered by the object, motion will not occur. Large muscles can produce more force than small muscles. Once an object is in motion, it takes less force to maintain its speed and direction (i.e., momentum) than it does to stop it. This may be readily observed in snow skiing, the glide in swimming, or rolling a ball. The heavier the object and the faster its speed, the more force is required to overcome its moving inertia or to absorb its momentum. It is harder to catch a heavy object than it is to catch a light object.

The **law of acceleration** states that the change in the velocity of an object is directly proportional to the force producing the velocity and inversely proportional to the object's mass. The heavier an object, the more force is needed to accelerate or decelerate it. This may be observed when a heavy object (shot put) and a light object (softball) are thrown a given distance. An increase in speed is proportional to the amount of force that is applied. The greater the amount of force imparted to an object, the higher the speed at which the object will travel. If the same amount of force is exerted on two bodies with a different mass, greater acceleration will be produced on the lighter or less massive object. The heavier object, however, will have greater momentum once inertia is overcome and will exert a greater force than the lighter object on something that it contacts.

The **law of action and reaction** states that for every action there is an equal and opposite reaction. This principle of counterforce is the basis for all locomotion and is evident when one leaves footprints in the sand. This principle applies to both linear and angular motion. Its application requires that adjustments be made by an individual to sustain the primary forces in any movement. For example, the use of opposition in the running pattern counters the action of one part of the body with that of another.

Receiving Force

To stop ourselves or a moving object, we absorb force over the greatest distance possible and with the largest surface area possible. The greater the distance over which the force is absorbed, the less the impact on whatever receives the force. This may be demonstrated by catching a ball with the arms straight out in front of the body and then catching again with the arms bent. The same thing may be observed when landing from a jump with the legs bent as opposed to landing with the legs straight. Forces should be absorbed over as large a surface area as possible. The impact is reduced in proportion to the size of the surface area, and the likelihood of injury is diminished. For example, trying to absorb the shock of a fall with the hands and arms extended will probably result in injury because the small surface area of the hand must receive the entire impact. It is far better to let as much of the body as possible absorb the impact.

The final direction of a moving object depends on the magnitude and the direction of all of the forces that have been applied. Therefore, whenever we kick, strike, or throw an object, its accuracy and the distance depend on the forces acting on it. If we are performing a vertical jump, we must work for a summation of forces in a vertical direction, whereas a good performance in the long jump requires a summation of horizontal and vertical forces so that the takeoff is at the appropriate angle.

Separate discussion of the principles of balance, giving force, and receiving forces should not be taken to mean that one is used in the absence of the others. Most of our movements combine all three. An element of balance is involved in almost all of our movements, and we give and receive force whenever we perform any locomotor or manipulative movement. A gymnast, for example, must maintain his or her equilibrium when performing a tumbling trick, such as a front flip, and also must absorb force from the body (on the landing). A tennis player must move to a position of readiness (giving force to and receiving force from the body), contact the ball (giving force to an object), and maintain balance. Although each of the movement patterns and skills discussed in the chapters that follow involve a specific sequence of movements, all incorporate the basic mechanics discussed here because these mechanical principles arec ommont o allm ovements ituations.

SUMMARY

Motor development represents one aspect of the total developmental process. It is intricately interrelated with the cognitive and affective domains of human behavior and is influenced by a variety of factors. The importance of optimal motor development must not be minimized or regarded as secondary in relation to other developmental areas. Common factors affecting motor development emerge. These factors illustrate the gradual progression from relatively simple levels of functioning to more complex levels. Biological, experiential, and physical factors influence the process and the products of motor development. Each individual is unique in his or her development and will progress at a rate determined by environmental and biological circumstances in conjunction with the specific requirements of the movement task.

QUESTIONS FOR REFLECTION

1. Neuromotor maturation seems to account for developmental progression in infants and children. What about the opposite: neuromotor regression frequently seen in individuals with cognitive impairments brought about by disease or old age?
2. The problem of obesity has reached “epidemic” proportions in the United States and several other countries. From an ecological perspective (see chapter 1), what in your view are the primary proximalc auses?
3. In your own life, how do you manage the issue of excess weight and what are your long-term personal strategies for combating overweight and obesity, and other eating disorders?
4. What are the primary causes and consequences of LBW and VLBW, and what are the best practices for combating this major health problem?
5. Why is a working knowledge of biomechanics important to physical education and sport educators as well as physical therapists and orthopedists?

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WEB RESOURCES

aappublications.org/

The homepage of the American Academy of Pediatrics. Information provided includes AAP policy, clinical reports, technical reports, clinical practice guidelines, and pages directed toward parents.

www.nichd.nih.gov/

The National Institute of Child Health and Human Development official homepage. Homepage contains NICHD's mission, organizational components, news releases, conferences, new policies, funding opportunities, and research materials.

www.anad.org/site/anadweb/

National Association of Anorexia Nervosa and Associated Disorders homepage. The page provides eating disorder information, resources, services/programs, treatments/referrals, and support groups focused on helping those individuals suffering from anorexia, bulimia, and compulsive overeating.

www.cdc.gov/nccdphp/dnpa/obesity/

Centers for Disease Control and Prevention website information regarding obesity in the United States. The site defines overweight and obesity terms and discusses trends, contributing factors, and health and economic consequences of being overweight or obese. Resources are included as well as state-by-state information links.

www.letsmove.gov/

Let's Move, the creation of First Lady Michelle Obama, is a program for children and youth designed to raise a healthier generation of kids.

UNIT

II

Infancy

. . . for I am fearfully and wonderfully made . . .

—Psalm1 39:14

CHAPTER

5 Prenatal Factors Affecting Development

KEY TERMS

High-riskp regnancy
Teratogen
Malnourishment
Illicitd rugs
Fetala lcohols yndrome
Downs yndrome
Genetic defects
Chemicalp ollutants
Sexuallyt ransmittedd iseases
Obstetrical medication

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Describe the influence of maternal nutrition on later development
- Critically analyze the impact of maternal chemical intake on fetal development
- List and discuss factors to be considered when determining the influence of a drug on an unborn child
- Distinguish between chromosome-based disorders and gene-based disorders
- List and describe the causes and effects of several chromosome- and gene-based disorders
- Describe the potential effects of radiation and chemical pollutants on later development
- List and discuss several maternal and fetal medical problems that may affect later development
- Describe the influence of maternal exercise during pregnancy on fetal development
- Demonstrate knowledge of birth process factors that may affect later development
- Critically analyze the prenatal period and describe the interrelated nature of a variety of factors that may influencel aterd evelopment

KEY CONCEPT

A number of prenatal factors, many of which can be controlled, affect motor development during infancy and beyond.

Among the most positive contributions of medical technology are advances that have been made in reducing infant mortality. Infant mortality rates have dropped significantly in most categories of death causations in the last two decades. Not long ago prenatal and neonatal illness and death were common in North America. One need, however, only look at less-advanced cultures throughout the world, and among the poor, deprived, and neglected in our society, to see that the threat of severely disabling conditions resulting from a variety of prenatal factors still exists. The current leading cause of severe impairment, among rich and poor, stems from prenatal factors. Birth defects refer to abnormal conditions such as heart defects, skeletal deformities, and body chemistry imbalances present at birth. Birth defects can range from mild to severe and may result in a physical or mental disability, debilitating disease, or early death. Birth defects are the leading cause of infant death, but fully 70% of the causes remain unknown (MOD, 2010).

A number of birth defects are associated with high-risk pregnancies. A **high-risk pregnancy** represents a situation when the expectant mother has a condition before or during pregnancy that increases her unborn child's chances of experiencing either prenatal or postnatal problems. Table 5.1 presents a list of conditions that may put a mother-to-be in the high-risk category. Several of these are described in further detail throughout this chapter.

NUTRITIONAL AND CHEMICAL FACTORS

Whatever the expectant mother ingests will affect the unborn child in some way. Whether these effects are harmful and will have lasting consequences depends on a variety of circumstances. The condition of the fetus, degree of nutritional or chemical abuse, amount or dosage, period of pregnancy, and presence of other influencing factors are a few of the circumstances that influence the probability of teratogenic effects. A **teratogen** is any substance that may cause the unborn child to develop in an abnormal manner. The fetus is "at risk" when any one or more of the following nutritional or chemical factors are present.

TABLE 5.1 Conditions That May Result in High-Risk Pregnancy

MedicalC onditions	Exposure to	Use of	History
Asthma	Certain medications	Alcohol	Age (<16, >35)
Cancer	Chemical pollutants	Illicit drugs	Bleeding
Diabetes	Cytomegalovirus	Tobacco	Heredity
Hypertension	Excessive radiation		Nutritional inadequacy
Heartd isease	Rubella		Previous miscarriage
Kidneydi sease	Toxoplasmosis		Seriously overweight or underweight
Liver disease			Poverty
Maternalst ress			
Thyroidd isorders			
Sexually transmitted diseases			

Prenatal Malnutrition

Prenatal malnutrition is a common cause of later developmental difficulties throughout the world. *Prenatal malnutrition* may result from one or more of the following three factors: (1) placental factors, (2) fetal factors, and (3) maternal factors.

Placental malnutrition arises out of problems associated with the supply and transport of nutrients from the placenta to the fetus. The fetus depends on the mother's blood supply and the osmotic action of the placenta and umbilical cord for its nutrients.

Fetal malnutrition is associated with the inability on the part of the developing fetus to use the nutrients available to it. This generally is due to complications in the metabolism of the fetus that interrupt or prevent the normal use of available nutrients.

Maternal malnutrition is associated with inadequacies in the expectant mother's current nutritional intake as well as her general level of nutrition. Because of this, deficiencies in the mother's diet both prior to and during pregnancy can have a harmful effect on the child. A sound, nutritious diet is absolutely essential for the mother's health and the health of her unborn child.

CONCEPT 5.1

Placental, fetal, and maternal malnutrition negatively influence human development throughout the world.

Malnourishment is of concern to nutritionists and specialists in child development in the West, where most people enjoy an abundance of food. Millions of women of childbearing age are malnourished worldwide. They are not receiving the proper nutrients through their normal daily intake of food. The reasons for maternal malnourishment range from poor eating habits to poverty, low socioeconomic class, anxiety, stress, and trauma.

Maternal malnutrition may result in inadequacies of certain nutrients that not only contribute to the overall health of the mother and unborn baby, but in some cases prevent birth defects. In recent years it has been demonstrated that the B-vitamin folic acid can help reduce neural tube defects (i.e., spina bifida) when taken prior to and during pregnancy (Locksmith & Duff, 1998). Because of the potential for unplanned pregnancies, it is generally recommended that all females of childbearing age should consume 400 micrograms of folic acid daily in addition to maintaining a healthy diet (American Academy of Pediatrics, 1999; Centers for Disease Control and Prevention, 1999). The primary results of inadequate maternal nutrition are giving birth to a low-birth-weight (LBW) or very-low-birth-weight (VLBW) baby. The largest percentage of infant deaths are directly associated with VLBW.

The amount of weight gained by the expectant mother, in the absence of other complications, may serve as a general indicator of the unborn child's nutritional status. Maternal weight gain of 20 to 28 pounds is generally recommended. Table 5.2 lists the proportions of average weight gain during pregnancy.

TABLE 5.2 Distribution of Maternal Weight Gain During Pregnancy

	Weight Averages (in pounds/kg)
Fetus	7.5/3.4
Placenta	1.0/.45
Amniotic fluid	2.0/.91
Increase inu terus'sw eight	2.5/1.1
Increase in breasts'w eight	3.0/1.4
Increasei nt hem other'sf at	4–8/1.8–3.6
	20–24 pounds/9.1–12.7 kilograms

Common Maternal Drugs

The wall of the placenta is porous, and chemicals may penetrate it with tragic results to the unborn child. The drugs found in the average person's medicine cabinet are potentially destructive to the fetus. Every drug has side effects, whether it is a prescription or nonprescription substance. Even if the drug has been given during pregnancy to other women without serious side effects, it cannot be regarded as safe for all unborn children. The following factors need to be considered whenever the influence of a drug on an unborn child is evaluated.

1. The time of pregnancy during which the drug ist aken
2. Thed osageo ft hed rug
3. The length of time the drug is taken
4. Theg eneticp redispositiono ft hef etus
5. Howt hesef ourf actorsi nteract

CONCEPT 5.2

Maternal drugs and medications frequently affect the fetus and later motor development.

A drug may affect the unborn child in various ways. Drugs may interfere with organ growth or cell differentiation and result in deviations from normal development. The penetrability of the placenta may be altered and reduce the flow of oxygen and nutrients or magnify the drug concentration flowing to the fetus. Drugs may impair development and functioning of the fetus's liver, which balances blood waste products called *bilirubin*. The inability of the biliary ducts to excrete bilirubin efficiently results in *jaundice*. Excessive jaundice results in a condition called *kernicterus*. Kernicterus can result in permanent and devastating brain damage. Table 5.3 provides a few examples of common drugs taken during pregnancy and their associated risk factors.

"Necessary" Maternal Drugs

During pregnancy the expectant mother may be under the care of a physician because of an illness or disease. Good, consistent medical care is doubly important because the developing fetus inside a mother with a special medical condition may also have special needs. The medications prescribed for the mother may have to be modified to protect her unborn child. A mother being treated for epilepsy, for example, should avoid the use of Dilantin and phenobarbital and other drugs used for seizure control. Although she may not be able to discontinue the use of medication completely, the drug should not be taken automatically and the dosage may need modification under medical supervision.

The expectant mother with cancer is at risk when chemotherapy is used to decrease the rate of

TABLE 5.3 Possible Effects of Common Drugs on the Unborn Child

Drug	Use	Possible Effects
Coumadin	Ana nticoagulant used for blood clots	May cause bleeding before or during birth, resulting in brain damage
Diuretics	To treat toxemia, particularly water retention	Water and salt imbalance. An electrolyte imbalance may result in brain damage
Streptomycin	To treat infection in the mother	Impairment of kidneys, hearing, and balance
Aspirin	For aches, pain, fever. Almost 80% of over-the-counter drugs contain aspirin	Death; congenital deformities; bleeding under the skull, causing brain damage; hemorrhaging during birth
Tetracyclines	For acne	Stunts bone and teeth growth

malignant cell growth, particularly during the first three months of pregnancy. The use of progesterone to correct menstrual cycle abnormalities and to prevent miscarriage should be avoided in expectant mothers because of the potentially harmful effects on the newborn.

CONCEPT 5.3

Many over-the-counter and prescription medications have the potential to impair fetal development.

The unborn child of a diabetic mother-to-be is particularly vulnerable. The severity of the disease and whether the mother is insulin-dependent has a great deal to do with possible problems. Prior to the development of insulin, diabetic women did not have children. After insulin became available (about 1922) more diabetic women were able to give birth. However, the prenatal mortality rate was over 50%, and many of the children who survived had serious congenital deformities. Today, with careful management of the diabetes, use of special tests to monitor fetal well-being, and excellent medical care, the fetal mortality rate has been sharply reduced (American Diabetes Association, 2000). Approximately one in every 100 women of childbearing age has diabetes prior to becoming pregnant with another 2 to 5% developing diabetes during pregnancy. It is critical in both cases to monitor blood sugar levels. Poorly controlled diabetes can result in serious birth problems such as heart defects and neural tube defects (NTD–birth defect of the brain or spinal cord). They also have an increased risk of miscarriage and stillbirth.

Table 5.4 summarizes some common medical conditions, treatments, and possible effects on the fetus.

CONCEPT 5.4

The use of illicit drugs by the expectant mother may cause devastating damage to her unborn child.

Despite decades of educational efforts by government and social service agencies, the use of **illicit drugs** by women of childbearing age is still alarmingly high. Nearly 4% of pregnant women in the United States use illicit drugs (MOD, 2010). The use of opiates (opium, heroin), amphetamines (speed), lysergic acid diethylamide (LSD), and cannabis (hashish, marijuana) is of great concern to those interested in the well-being of unborn children. Pregnant drug users are at an increased risk for miscarriages and stillbirths while their newborn babies have higher incidents of low birth

TABLE 5.4 Common Drugs for Medical Conditions During Pregnancy and the Possible Effects on the Unborn Child

MaternalC ondition	Drug	Possible Effects
Hypertension	Resperine	Choking, gasping, nasal congestion at birth
Thyroid	Thiouracile iodides Radioactivei odine	Thyroid abnormalities in child: cretinism (hypothyroidism)
Diabetes	Insulin	Excessive birth weight, prematurity, heart defects, jaundice, low blood sugar, convulsions, mental and physical retardation, deformities
Menstrual abnormality	Progesterone	Gross deformities, masculinization of female organs
Allergyo r cold	Antihistamines	Deformities (in animal studies)
Epilepsy	Seizure control drugs	Cleft palate and other malformations

weight and smaller head sizes than those born to nondrug users.

The use of cocaine by pregnant women has received a great deal of attention due to its triple properties of being addictive, toxic, and teratogenic. In teratogenic effects, research data as well as clinical observation clearly indicate that cocaine-exposed infants are at risk of increased mortality, morbidity, and problems in development and long-term behavior. Such problems include low birth weight, withdrawal symptoms, hypertension, mental disabilities, cerebral palsy, and malformation of the urinary tract (MOD, 2010). As prenatally exposed children grow older, they have been shown to have deficits in both gross and fine motor development, in particular balance and eye-hand coordination (Arendt et al., 1999).

Table 5.5 provides an overview of the possible effects of some mind-altering drugs on the newbornc hild.

TABLE 5.5 Possible Effects of Illicit Drugs on Development of the Unborn and Newborn Child

Drug	Possible Effects
Heroin and morphine	Irritable. Sleeps poorly. High-pitched cry Vomiting and diarrhea Marked physiological withdrawal symptoms Decreased oxygen in the blood tissues Hepatitis from unclean needle Susceptible to infection Complications: 1. Toxemia 2. Breech birth 3. Prematurity 4. Small for date of birth 5. Premature separation of the placenta Complications if not treated: 1. Dehydration 2. Respiratory distress 3. Shock 4. Coma 5. Death
Amphetaminesa ndb arbiturates	Miscarriage Birth defects
Tranquilizers	Such drugs as Sominex,® Nytol,® Sleep-Eze,® and Compoz® contain two antihistamines that have produced congenital deformities in animals
LSD (lysergic acid diethylamide)	May cause chromosome damage Sometimes contaminated with quinine or other materials that may harm the unborn child. A few surveys have found a higher incidence of congenital defects in children of LSD users
Cocaine	Physiological withdrawal Hypertension Poor thermal regulation Low birth weight Learning disabilities Behavioral problems Increased mortality

Alcohol and Tobacco

Although alcohol and tobacco are considered by many to be mind- or mood-altering drugs, we are treating them separately because of the frequency of their use and to amplify their potential hazards. It has been variously reported that there are more than 1 million alcoholics of childbearing age. The fetus is affected twice as fast as the mother by her alcohol consumption and at the same level of concentration. At one time, the widespread myth that the fetus takes what it needs from its mother and is uninfluenced by her consumption of foods and beverages caused expectant mothers to be unconcerned about their alcohol consumption. The potential dangers of alcohol to the unborn child were recognized, however, as far back as the Greek era, when newly married couples were forbidden to consume alcohol in order to prevent conception while intoxicated.

In the 1890s William Sullivan, a physician at a Liverpool, England, prison for women, was the first to carefully document the effects of chronic alcoholism on the offspring of 120 alcoholic inmates. This early study revealed a significantly greater mortality rate among the 600 offspring and a much higher number of developmental difficulties in the infants (Rosett & Sander, 1979). Further research into the effects of maternal alcoholism lagged in the United States and Great Britain after 1920, following the enactment of Prohibition, although some research continued in France and Germany. It was not until 1970 that the "discovery" and labeling of **fetal alcohol syndrome** (FAS) took place (Witti, 1978).

CONCEPT 5.5

Although completely preventable, alcohol use is a leading cause of birth defects in the United States.

Alcohol consumption by an expectant mother is one of the most common causes of birth defects. Each year in the United States approximately 40,000 infants are born with some degree of fetal alcohol spectrum disorder (FASD; MOD, 2010). Fetal alcohol spectrum disorder is entirely preventable. At the most severe end of the spectrum, children are born with mental retardation and marked physical defects. As they age, deficits in a number of psychomotor characteristics are observed as well (Larroque et al., 1995). On the other hand, children at the less severe end of the spectrum are often at additional risk because they appear to be normally developing and frequently do not receive the attention they need during the crucial early years to help them reach their full potential.

Alcohol in the mother's blood passes directly through the placenta to the fetus. The fetus does not have any ethanol-oxidizing or alcohol dehydrogenasic abilities; therefore, the alcohol is fed directly into its system. Evidence is unclear on the exact amounts of alcohol harmful to the fetus and on the critical periods during which it should be avoided. However, a review of the research on fetal alcohol syndrome clearly reveals that consumption of large quantities of alcohol is likely to result in central nervous system damage, growth and mental retardation, and distinct facial abnormalities, while moderate to small doses of alcohol may have similar results. Such results have led some of the premiere health advocacy groups such as the March of Dimes (2010) and the American Academy of Pediatrics (2011) to recommend abstinence from all alcohol consumption for women who are pregnant or who are planning a pregnancy.

CONCEPT 5.6

Smoking by the expectant mother has been shown to have negative effects on fetal development.

It has been estimated that about 13% of pregnant women smoke during their pregnancy. It is further estimated that 12% of infants born to mothers who smoked while pregnant were classified as low birth weight. Smoking has been implicated in numerous studies as a cause of low birth weight in infants and increased risk of preterm delivery (MOD, 2010). Additional conditions such as cleft lip and/or palate and mental retardation have been associated with maternal smoking as well (Drews et al., 1996). Postnatal exposure to environmental tobacco smoke has also been associated with lower respiratory illness, serious infectious diseases, asthma, and sudden infant death syndrome (American Academy of Pediatrics, 1997). The cessation of smoking by women who are planning a pregnancy or who are pregnant results in significantly positive health benefits for both the baby and the mother.

Hereditary Factors

Until relatively recently the study of heredity through the science of genetics was only a matter of theory and speculation. Today, however, with the initiation of the Human Genome Project in 1990, funded by the U.S. Department of Energy and the National Institutes of Health, our knowledge of genetics and heredity has increased dramatically. It is impossible to discuss it in detail within the confines of this chapter, so we will concern ourselves with the potential impact of various hereditary factors on later development.

The union of a sperm with an egg begins the process of development. The sperm carries 23 chromosomes, which contain all of the father's hereditary material. The egg also contains 23 chromosomes, the mother's contribution to the child's heredity. The new embryo, therefore, contains a total of 46 chromosomes (23 pairs). Each chromosome, by the process of cell division (*mitosis*), has a replica in every cell of the body. Genes are found on each chromosome. It has been estimated that each chromosome may contain up to 20,000 genes. The genes determine the vast variety of individual characteristics such as gender, hair and eye color, body size, and physical structure.

Concept 5.7

The genetic inheritance of the fetus will control the upper and the lower limits of its functioning.

Under most conditions the chromosomes and genes remain unaltered throughout the prenatal period. (There is growing speculation that certain chemical substances may contribute to chromosomal damage after conception.) However, a variety of genetic factors prior to conception have been shown to alter the normal process of development.

Chromosome-Based Disorders

It has been estimated that 15 to 50% of pregnancies are terminated by spontaneous abortion, usually during the first trimester. Most of these spontaneous abortions are the result of chromosomal abnormalities (Malina, Bouchard, & Bar-Or, 2004; Santrock, 2011). Most chromosome variations are so potent that they are rarely seen in surviving newborns, but 1% of live infants show evidence of chromosomal damage.

Probably the most common chromosomal alteration is that of **Down syndrome**. The most common type of Down syndrome is the result of an error in which 47 chromosomes are present rather than the standard 46. This cause of Down syndrome is called trisomy 21 because of the presence of three #21 chromosomes. Trisomy 21 accounts for the majority of Down syndrome cases and occurs in approximately 1 in 800 to 1,000 births (MOD, 2010). The rate of incidence seems to be age-related and shows dramatic increases as women give birth at older ages. According to the National Down Syndrome Society (2001), a pregnant mother who is 35 years of age has a 1 in 400 chance of conceiving a child with Down syndrome. This chance increases gradually until age 40 where she has a 1 in 110 chance. At age 45 the incidence becomes approximately 1 in 35.

Children with Down syndrome are often born prematurely. Their rate of growth is slower than normal, often resulting in shorter stature. The nose, chin, and ears tend to be small; the teeth are poorly developed; and the eyesight is weak. Poor balance, hypotonus, short arms and legs, and nonelastic skin are other characteristics of the child with Down syndrome. Cardiovascular defects resulting in frequent respiratory ailments are common, along with limited intellectual functioning. Language and conceptualization skills are generally poor. Motor development appears to proceed in sequence as in the normal infant, but at a substantially slower rate.

The major findings of studies describing the motor development of infants with Down syndrome include: (1) delays in the emergence and inhibition of primitive and postural reflexes, (2) hypotonia and hyperflexia, and (3) substantial delays in the attainment of motor milestones. Elementary school–aged children with Down syndrome display levels of motor development consistently behind their nondisabled peers. Furthermore, they tend to fall farther and farther behind as they grow older (Henderson, 1985; Block, 1991). This, however, is linked more closely to insufficient environmental stimulation than to identifiable biological factors. Early identification and intervention programs appear to be successful in improving the motor functioning of infants and young children with Down syndrome (Ulrich, 1997, 1998; Ulrich et al., 2001). Activities to improve reflexive behavior and to facilitate the acquisition of rudimentary movement skills such as independent sitting, standing, and walking should be provided during the crucial early years. As children with the condition mature, additional opportunities and assistance with fundamental movement skill development should be provided (Ozmun & Gallahue, 2011). Developmentally appropriate activities should serve as the basis for teaching fundamental movement skills. If and when appropriate, basic sport skills may be introduced.

CONCEPT 5.8

Chromosome-based and gene-linked abnormalities will have an impact, ranging from mild to severe to catastrophic, on later development.

Gene-Based Disorders

Genetic defects vary widely in their consequences. The severity of the defect depends on whether the mutant gene is on an autosomal or on a sex-linked chromosome and whether it is on a single gene or also on its mate. Delay and retardation in motor and cognitive functioning are not usually present in autosomal dominant mutations. Autosomal recessive mutations, however, are often associated with mental retardation and problems in motor development. Among the more common autosomal mutations that affect later motor development are talipes, sickle cell disease, Tay-Sachs disease, phenylketonuria (PKU), and spina bifida.

Talipes, often referred to as clubfoot, is one of the most common of all birth defects and historically has been one of the major orthopedic problems of children. About 1 in 700 babies born in the United States each year has a severe form of talipes, and boys are twice as likely to have this condition as girls (MOD, 2010). There are three major forms of talipes: equinovarus, calcaneal valgus, and metatarsus varus (Figure 5.1). With *equinovarus* the foot is twisted inward and downward. The Achilles tendon is generally very tight, making it impossible to bring the foot into normal alignment. *Calcaneal valgus* is the most common form of talipes. The foot is sharply angled at the heel, with the foot pointing up and outward. This condition is less severe than equinovarus and easier to correct. *Metatarsus varus* is the mildest form of talipes. The front part of the foot is turned inward and is often not diagnosed until the baby is a few months old. With all forms of talipes, early, persistent treatment will maximize the chances for normal lives. Left untreated until too late in childhood, talipes will be a major limiting factor in normal upright locomotion.

Sickle cell disease is an inherited blood disease. It is a relatively common gene-based disorder occurring in approximately 1 in every 400 African Americans. It can also occur in people of Hispanic, Arabian, Greek, Italian, and southern Asian ancestry. One in 12 blacks carry the sickle cell gene, and there is a 1-in-4 chance that a child of a gene carrier will develop the disease (MOD, 2008). The effects of the disease vary greatly from person to person–anemia, pain, damage to vital organs, and death in childhood or early adulthood are possible. The growth and motor development of individuals with sickle cell disease are often impaired. Also,

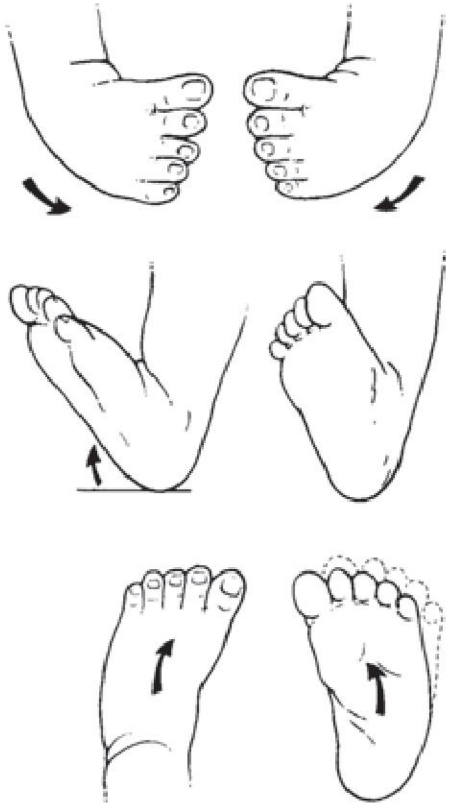

Figure5 .1
Three forms of talipes.

patients tend to tire easily and are frequently short of breath. The sickle cell trait or disease can be easily detected through a blood test called hemoglobin electrophoresis. A prenatal test to determine whether the fetus will carry the trait, be normal, or will develop the disease is also available.

Tay-Sachs disease is a gene-based disorder typical of descendants of Central and Eastern European Jews known as Ashkenazim. Nearly 1 out of every 30 American Jews carries the Tay-Sachs gene. Another group with similar risk is non-Jewish individuals of French-Canadian ancestry, including the Cajun population in Louisiana (MOD, 2009). If both parents carry the Tay-Sachs gene, there is a 1-in-4 chance that any of their children will develop Tay-Sachs disease or become carriers. If only one parent carries the gene, none of their children can have the disease, but the chance of becoming a carrier is 1 in 2. There is no known cure for Tay-Sachs disease, and it is always fatal. It first appears in infancy with the baby losing motor control. Blindness and paralysis follow, with death by age 5. Tay-Sachs disease can be diagnosed through amniocentesis prior to birth. A simple blood test prior to pregnancy will determine if one is a carrier.

Phenylketonuria (PKU) is the only gene-based disorder completely treatable if detected early enough. PKU, a metabolic disorder, is the result of a recessive gene that inhibits production of phenylalanine hydroxylase, necessary to convert the amino acid phenylalanine to tyrosine. Without this enzyme the child is unable to digest many foods, including dairy products. Identification is done through a routine blood test at birth, required in every state in the United States. Treatment consists of following a scientifically controlled diet that eliminates foods containing phenylalanine. The can of diet cola you may consume periodically probably contains phenylalanine with a warning on the label. Left untreated PKU will result in severe mental retardation. However, if PKU is detected (about one week after birth), the devastating results can be entirely avoided with proper dietary precautions. This dietary control should be maintained throughout the individual's life (American Academy of Pediatrics, 1996; MOD, 2008).

Spina bifida is a birth defect of the spinal column, caused by a weakened or absent formation of the vertebral arch. About 1 in every 2,000 babies born each year has spina bifida ("open spine"). Spina bifida follows no particular law of inheritance, although it does appear to run in certain families. Families with one affected child have about a 1-in-40 chance of having a second with spina bifida. Families with two affected children have about a 1-in-20 chance of having a third child with the condition. Spina bifida may take three forms. The first may be so slight that only an X-ray of the spinal column will detect its presence. This form rarely bothers the child. In the second form, a lump or cyst that contains the spinal cord pokes through the open part of the spine. The lump may be surgically removed, permitting the baby to grow normally. In the third and most severe form of spina bifida, the cyst holds deeper nerve roots of the spinal cord. Little or no skin protects the lump and spinal fluid may leak out. The site of this cyst is generally in the lower spine, resulting in paralysis and loss of sensation to the legs, a permanent condition. Spina bifida can be detected during pregnancy through a combination of blood screening, ultrasound, and amniocentesis techniques. As mentioned earlier in this chapter, recent findings have indicated that the consumption of recommended amounts of folic acid by females of childbearing age can greatly reduce the incidence of spina bifida. It is estimated that through the addition of this supplement the risk of spina bifida and other neural tube defects can be reduced by 50% (American Academy of Pediatrics, 1999; MOD, 2009).

Table 5.6 summarizes a variety of gene-based birthd efects.

ENVIRONMENTAL FACTORS

For some time the effects of the general environment on prenatal development have attracted attention. The influence of radiation and chemical pollutants is an area of particular concern to parents of unborn children.

Radiation

The environment's influence on development is evident in the effects of high doses of radiation. Radiation dosage is measured in units called *rads*.

TABLE 5.6 Common Gene-Based Birth Defects

GeneticD efect	Condition
Talipes(Clubfoot)	Equinovarus Calcaneal Valgus Metatarsus Varus
Sickle Cell Disease	Anemia, pain, damage to vital organs, slow growth and motor development, possible death
Tay-Sachs Disease	Loss of motor control, blindness, paralysis, certain death
Phenylketonuria(PKU)	Severe mental retardation
SpinaB ifida	Paralysis in legs, poor bladder and bowel control

An exposure to the developing fetus of more than 25 rads would be considered a high dosage. The fetus is most vulnerable during the first trimester of pregnancy. Excessive radiation has been implicated in *microcephaly* (small head and brain) and mental retardation. Therefore, exposure to X-rays early in pregnancy, especially repeated X-rays of the pelvic region, may put the developing fetus at risk. Radiation prior to pregnancy is also an area of concern. A few studies have suggested a relationship between ovarian radiation and chromosomal defects and between the buildup of rads over the years and genetic damage.

CONCEPT 5.9

A variety of environmental factors have been shown to affect later development of the fetus.

Chemical Pollutants

It is difficult to establish a direct causal link between **chemical pollutants**, the pregnant mother, and later developmental abnormalities in her offspring. A number of other variables may account for, or interact with, chemical pollutants to cause birth defects. Lead and mercury, however, have been conclusively linked to birth defects in humans (March of Dimes, 2004; American Academy of Pediatrics, 1998).

DEVELOPMENTAL DILEMMA

What AboutD ad?

What about the expectant father? Can his exposure to over-the-counter drugs, illicit drugs, and other chemical pollutants including lead, mercury, and chemotherapy cause birth defects before conception or during his partner's pregnancy? The short answer is no. There is, however, an increased likelihood of damage to the sperm resulting in fertility problems and miscarriages. Genetic changes to the sperm may also occur as a result of chemotherapy that result in increased forms of some cancers in children. Some men, including seven-time Tour de France bicycle champion Lance Armstrong, choose to bank their sperm prior to undergoing chemotherapy or radiation treatment as a means of ensuring its integrity (MOD, 2010).

MEDICAL PROBLEMS

The causes and effects of developmental difficulties in the offspring of mothers with various sexually transmitted diseases, infections, hormonal and chemical imbalances, Rh incompatibility, and severe stress are continually being investigated. These conditions play a significant role in placing the unborn child at risk.

CONCEPT 5.10

A number of maternal medical conditions may contribute to developmental difficulties in offspring.

Sexually Transmitted Diseases

Over the last two to three decades there have been a growing awareness and concern over a variety of **sexually transmitted diseases (STDs)**. The ravages of genital herpes, chlamydia, gonorrhea, syphilis, and HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) are a direct threat to the unborn child. A mother's STD can be passed on to her child before birth, during delivery, or through her breast milk. STDs such as syphilis cross the placenta and infect the baby in utero. Gonorrhea, chlamydia, and genital herpes can be transmitted to the newborn baby at the time of delivery as the infant passes through the birth canal. HIV infection can be transmitted in utero, during the delivery, and from breast feeding. The consequences of STDs can be devastating to both mother and child. It is imperative that women planning a pregnancy or who are already pregnant be tested for STDs by a health care professional.

Genital herpes has become a serious health problem with an estimated 45 million sufferers in the United States (MOD, 2008). A pregnant woman with an active case of genital herpes may infect her baby, resulting in permanent brain damage or death. The baby may be protected through a cesarean delivery.

Chlamydia is a bacterial infection. It is a highly contagious sexually transmitted disease that has been significantly underreported. In 1999, only about 600,000 cases were reported, but it is estimated that around 3 million U.S. citizens contract the disease each year (CDC, 2011; MOD, 2010). Although curable with certain antibiotics, it is difficult to diagnose. If left untreated, chlamydia may result in sterility or premature births and stillbirths as well as infant pneumonia, eye infections, and blindness.

Gonorrhea is a common sexually transmitted disease contracted by approximately 700,000 people in the United States each year (CDC, 2010; MOD, 2010). Although curable with antibiotics, some strains of the bacteria have become resistant to treatment. Gonorrhea may result in ectopic pregnancies and eye damage to the newborn.

Maternal syphilis is easily cured with antibiotics if detected in the early stage. The newborn with congenital syphilis is likely to be stillborn or display severe illnesses. The long-term effects of maternal syphilis are still unclear, but preliminary data indicate a greater incidence of prematurity and later motor, sensory, and cognitive disabilities.

HIV/AIDS is the most deadly of the various sexually transmitted diseases. HIV is the virus that causes AIDS. A person with AIDS cannot resist other diseases and is at a greater risk for infections, cancer, and other serious problems that are life-threatening or fatal. HIV is transmitted through sexual contact, contaminated needles, and transfusions. Mothers with HIV/AIDS are at risk of transmitting the virus during pregnancy, childbirth, or breast feeding. Each year approximately 6,000 HIV positive women in the United States give birth (MOD, 2010). This maternal-child transmission is referred to as *perinatal HIV infection.* These statistics pale in comparison to percentages of children in some developing countries who have contracted HIV.

Table 5.7 summarizes the possible effects of sexuallyt ransmittedd iseases.

Maternal Infections

Perhaps the most significant diseases contracted by the mother that adversely affect her fetus are cytomegalovirus (CMV) and rubella contracted during the first trimester of pregnancy. Both of these diseases pass through the placenta to the fetus and can have serious debilitating effects.

CMV is a common infectious cause of birth defects, including blindness, deafness, and mental retardation. Little is known about this virus and its effects. It is still unclear whether the virus is introduced into the fetus by a primary infection to the mother during pregnancy or whether it may already be present genetically but in latent form. About 4% of pregnant women secrete the virus, but 95% of infected infants are asymptomatic. The remaining 5% will suffer a range of developmental difficulties ranging from mild to severe motor retardation in the form of speech and problems in gross and fine motor coordination.

TABLE 5.7 Sexually Transmitted Diseases and Their Possible Effects

SexuallyT ransmitted Disease	Possible Effects on the Newborn Child
AcquiredI mmunodeficiency Syndrome (AIDS)	Fever, weight loss, lethargy, diarrhea, pneumonia, death
Chlamydia	Prematurity, stillbirths, pneumonia, eye infections, blindness
GenitalH erpes	Brain damage, death
Gonorrhea	Ectopic pregnancies, eye damage
Syphilis	Severe illnesses, nervous system damage, death

INTERNATIONAL PERSPECTIVES

HIV/AIDS: A Worldwide Epidemic

According to new data new HIV infections have been reduced by 17% since 2001 when the United Nations Declaration of Commitment on HIV/AIDS was signed. The number of new infections in sub-Saharan Africa is now approximately 15% lower, totaling about 400,000 fewer infections in 2008. In East Asia HIV incidence has declined by nearly 25% and in South and Southeast Asia by 10% in the same time period. In Eastern Europe, after a dramatic increase in new infections among injecting drug users, the epidemic has leveled off considerably. However, in some countries there are signs that HIV incidence is rising again.

The report, released by the Joint United Nations Programme on HIV/AIDS (UNAIDS) and the World Health Organization (WHO), highlights that beyond the peak and natural course of the epidemic, HIV prevention programs are making a difference.

Data from the AIDS epidemic update in 2009 also show that at approximately 33.4 million, there are more people living with HIV than ever before. People are living longer due to the beneficial effects of antiretroviral therapy. The number of AIDS-related deaths has declined by over 10% over the past five years as more people gain access to lifesaving treatment. UNAIDS and WHO estimate that since the availability of effective treatment in 1996, some 2.9 million lives have been saved.

Source: WHO. (2010). *HIV/AIDS Programme highlights 2008–09*. Online at: http://whqlibdoc.who.int/publications/2010/9789241599450_eng.pdf

Rubella, sometimes called the "three-day measles," is caused by a mild, contagious virus. It is not the same as regular measles, called rubeola. Vaccination against rubella has been possible since 1969 and has greatly reduced the incidence of birth defects due to this virus, to the point that no cases were reported in 1994. However, those who received the vaccine during the late 1960s and early 1970s need to be retested for immunity, because not all vaccines were found to be lifelong. Vaccination should occur during childhood and not during pregnancy. A blood test called a "rubella titer" is available to determine whether a person has had rubella or is immune. The child born of a mother who has had rubella during the first trimester of pregnancy is likely to be deaf, blind, or mentally retarded due to interference with sensory and/or cognitive development during the embryonic or early fetal period.

Hormonal and Chemical Imbalances

An inadequate hormonal or chemical environment in the thyroid patient can result in congenital hypothyroidism and cretinism in the infant due to a lack of thyroxine in the mother's blood during the early months of pregnancy. Diabetes in the expectant mother is a chronic chemical imbalance that may adversely affect a child's later development. The inadequate production of insulin prevents the proper metabolizing of sugar and other carbohydrates. Untreated diabetes can result in mental retardation, circulatory and respiratory problems in the infant, or even death. Many women are diabetic only during pregnancy. As a result it is prudent for all expectant mothers to be regularly checked.

Rh Incompatibility

Rh incompatibility results from the incompatibility of blood types between mother and child. Although the bloodstream of the infant and that of the mother have no direct link, some seepage of blood from the fetus to the mother may occur during the later stages of pregnancy. If an expectant Rh negative mother is carrying her first Rh positive child, this seepage will cause the mother to produce antibodies in her blood. The production of antibodies generally has no effect on the first child. The time lag between the first and subsequent children, however, provides ample opportunity for the production of antibodies in the mother. These antibodies may have a devastating effect on future pregnancies by destroying the fetal red corpuscles of Rh positive babies.

Erythroblastosis fetalis is the name given to this condition, characterized by anemia and jaundice. Rh incompatibility occurs only in cases where the father is Rh positive and the mother is Rh negative. Routine blood tests and a *rhogam* injection immediately after birth of the first child will prevent the formation of antibodies. Rhogam is the gamma globulin component of blood obtained from an Rh negative person previously sensitized to the Rh factor. The rhogam neutralizes the Rh factor in the mother and prevents the buildup of antibodies. A rhogam injection must be given with each Rh positivep regnancy.

Teenage Pregnancy

In the United States more than a half million girls give birth each year. Babies born to teen mothers have a much higher risk of serious health problems than do children born to a fully mature mother. Teenage mothers as a group are more likely to have children born small-for-date or young-for-date. Low-birth-weight babies are statistically more likely to suffer from a variety of developmental abnormalities, including mental retardation, immature organ systems, thermoregulatory difficulties, learning difficulties, respiratory problems, and death. Furthermore, the maternal death rate from complications in pregnancy is much higher among girls under age 15 who give birth than among older mothers.

Additional risk factors often found in teenage pregnancies include psychological stress, low socioeconomic status, inadequate parenting behaviors, maternal drug and alcohol abuse, and poor or nonexistent medical care. The complex risks involved in teenage pregnancies need further investigation so that appropriate intervention strategies may be devised.

Toxoplasmosis

In addition to the infections, diseases, and special conditions already discussed as high-risk considerations, expectant parents need to be aware of *toxoplasmosis* so that they can protect their unborn children against the offending protozoan. Toxoplasmosis is amazingly prevalent. It has been estimated that 1 in every 1,000 infants is infected (MOD, 2008). Infected children, although often small-for-date at birth, may appear normal at birth and even into their 20s. But the toxoplasma cysts may rupture at any time, releasing thousands of parasites that attack the eyes, heart, other internal organs, and central nervous system.

The natural reservoir of the *Toxoplasma gondii sporozoan* is the mouse, and most cats come in contact with mice. The spores passed in the feces of infected cats can be inhaled or ingested. The symptoms of infection in humans are similar to the flu, but many times there are no symptoms. Persons who have been infected carry antibodies against toxoplasmosis. However, the fetus does not have the ability to make such antibodies and takes the effects of the infection full force. About 10% of the 3,000 infants infected with toxoplasmosis each year are severely brain damaged and suffer a variety of sensory and motor disabilities.

Toxoplasmosis is a more prevalent health problem than either rubella or PKU, but its devastation to the unborn child has had little publicity. However, the parents of an unborn child can do some specific things to protect their child from this infection. All beef, pork, and lamb should be cooked until well done because the protozoan cysts exist in the muscle of meat. Because the toxoplasma organisms are transmitted through cat feces, it is wise to avoid contact with cats during pregnancy.

Prenatal Diagnosis and Treatment

A variety of prenatal diagnostic procedures have become available and are frequently used to detect the presence of fetal developmental abnormalities. Among the most recognized diagnostic techniques are amniocentesis, chorionic villus sampling, ultrasound, and fetoscopy.

CONCEPT 5.11

Prenatal diagnostic techniques are valuable tools for determining the status of the developing fetus.

Amniocentesis is a technique whereby a hollow needle is inserted into the pregnant woman's abdomen. It is an almost painless procedure that sounds much worse than it feels. A small amount of amniotic fluid is withdrawn through the needle and analyzed. Fetal cells are contained within the amniotic fluid and can be analyzed to detect any form of chromosomal abnormality, nearly 100 metabolic disorders, and some structural defects.

Amniocentesis is generally performed between the sixteenth and eighteenth weeks of pregnancy. It can, however, be performed late in the pregnancy as a means of determining fetal maturity and the severity of Rh disease. Amniocentesis is an invasive procedure known to cause miscarriages in a small but significant number of cases. Therefore, it should only be used for specific medical purposes and not for determining gender or for routine examination of the developing fetus.

Chorionic villus sampling (CVS) is a similar procedure to amniocentesis but instead of amniotic fluid being removed and analyzed, chorionic villi fragments from the developing placenta are extracted. The primary advantage of CVS over amniocentesis is that laboratory results can be obtained much earlier in the pregnancy.

Ultrasound, which uses high-frequency sound waves, is another prenatal diagnostic technique to determine the size and structure of the fetus. It also provides visual information about the fetus's position in the womb. Ultrasound is used in conjunction with amniocentesis as a means of guiding the physician when inserting the needle through the abdomen and into the uterus. It can be performed anywhere from 5 weeks of prenatal life until birth.

Additional methods of screening for prenatal conditions include *magnetic resonance imaging (MRI), fetal echocardiography,* and *maternal serum screening* (Wittmer & Petersen, 2006).

Open fetal surgery represents a unique and amazing form of treating certain types of prenatal conditions. Although first performed in 1981 on an unborn baby to correct a urinary obstruction, it is a procedure that has been conducted numerous times since to correct birth defects in utero. Many have been performed for the condition spina bifida. The procedure involves surgically extracting the mother's uterus, which is opened to work on the unborn child. It can be risky due to blood loss, potential infections, and preterm labor and delivery, but has tremendous potential for the future.

VIGOROUS ACTIVITY DURING PREGNANCY

Fundamental societal changes regarding vigorous exercise and the continual quest for fitness have prompted important questions concerning vigorous physical activity during pregnancy. Among them are: How will maternal exercise affect fetal development? Will maternal exercise help or hinder delivery? Will maternal exercise influence infant development? Conclusive answers to each of these questions are still being determined, but a growing body of research has begun to shed some light on the topic.

A number of studies were conducted in the 1990s and summarized in various reviews (ACOG, 2010; Bell & O'Neill, 1994; Clapp, 2000; Wolfe et al., 1994). It appears that there is strong support for exercise during pregnancy as long as the type, intensity, frequency, and duration of the exercise are monitored. Benefits for the mother include the maintenance or improvement of cardiovascular fitness, limited weight gain, lower fat retention, easier labor, and an improvement in a number of psychological and emotional factors. Benefits to the unborn baby include a decrease in fat and an improved stress tolerance. Long-term benefits for the child include leaner body composition during the early childhood years.

There are certainly some concerns regarding exercise during pregnancy when the mother has one or more conditions that place her pregnancy at high risk. Some of these conditions include persistent vaginal bleeding, incomplete cervix, ruptured membranes, and if the mother has experienced preterm labor in a previous pregnancy.

For pregnant women who are sedentary but have no medical contraindications, it is recommended that they participate in some daily physical activity such as walking, housework, or gardening for 30 minutes or several times a day in 10-minute bouts. Women who are expecting and exercised regularly prior to their pregnancy should be encouraged to maintain their prepregnancy activity level (Clapp, 2000; March of Dimes, 2010).

CONCEPT 5.12

Mothers-to-be may continue to exercise throughout their pregnancies with the guidance of their physicians and careful self-monitoring.

BIRTH PROCESS FACTORS

The average length of intrauterine life is 279 days from the day of conception to the day of birth. Two-thirds of expectant mothers give birth within 279 days, plus or minus a two-week period. The beginning of labor is marked by the passage of blood and amniotic fluid from the ruptured amniotic sac through the vagina and the onset of labor pains. There are three distinguishable stages of labor. In the first stage the neck of the uterus (the cervix) dilates to about 4 centimeters in diameter. Dilation is responsible for labor pains and may last for only one or two hours or up to eighteen to twenty-four hours. Labor is generally longer with the first child (*primiparas*) than for subsequent children (*multiparas*). When the cervix reaches 2 centimeters, full labor begins. It is at this point that the amniotic sac breaks and the fluid flows out of the mother. Complete dilation to about 10 centimeters marks the onset of the second stage of labor: the expulsion stage. During this stage the baby, through the continued increase in uterine pressure, is forced down the birth canal. This phase takes an average of ninety minutes for the first child and about half as long for subsequent children. The third stage of labor begins after the baby has emerged and continues until after the umbilical cord and placenta (afterbirth) have been delivered. During any stage of the birth process a number of obstetrical medications and obstetrical procedures may influence later development of the child.

CONCEPT 5.13

Obstetrical medications and birthing procedures have an impact on the later development of the child.

Obstetrical Medication

A controversial issue among obstetricians and infant researchers involves the effects of **obstetrical medication** commonly used during the birth process. Several years ago Brackbill (1979) argued that drugs given during childbirth will impair the newborn and its subsequent development because of the structural and functional immaturity of the infant's nervous system at birth and because of the rapid absorption rate across the placenta. Table 5.8 lists common types of predelivery, general, and local anesthetics used during delivery. These medications are used to initiate or augment labor (*oxytocics*), relieve pain (*analgesics*), and relieve anxiety (*sedatives*).

Earlier studies have indicated a relationship between drug use during labor and motor and cognitive development (Brackbill, 1970; Conway & Brackbill, 1970; Goldstein et al., 1976; Muller et al., 1971). Currently, an increase in the knowledge of drug dosage and the development and administration of new medication such as *prostaglandins* decreases the possibility of problems during delivery.

Birth Entry

A variety of birth entry factors also have been shown to put the infant at risk. Among them are malpresentation, the use of forceps, and cesarean section. About 4 in every 100 babies are

TABLE 5.8 Function of Common Types of Predelivery and Delivery Drugs

Predelivery Drugs	Delivery Drugs
Oxytocics (premedication agents)	*General Analgesics* (inhalants, intravenous injections)
Induce labor	Relieve fetal distress
Augmentl abor	Speed up delivery
Increaseu terinet onus	Mother emotionally unsuited to remain awake
Sedatives (Demerol, meperidine)	Multiple births
Reducea nxiety	*Local Analgesics* (caudal, lumbar, spinal)
Reducee xcitement	Pain relief
Slowd ownl abor	Relaxation

born buttocks first or feet first (*breech birth*) and 1 out of 100 are in a crosswise position (*transverse presentation*). Breech or transverse fetal presentations are found in one-third to one-half of infants delivered at less than 1,500 grams. These presentations can sometimes be altered by the attending physician or midwife. The danger in malpresentation, as with drug-assisted labor and umbilical cord difficulties, is anoxia. Anoxia is generally considered to be the major cause of perinatal death and has been implicated as the cause of mental retardation, learning disabilities, and cerebral palsy.

Forceps are occasionally used to withdraw the baby from the birth canal. Today, the use of forceps is limited largely to emergency situations, but they were used routinely in obstetrics until the 1940s. Forceps are now used to speed delivery when the mother is displaying uncontrollable pushing, when the infant has a weak heartbeat, when the umbilical cord emerges before the head and endangers the baby's oxygen supply, or when there is a premature separation of the placenta. Forceps play a vital role in obstetrics as a lifesaving device, but their overuse and misuse have had debilitating and lethal effects on both mothers and children.

In the United States, over 38% of all births are via cesarean section (Martin et al., 2010). A cesarean delivery is a major operation and in the past was considered only in cases of malpresentation, fetal distress, and failed use of forceps.

CONCEPT 5.14

Both mother- and father-to-be have an obligation to their unborn child to ensure its optimal development by monitoring those factors over which they can exercise control.

The birth process is an important beginning in the three-way bonding among mother, infant, and father. Because of this, parents frequently choose the method in which they wish to introduce their offspring into the world. The Lamaze and the Leboyer methods of childbirth are two procedures from which prospective parents can choose. The Lamaze method centers on the mother and father. It uses conscious relaxation techniques that incorporate rhythmical breathing to block the sensations of pain. It relies on the mother's complete knowledge of what to expect during labor and delivery (Lamaze, 1976). The Leboyer method focuses almost entirely on the infant. The aim is to simulate the conditions of the womb as closely as possible. Delivery occurs in a dimly lit room without loud noises. The baby is immediately immersed in a warm fluid solution and gradually, but gently, introduced into the world. Many hospitals have made dramatic changes in their delivery procedures. Birthing rooms, birthing chairs, and rooming-in are widely popular procedures that reflect greater concern for the health and comfort of both mother andc hild.

Summary

This chapter discussed a wide variety of prenatal factors that impact on later development in general and motor development in particular. There is growing realization among many prospective parents that they can do something to reduce the chances of putting their offspring at risk. Many now understand that poor choices in what expectant mothers ingest in the way of nutrients, alcohol, tobacco, drugs, and medications can be devastating to unborn children. Many are now sensitive to the possible harmful effects of caffeine, certain food additives, overexposure to radiation, noxious chemicals, and obstetrical medications. As a result there has been a resurgence of interest in "natural" childbirth techniques, rooming-in, and home births and a return by many to a more responsible attitude about giving birth. More mothers are asserting their rights for drug-free pregnancies and are working knowledgeably with concerned obstetricians to produce the healthiest offspring possible.

The prenatal period is too important to be left to chance. An "intelligent" pregnancy and delivery, although not a guarantee, can do much to reduce the risk of problems for both mother and child.

Questions for Reflection

1. The vast majority of pregnancies are uneventful and result in a healthy newborn. What could you and your partner do to help ensure a healthy pregnancy and positive outcome?
2. Alcohol and tobacco use during pregnancy can have severe negative effects on the unborn child. What are they, and why, in your view, do some expectant parents continue to smoke and/or drink duringp regnancy?
3. Despite having one of the most comprehensive and advanced medical care systems in the world, the United States still ranks number 9 among industrialized countries in infant mortality. What are the primary contributors to this unfortunate statistic and how might they be remedied?
4. Heredity plays an important role in both chromosome- and gene-based disorders. What familial factors need to be considered prior to becoming pregnant?
5. What about exercise during pregnancy? What activities are recommended and which ones should be avoided?

Critical Readings

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Web Resources

www.aap.org

American Academy of Pediatrics homepage. The academy is "committed to the attainment of optimal physical, mental, and social health and well-being of all infants, children, adolescents, and young adults." Site contains a parenting center, section on health topics, bookstore, professional resources, and publications.

http://acog.org/

Homepage of the American College of Obstetricians and Gynecologists. ACOG serves as a strong advocate for quality health care for women, maintaining the highest standards of clinical practice and continuing education for its members. It promotes patient education and stimulates patient understanding of and involvement in medical care, increasing awareness among its members and the public of the changing issues facing women's health care. The site provides a bookstore, news releases, and information on women's and technical information.

www.cdc.gov/

Centers for Disease Control and Prevention homepage. The CDC is the leading federal agency for protecting the health and safety of people. The site provides information on a wide variety of topics such as health and safety topics, publications and products, and data and statistics.

www.doegenomes.org/

U.S. Department of Energy Office of Science webpage dedicated to genome programs. Site directory includes links to Human Genome Project Information; Genomics: GTL; Microbial Genome Program; General Resources; Education; Media; Ethical, Legal, and Social Issues; and Medicine.

www.modimes.org/

March of Dimes homepage. "The mission of the March of Dimes is to improve the health of babies by preventing birth defects and infant mortality." Site information includes history of the March of Dimes, current efforts in regard to its national campaign, global health, and government advocacy, as well as current news and archives.

www.pbs.org/wgbh/nova/miracle/program.html

Life's Greatest Miracle: Watch this riveting hour-long documentary divided into eight segments covering the time period from conception to birth. Watch each separately or in their entirety.

www.teratology.org/

Homepage of the Teratology Society, a society heavily involved in birth defects research. The site provides news and events about the society, as well as information on publications and becoming a member. "Just for Students" section contains extensiveda tabases and links.

CHAPTER

6

PRENATAL AND INFANT GROWTH

KEY TERMS

Zygote
Mitosis
Embryo
Ectoderm
Mesoderm
Endoderm
Congenitalm alformations
Fetus

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Discuss embryonic and fetal growth and biologicalm aturation
- Describe and interpret the normal displacement and velocity graphs of infant growth
- Discuss proportional changes in segmental length from birth through childhood
- Speculate on prenatal periods critical to normalg rowth
- Describe the process of prenatal growth from conceptiont ob irth

KEY CONCEPT

The rate of growth from conception through infancy is unsurpassed throughout the rest of life.

This chapter focuses on the process of typical growth from conception through the period of infancy. It is important for the student of motor development to have a reference point from which to view the normal growth process. The approach taken here provides that reference point from the standpoint of the mythical "average" child. In other words, heights, weights, and other growth statistics are presented in averages. There may be considerable normal variation from these figures as a result of the interaction between biological and environmental processes.

PRENATAL GROWTH

Growth begins at the moment of conception and follows an orderly sequence throughout the prenatal period. Prechtl's (1986) studies of the motor development of the fetus demonstrated that prenatal movement and growth patterns are as predictable during the fetal period as they are throughout infancy. The uniting of a mature sperm and ovum marks the beginning of this process. The ovum is one of the largest cells in the female body. It is about 0.004 of an inch (.01 mm) in diameter and is barely visible to the naked eye. The sperm, on the other hand, is microscopic and one of the smallest cells in the male body. Fertilization occurs if one of the approximately 20 million sperm released from the male during intercourse meets and penetrates the ovum in the fallopian tube. Fertilization may also occur through an in vitro process. Once the sperm cell penetrates the outer membrane of the egg, fertilization occurs. Each parent contributes twenty-three chromosomes (barlike structures in cells that carry all of a person's genetic information). The two cell nuclei lie side by side for a few hours before they merge to form a **zygote** (the fertilized egg with forty-six chromosomes). It is at this instant that one's genetic potential is determined. Realization of this potential will depend on many environmental as well as hereditary factors. The genetic inheritances of both mother and father are transferred to this single cell. The pattern for a variety of traits is now established, including eye and hair color, general body shape, and complexion.

During the germinal period, the zygote splits into two cells through a process called **mitosis.** The two cells form four cells, and the four cells form eight. Three days after conception the zygote has grown into thirty-two cells, and after four days it consists of about ninety cells. Because all cells have the same genetic arrangement except for sex cells, the division of cells is not simultaneous, and stages in early embryonic life have been observed in which there is an odd number of cells. After the first three or four days of mitotic cell division, the zygote travels down the fallopian tube to the uterus, where it attaches to the uterine wall. This implantation process marks the true onset of pregnancy, although the days of pregnancy are counted from the first day of the last menstrual bleeding. The ovum is normally fertilized within a day of ovulation, near the fourteenth day of the menstrual cycle. Therefore, during the first two weeks of what is considered pregnancy, the woman is not pregnant. Implantation generally occurs by the end of the first week after fertilization.

CONCEPT 6.1

The union of ovum and sperm marks the point of conception and the determination of one's genetic inheritance.

Zygotic Period (Conception–1st Week)

During the first week (period of the zygote), the fertilized egg remains practically unchanged in size. It lives off its yoke and receives little outside nourishment. By the end of the first week, the zygote is only a small round disk about 0.01 of an inch (2.5 mm) wide. The situation for the zygote is especially precarious during this time. Although the mother-to-be may not be aware that she is pregnant, her system will automatically attempt to slough off this foreign body, as it would any foreign matter. The expectant mother may continue to ingest a variety of chemical substances, drugs, alcohol, and tobacco that could prove damaging, if not lethal, to the zygote. It is estimated that, for a variety of reasons, approximately 50% of fertilized eggs spontaneously abort during the first trimester (Malina, Bouchard, & Bar-Or, 2004). Although this statistic may appear alarmingly high, this process of spontaneous abortion helps to ensure that only the fittest of zygotes survive.

CONCEPT 6.2

Pregnancy does not begin until the zygote is implanted on the uterine wall.

Embryonic Period (2nd Week–2nd Month)

The differentiation of embryonic cells into layers marks the end of the period of the zygote and the beginning of the period of the **embryo.** By the end of the first month there is a definite formation of three layers of cells. The **ectoderm,** from which the sense organs and nervous system develop, begins to form. The **mesoderm** accounts for the formation of the muscular, skeletal, and circulatory systems. The **endoderm** eventually accounts for the formation of the digestive and glandular systems (Table 6.1). Every part of the body develops from these three kinds of cells and is formed in rudimentary structure by the end of the embryonic period. Special cells form the *placenta,* through which nutritive substances will be carried and wastes removed. Another special layer of cells begins formation of the *amnion,* which will enclose the embryo except at the umbilical cord throughoutt hep renatalp eriod.

The embryonic period is an especially important time in the formation of all of the body systems and, as such, is a highly sensitive period for susceptibility to **congenital malformations.** Congenital malformation refers to a condition with which the infant is born but does not refer to the specific defect. The risk of congenital malformations is greatest during the embryonic period. This period of rapid cell division is vulnerable to changes in the sequence, rate, and timing of events. A wide variety of environmental factors (see chapter 5 for a complete discussion) as well as the embryo's specific genetic composition determine its susceptibility to congenital malformations.

TABLE 6.1 Systems That Develop from Three Layers of Cells

Layer	Systems
Endoderm (inner layer)	Digestive system Respiratory system Glandular system
Mesoderm (middle layer)	Muscular system Skeletal system Circulatory system Reproductive system
Ectoderm (outer covering)	Central nervous system Sensory end-organs Peripheral nervous system Skin, hair, nails

CONCEPT 6.3

The cell layers that will eventually form the various systems of the body are differentiated during the embryonic period.

By the end of the first month the embryo is about ¼ of an inch (6 mm) long and weighs about 1 ounce (28 g). It is crescent shaped, with small bumps on its sides (limb buds). It has a tail and tiny ridges along the neck. These gill-like ridges mark the beginning of a primitive mouth opening, heart, face, and throat. By the end of the first month the embryo has a rudimentary circulatory system, and the heart begins to beat. Growth accelerates toward the end of the first month. The organism grows about ¼ of an inch (6 mm) each

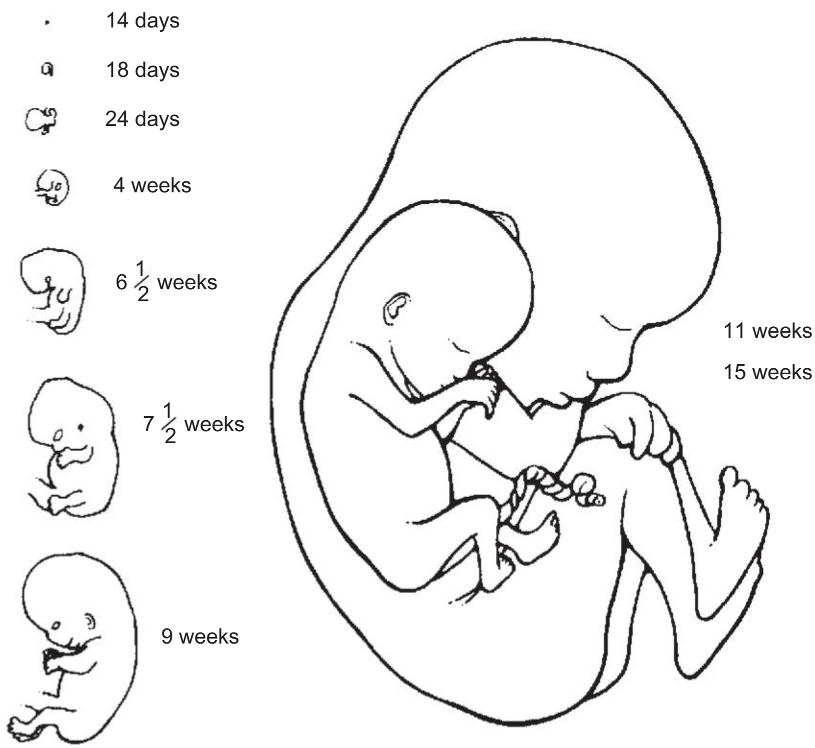

Figure6 .1
Embryos drawn to actual size.

week. By the end of the second month the embryo is about 1½ inches (4 cm) long. The beginnings of the face, neck, fingers, and toes develop, and the embryo starts to take on a more human appearance. The limb buds lengthen, the muscles enlarge, and the sex organs begin to form. Brain development is rapid, and the head is large in comparison to the rest of the body. The embryo is now firmly implanted in the uterine wall and receiving nourishment through the placenta and the umbilical cord. This marks the end of the embryonic period and the beginning of the fetal period of prenatal life (Figure 6.1).

Early Fetal Period (3rd–6th Month)

The period of the **fetus** begins around the third month and continues until delivery. Although no new anatomical features appear during this period, this critical time for the fetus is easily influenced by a variety of factors over which it has no control. During the third month the fetus continues to grow rapidly. It is about 3 inches (8 cm) long by the end of the third month. Sexual differentiation continues, buds for the teeth emerge, the stomach and kidneys begin to function, and the vocal cords appear. By the beginning of the third month the first reflex actions are felt. The fetus opens and closes its mouth, swallows, clenches its fist, and can even reflexively suck its thumb. The growth rate during the fourth month is the most rapid for the fetus. It doubles in length to about 6 to 8 inches (15–20 cm) and weighs about 6 ounces (171 g). The hands are fully shaped, and the transparent cartilaginous skeleton begins to turn into bony tissue, starting in the middle of each skeletal bone and progressing toward the ends. The lower limbs, which lagged behind in their initial development, now catch up with the rest of the body. By the beginning of the fifth month the fetus has reached half of its birth length but only 10% of its birth weight. The fetus is now sloughing off skin and respiratory cells and replacing them with new ones. Sloughed off cells remain in the amniotic fluid, providing a basis for amniocentesis (refer to chapter 5 for a brief discussion of this technique).

CONCEPT 6.4

Movement first becomes apparent to the mother-to-be during the early fetal period.

At the beginning of the fifth month the fetus is about 8 to 10 inches (20–26 cm) long and weighs about ½ pound (227 g). Skin, hair, and nails appear. The internal organs continue to grow and assume their proper anatomical positions. The entire body of the fetus is temporarily covered with a very fine soft hair called *lanugo*. The lanugo on the head and eyebrows becomes more marked by the end of the fifth month and is replaced by pigmented hair. The lanugo is generally shed before birth, although some may still remain. The larger size and cramped quarters of the rapidly developing fetus generally result in considerable reflexive movement during the fifth month.

By the sixth month the fetus is about 13 inches (33 cm) long and weighs about a pound (.45 kg). During this month the eyelids, which have been fused shut since the third month, reopen and are completed. The *vernix caseosa* forms from skin cells. It is a fatty secretion that protects the thin and delicate skin of the fetus. There is little in the way of subcutaneous fat at this point, and the fetus appears red and wrinkled and resembles an old and frail individual. An infant born prematurely during the sixth month has a very poor chance of survival even with the most sophisticated technology available. Although it can cry weakly and move about, it cannot perform the more basic functions of spontaneous breathing and temperature regulation. By the end of the sixth month, the fetus weighs approximately 2 pounds (.9 kg) and is about 14 inches (36 cm) long. It is structurally complete but needs additional time for the various systems of the body to become functionally mature.

Later Fetal Period (7th–9th Month)

From the seventh month to term the fetus triples its weight. A layer of adipose tissue begins to form under the skin and serves as both an insulator and food supplier. The lanugo hair is shed, along with much of the vernix fluid, and the nails often grow beyond the ends of the fingers and toes, necessitating an immediate manicure after birth to prevent scratching. During the seventh month the fetus is often quiet for long periods as if resting up for the "big event." The fetal brain becomes more active and assumes increasing control over the body systems. The majority of fetuses born at the end of the seventh month survive, although many require special handling during the early weeks after birth.

CONCEPT 6.5

The last two months of fetal life are a time for filling out in preparation for birth.

During the eighth and ninth months the fetus becomes more active. The cramped quarters result in frequent changes in position, kicking, and thrusting of the legs and arms. The skin's red coloration disappears as fatty deposits become more evenly distributed in these last two months. The birth process is initiated by the placenta and contraction of the uterine musculature and not the fetus. Birth generally occurs after about 40 weeks of gestation. Normal variation in gestational age ranges from 38 to 42 weeks. At birth the normal-term infant is about 19 to 21 inches (48–53 cm) long and weighs between 6 and 8 pounds (3–4 kg). Table 6.2 includes a summary of development during the fetal period.

TABLE 6.2 Highlights of Prenatal Growth and Development

Age	Length	Weight	Major Events
Conception	1 cell	Less than 0.03 oz/1 g	Genetic inheritance determined
1 week	0.01 in./.25 mm	Less than 0.03 oz/1 g	Germinal period, period of rapid cell differentiation
2 weeks	0.05 in./1.3 mm	0.05 oz/1.5 g	Implantation in the uterus
1 month	0.25 in./6.4 mm	1 oz/29 g	Endoderm, mesoderm, and ectoderm formed; growth organized and differentiated
2 months	1.5 in./4 cm	2 oz/57 g	Rapid growth period, begins to take on human form; weak reflex activity
3 months	3 in./7.6 cm	3 oz/86 g	Sexual differentiation; stomach and kidney function; eyelids fuse shut
4 months	6–8 in./15–20 cm	6 oz/171 g	Rapid growth period, first reflexive movements felt; bone formation begins
5 months	8–10 in./20–25 cm	8 oz/228 g	Half birth height; internal organ completion; hair over entire body
6 months	13–15 in./33–38 cm	1–2 lb/0.45–0.9 kg	Eyes reopen; vernix caseosa forms; structurally complete but functionally immature
7 months	14–16 in./36–41 cm	2–4 lb/0.9–1.8 kg	Rapid weight gain, adipose tissue deposited
8 months	16–18 in./41–46 cm	4–6 lb/1.8–2.7 kg	Active period, fatty deposits distributed
9 months	19–21 in./48–53 cm	6–8 lb/2.7–3.6 kg	Uterine contractions, labor, and delivery

DEVELOPMENTAL DILEMMA

Extremely Low Birth Weight: Daunting Decisions

In industrialized countries throughout the world the survival rate of premature infants has steadily increased over the past several years. The survival rate of extremely premature infants (i.e., those with a gestation period of 23 weeks or less) and those born at an extremely low birth weight (ELBW) of 2 pounds, 3 ounces (1,000 g) or less are at a rate unimaginable little over a generation ago. In fact, the survival rate of ELBW infants under 1 pound (about 500 g) has significantly increased also.

Improvements have been due primarily to the continued advances in neonatal intensive care unit technologies and drug therapies. Females tend to have a more positive outcome than males, and single birth babies tend to fare better than multiple birth babies. And, of course, as birth weight increases the chances of a favorable outcome increase also.

Often, though, the dilemma that parents and physicians face is one of enormous consequences. In extreme cases of prematurity accompanied by VLBW, failure to provide all that is medically possible will result, almost certainly, in death. On the other hand, doing all that is medically possible may still result in death or severe, lifelong developmental disabilities.

The moral, ethical, financial, and legal issues are huge, often generating more questions than answers. Daily, physicians and parents of newborns from all walks of life face heart-wrenching decisions that when viewed through the many and varied prisms of consideration are daunting indeed. Where do you stand? Why?

INFANT GROWTH

The growth process during the first two years after birth is truly amazing. The infant progresses from a tiny, helpless, horizontal, relatively sedentary creature to a considerably larger, autonomous, vertical, active child. The physical growth of the infant has a definite influence on its motor development. The size of the head, for example, will influence the child's developing balance abilities. Hand size will influence the mode of contact with different-size objects, and strength development will influence the onset of locomotion.

CONCEPT 6.6

Increases in body proportions are uneven and influenced by the principles of proximodistal and cephalocaudal development.

Neonatal Period (Birth–4 Weeks)

The neonatal period is generally considered to comprise the first two to four weeks of postnatal life. The typical full-term newborn is 19 to 21 inches (48–53 cm) long, but the head accounts for fully one-fourth of that length. The proportionately large head size makes it difficult for the baby to gain and maintain equilibrium. The remaining body length is taken up with a 4-to-3 ratio of trunk to lower-limb length. The eyes are about half their adult size, and the body is about one twentieth its eventual adult dimension (Figure 6.2).

There is considerable normal variation in the weight of newborns, which may be attributed to a variety of environmental and hereditary factors. Birth weight is closely related to the socioeconomic and nutritional status of the mother. The birth weight of male infants is about 4% higher than that of females. Optimal growth requires proper nutrition, a positive state of health, and a nurturing environment. However, low-birth-weight babies and young-for-date babies tend to catch up to their age-mates if their deficiencies are not too severe and corrective intervention strategies have been implemented. J. M. Tanner (1978), a physician, devoted much time to the study of the growth characteristics of the infant. He noted that an individual's ultimate growth potential seemed to be determined early in life and could be amended under limited conditions if prematurity, illness, or malnutrition deflected the child from his or her normal growth curve. If an infant is moderately malnourished or ill, the growth rate will slow and then accelerate (or

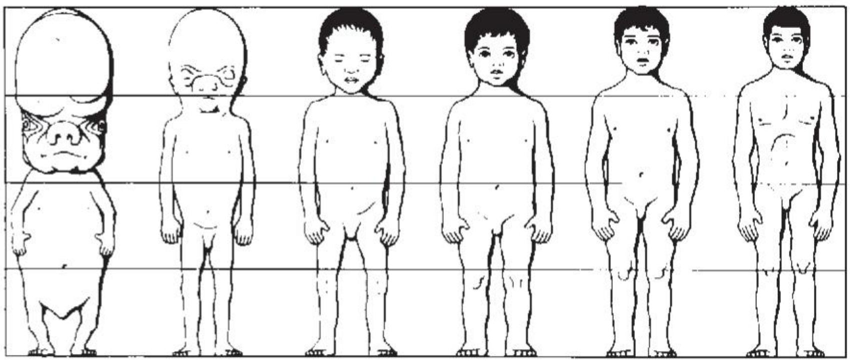

Figure6 .2
Changes in body form and proportion before and after birth.

catch up) to the typical trajectory with an adequate diet or the termination of the illness. The rate will then slow down again. Under most conditions we see infants and children fitting into broadly determined ranges for height and weight, with little in the way of extremes at either end of the developmental continuum. Although the trajectory approximates the normal curve, low-birth-weight children usually remain somewhat smaller than full-term children throughout life.

Figures 6.3 and 6.4 provide graphic representations of changes in body length and weight of both boys and girls from birth to age 2. *Body length* is the term used when it is measured from a recumbent position, the commonly accepted means of measurement from birth to age 2 or 3. After that an erect standing measure is taken and referred to as *height*. They are the result of data collection that involved infants and children of various ethnic and racial backgrounds and reflect a combination of breast-fed

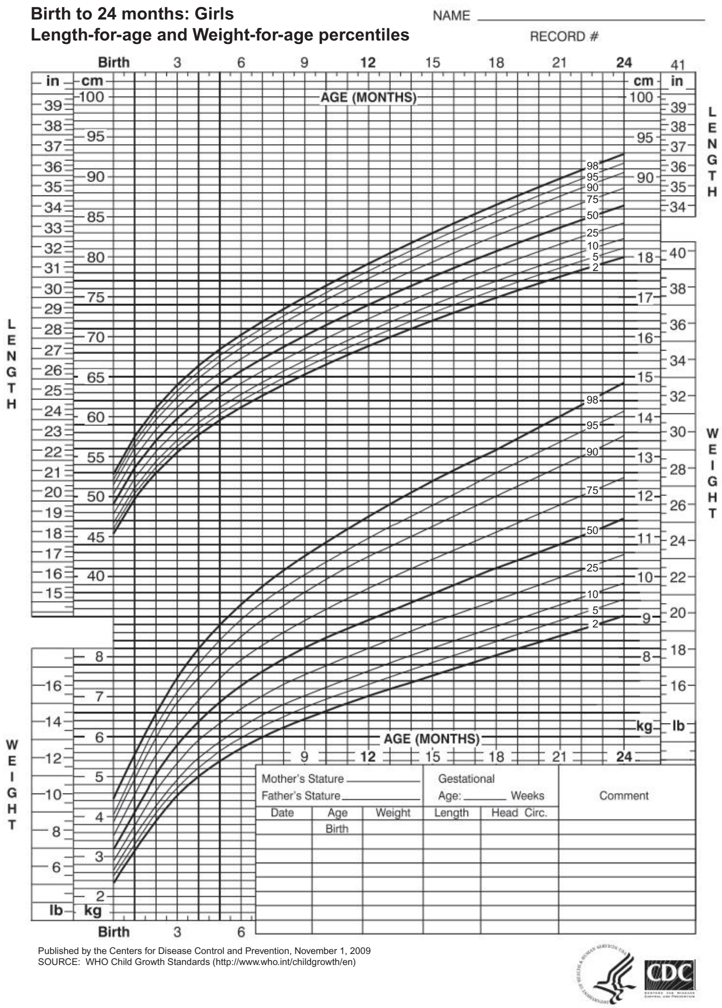

Figure6 .3

Girls: Length-for-age and weight-for-age percentiles, birth to 24 months.

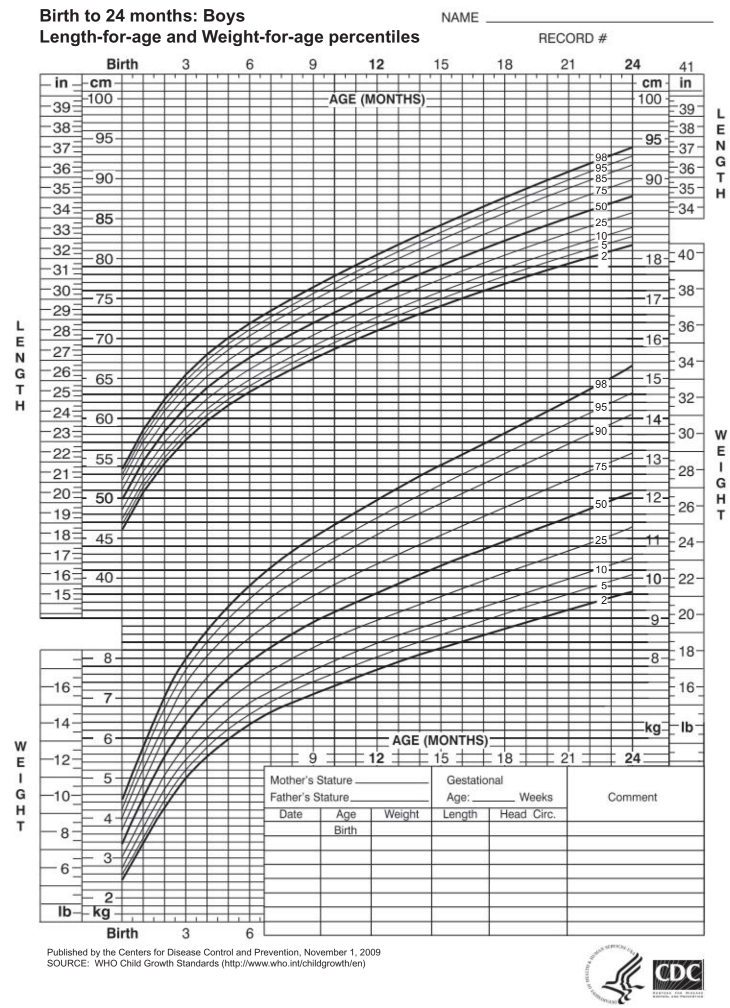

Figure6 .4

Boys: Length-for-age and weight-for-age percentiles, birth to 24 months.

and bottle-fed subjects. Previous growth curves represented a more narrow sample of the U.S. population. Thus, greater generalizability can be achieved through these most recent growth curves.

Early Infancy (4 Weeks–1 Year)

During the child's first year there are rapid gains in both weight and length. In the first six months, growth is mainly a process of "filling out," with only slight changes in body proportions. In fact, the "newborns" often pictured in advertisements are actually 2 or 3 months old, displaying a chubby look rather than the wrinkled look of the actual newborn.

Birth weight is doubled by the fifth month, almost tripled by the end of the first year, and quadrupled by 30 months of age. Length increases to around 30 inches (76 cm) by the first birthday. After 6 months of age, the thoracic region is larger than the head in typical children and increases with age. Infants suffering from malnutrition will have a weight deficit but generally have head sizes larger than the thoracic regions.

CONCEPT 6.7

Early infancy is characterized by rapid growth in length and substantial increases in subcutaneous tissue.

Later Infancy (1 Year–2 Years)

Physical growth during the second year continues at a rapid pace but at a slower rate than the first year. By age 2 the height of the average boy is about 35 inches (89 cm). Girls are about 34 inches (86 cm) tall and weigh about 26 pounds (12 kg), whereas boys average 28 pounds (12.7 kg). Height and weight have about a .60 correlation, showing a moderate degree of relationship between these two indices of physique. Because growth follows a directional trend (i.e., proximodistal and cephalocaudal), increase in size of the body parts is uneven. Upper arm growth precedes lower arm growth and hand growth. Therefore, from infancy to puberty the greatest amount of growth takes place in the distal portions of the limbs. Head growth slows from infancy onward, trunk growth proceeds at a moderate rate, limb growth is faster, and growth of the hands and feet is most rapid.

INTERNATIONAL PERSPECTIVES

WHO Infant Growth Charts

In 2000 the Centers for Disease Control and Prevention (CDC) published its most recent growth charts for children ages 0–19. Data for these charts were exhaustively gathered and represent a broad cross section of typical infants, children, and youth throughout the United States. These charts, much like their predecessors, soon became a primary means by which physicians, parents, and educators gauged children's growth in height and weight. In fact, the previous two editions of this textbook faithfully reproduced the 2000 CDC charts for its readers to study and use.

In 2006, the World Health Organization (WHO) published its own growth charts for infants and young children from 0 through 59 months of age. The WHO researchers gathered data from six countries (including the United States) regarded as having generally optimal environments for growth. The charts provide standards for how children grow under these conditions, not how they may grow in conditions that fail to support optimal growth.

After careful study the CDC concluded that for infants 0 to 24 months of age it is preferable to use the WHO growth charts for the following reasons:

1. WHO growth charts establish breast-fed babies as the norm for growth, which is the recommended standard for infant feeding.
2. WHO growth charts provide optimal standards of growth that are better descriptors of physiological growth during infancy than the CDC charts that look only at typical growth.
3. The WHO standards are based on complete, high-quality longitudinal data gathered specifically for generating growth charts, whereas the CDC charts have numerous gaps in the data points for the first six months.

The CDC, however, continues to recommend that its 2000 growth charts for childhood and adolescence (see chapter 10) be used because they can be used from ages 2 to 19, and the WHO charts can only be used through age 5. Additionally, comparison for ages 2–5 are quite similar for both the WHO and CDC growth charts.

Source:www .cdc.gov/growthcharts/who_charts.htm

SUMMARY

The prenatal period of human development begins at conception and ends at birth. It is a time of tremendous changes in structure and function. It begins with the zygotic period, is followed by the embryonic period, and concludes with the fetal period. The neonatal period begins at birth followed by the period of development referred to as infancy.

The normal process of prenatal and infant growth is crucial to the motor development of the child. The length, weight, physique, and maturational level of the child play an important role in his or her acquisition and performance of rudimentary movement patterns. The prenatal period and infancy set the stage for what is to come in the development of the young child's repertoire of fundamental movement and physical abilities.

QUESTIONS FOR REFLECTION

1. Why is the first trimester of pregnancy so critical for ensuring a healthy newborn?
2. What are the major growth highlights of the embryonic, early fetal, and later fetal periods?
3. The body proportions of the newborn are considerably different from those of early childhood and beyond. What implications might this have for early stability and locomotor movement abilities?
4. Growth charts are provided to us by the CDC and WHO. During infancy there are differences that recently led the CDC to recommend use of the WHO growth charts for ages 0–24 months rather than their own. Why and for what purposes?
5. What are the implied differences between growth charts based on "standards" and those based on the "typically" developing individual?

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WEB RESOURCES

www.aap.org

American Academy of Pediatrics homepage. The academy is "committed to the attainment of optimal physical, mental, and social health and well-being of all infants, children, adolescents, and young adults." Site contains a parenting center, section on health topics, bookstore, professional resources, and publications.

www.cdc.gov/

Centers for Disease Control and Prevention homepage. The CDC is the leading federal agency for protecting the health and safety of people. The site provides information on a wide variety of topics such as health and safety topics, publications and products, and data and statistics.

www.who.int/nutgrowthdb/

The World Health Organization's Global Database on Child Growth and Malnutrition, generated by the WHO Department of Nutrition for Health and Development. Site includes summary papers dealing with global trends in child malnutrition as wella so besity.

CHAPTER 7

INFANT REFLEXES AND RHYTHMICAL STEREOTYPIES

KEY TERMS

Primitivesur vivalr eßexes
Primitivep osturalr eßexes
Encodings tage
Decodings tage
Neuromaturationalt heory
Dynamic systems theory
Rhythmicals tereotypies

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Describe primitive and postural reßexes that appear before birth or during the Þrst year, and explain the neural development that occurs with these changes
- Relate inhibition of speciÞc reßexes and appearance of speciÞc reactions to development of particular voluntary motor skills
- Distinguish between Òprimitive reßexesÓand Òpostural reßexesÓ
- Speculate on the relationship of reßexes and rhythmical stereotypies to later voluntary movement behavior
- Identify and discuss several rhythmical stereotypies present in the human infant
- Speculate on the purpose and role of rhythmical stereotypies
- Devise an infant reßex/stereotypy observationala ssessmenti nstrument

Key Concept

The study of infant reflexes and stereotypical patterns of behavior yields useful information for understanding the process of motor development.

Reßex movements are evident in all fetuses, neonates, and infants to greater or lesser degrees, depending on their ages and neurological makeups. Reßex movements are involuntary reactions of the body to various forms of external stimulation. Most reßexes are subcortical in that they are controlled by the lower brain centers, which are also responsible for numerous involuntary life-sustaining processes such as breathing. Although not the topic of this chapter, equilibrium reßexes are mediated by the cerebral cortex. Voluntary motor control in the normal child is a function of the maturing cerebral cortex. Consciously controlled movements result from nerve impulses transmitted from the cerebral cortex along motor neurons.

Many early reßexes are related to infant survival (**primitive survival reflexes**), whereas others are precursors of voluntary movements that will appear between the ninth and Þfteenth months after birth (**primitive postural reflexes**). Reßexive walking, swimming, crawling, and climbing movements were reported by Shirley (1931), McGraw (1939), and Ames (1937). These reßexes are inhibited prior to the appearance of their voluntary counterparts, but their mere presence is an indication of how deeply locomotor activities are rooted within the nervous system.

Concept 7.1

Reflexes are the first forms of human movement and provide interesting insights into the process of motor development.

From about the fourth month of fetal life until the fourth month of infancy, most of a babyÕs movements are reßexive. Involuntary reactions result from changes in pressure, sight, sound, and tactile stimulation. These stimuli and the responses form the basis for the *information-gathering stage*, or **encoding stage,** of the reßexive movement phase. Reßexes, at this point in the childÕs life, serve as a primary information-gathering device for information storage in the developing cortex. As higher brain centers gain greater control of the sensorimotor apparatus, the infant is able to process information more efÞciently. This *information-processing stage*, or **decoding stage,** parallels PiagetÕs Þrst three stages within his sensorimotor phase of development, namely, the use of reßexes, primary circular reactions, and secondary circular reactions.

Concept 7.2

Infant reflexive behaviors serve as a primary information-gathering source during the neonatal period.

Reflexive Behavior and Voluntary Movement

Two main functions of the primitive survival reßexes are to seek nourishment and to seek protection. Several primitive reßexes during early infancy resemble later voluntary movements. These postural reßexes, as they are sometimes called, have been subjected to considerable debate over time. Over the last few decades it has been hypothesized and demonstrated that these reßex movements form the basis for later voluntary movement (Bower, 1976; McGraw, 1954; Thelen, 1980; Zelazo, 1976). As the cortex gradually matures, it assumes control over the postural reßexes of stepping, crawling, and swimming. Over three decades ago, Zelazo questioned the dualistic position of the anatomists in favor of a hierarchical view, stating,

> Indeed, current behavioral and neurological research with infants challenges the validity and generality of the hypothesized independence between early reßexive and later

> instrumental behavior. An alternative hypothesis holds that the newbornÕs reßexes do not disappear but retain their identity within a hierarchy of controlled behavior (p. 88).

Anatomists and neurologists, on the other hand, argued that a recognizable gap of up to several months occurs between the inhibition of a postural reßex and the onset of voluntary movement (Kessen et al., 1970; Pontius, 1973; Prechtl and Beintema, 1964; Wyke, 1975). This time lag, they contended, clearly indicated that there was no direct link between postural reßexes and later voluntary movement. Therefore, ZelazoÕs view was heavily criticized. Furthermore, anatomists and neurologists argued that the performance of reßexive movements and voluntary movements was controlled by entirely different brain centers. Bower (1976), however, contended that Òsuch results pointed to the possibility that the reason abilities disappear is that they are not exercisedÓ (p. 40).

Concept 7.3

There appears to be a link between early reflexive behaviors and later voluntary movement.

From the anatomistsÕ theoretical point of view it was perceived that there was little basis for assuming that the infantÕs Þrst reßexive movements prepared him or her for later voluntary movement in a direct way. By the mid-1970s it proposed that the results of early reßexive activity of the infant were internalized and that this information was stored for future use (Zelazo, 1976). Thelen (1985) further argued that studies demonstrate continuity between reßexive and voluntary walking. She contended, as did Bower (1976), that the period of inhibition disappears if the reßex is exercised. Thelen argued that the reßex disappears because leg mass increases. Preservation of the reßex strengthens the leg and lower body, thus permitting the infant to continue the movement with little or no lag between the locomotor reßex and its voluntary counterpart. Explanations such as this account for at least an indirect link between the infantÕs postural reßexes and later voluntary movement.

Anyone interested in the study of movement must have a clearer understanding of the Þrst forms of movement behavior. Two theories that attempt to bring clariÞcation to this area are the neuromaturational theory and the dynamic systems theory.

The **neuromaturational theory** of motor development (Eckert, 1987) holds that as the cortex develops it inhibits some of the functions of the subcortical layers and assumes ever-increasing neuromuscular control. The cortex joins in its ability to store information received by way of sensory neurons. This phenomenon is evidenced in the phasing out of reßex behaviors and the assumption of voluntary movements by the infant. Concurrent formation of myelin prepares the body for the mature neuromuscular state. Movements become more localized as functional neural pathways serve isolated regions of the body with greater precision and accuracy.

More recently, the **dynamic systems theory** contends that neuromaturation serves as a constraint to development and is only one of many rate limiters inßuencing the emergence of controlled voluntary movement (Thelen, 1986b; Thelen et al., 1987; Thelen and Ulrich, 1991). The dynamics of the system shape movement, and a *rate limiter* is something in the individual, task, and/or environment that constrains or restricts coordinated movement from occurring with little central input. Such things as body proportions, insufÞcient myelination, body weight, muscular strength, or a host of environmental conditions inhibit or promote progress from the reßexive to the rudimentary movement phase of development.

Diagnosing Central Nervous System Disorders

It is common for a pediatrician to attempt to elicit primitive and postural reßexes in the neonate and young infant. If a reßex is absent, irregular, or uneven in strength, neurological dysfunction is suspected. The absence of normal reßexive movements or the prolonged continuation of various reßexes beyond their normal periods may also cause the physician to suspect neurological impairment.

CONCEPT 7.4

Infant reflex behavior may be used as an effective diagnostic tool for assessing the integrity of the central nervous system.

The use of developmental reßexes as a tool for diagnosing central nervous system disorders has been widespread. Over the years, scientists have compiled an approximate timetable for the appearance and inhibition of neonatal and infant behaviors. For example, the resting posture of the newborn tends to be the ßexed position. The ßexors are dominant over the extensors in the early part of infancy. Shortly, however, increased cortical control permits the normal neonate to raise its head from the prone position. An absence of the head-lifting response in the Þrst week or two following birth may suggest the possibility of neurological abnormalities.

Several other meaningful examples of this principle exist. The *doll-eye* movements of the neonate permit it to maintain constancy of the retinal image. When the head is tilted back, the eyes look down toward the chin, and when the head is tilted forward, the eyes look up toward the forehead. This response is almost always seen in premature infants and during the Þrst day following birth in the normal neonate, after which it is replaced by voluntary eye movements. Perseveration of this reßex could indicate delayed cortical maturation.

One means of diagnosing possible central nervous system disorders, therefore, is through perseverating reßexes. Complete absence of a reßex is usually less signiÞcant than a reßex that remains too long. Other evidence of possible damage may be reßected in a reßex that is too strong or too weak. A reßex that elicits a stronger response on one side of the body than on the other may also indicate central nervous system dysfunction. An asymmetrical tonic neck reßex, for example, which shows full arm extension on one side of the body and only weak extensor tone when the other side is stimulated, may also provide evidence of damage.

Only a trained examiner should inspect and evaluate reßexive behaviors in the neonate. The examinations provide physicians with a primary means of diagnosing central nervous system integrity in full-term, premature, and at-risk infants.

INTERNATIONAL PERSPECTIVES

Infant Reflexes: A Worldwide Phenomenon with Significant Consequences

Infant reflexes are subcortically controlled and maturationally based. As a result, in the typically developing newborn, they are the same worldwide. It does not matter if one is born in Africa, Asia, North America, or South America, all typically developing infants display the same primitive and postural reflexes. Moreover, they appear and "disappear" in the same manner and at the same rate.

Only in cases of extreme deprivation, including extreme prematurity and extremely low birth weight, do we see a change in the rate of appearance of reflexive behaviors. A shorter gestation period, under 27 weeks, does not enable the nervous system to sufficiently mature in the womb. As a result several reactions, including the search and sucking reflexes, typical of the newborn are weak or even absent. Expert care in the neonatal intensive care unit will buy precious time for these responses to mature while intravenous feeding is provided. In developing countries, however, such medical technology is often unavailable, thus leading to additional complications that threaten the very survival of the newborn because of its inability to seek and take nourishment from its mother's breast. Internationally, much needs to be done to improve the outcome of infants born prematurely.

Furthermore, they serve as a basis for intervention by physical and occupational therapists working with individuals displaying pathological reßexive behaviors beyond their expected periods of inhibition. Neurological dysfunction may be suspected when any one of the following conditions appear:

1. Perseverationo fa r eßex beyond the age at which it should have been inhibited by corticalc ontrol
2. Completea bsenceo fa r eßex
3. Unequalb ilateralr eßex responses
4. Responsest hata ret oos trongo rt oow eak

CONCEPT 7.5

Infant reflexes appear and are inhibited on a predictable schedule of rate and sequence.

PRIMITIVE REFLEXES

Primitive reßexes are closely associated with the obtainment of nourishment and the protection of the infant. They Þrst appear during fetal life and persist well into the Þrst year. The following is a partial list of the numerous primitive reßexes exhibited by the fetus and the neonate. Their approximate times of appearance and inhibition are found in Table 7.1, which also includes information about postural reßexes.

Moro and Startle Reflexes

The Moro and startle reßexes may be elicited by placing the infant in a supine position and tapping on the abdomen or by producing a feeling of insecurity of support (for instance, allowing the head to drop suddenly backward a short distance). It

TABLE 7.1 Developmental Sequence and Approximate Rate for Appearance and Inhibition of Selected Primitive and Postural Reflexes

	Month												
PrimitiveR eflexes	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Moro	×	×	×	×	×	×	×						
Startle								×	×	×	×		
Search	×	×	×	×	×	×	×	×	×	×	×	×	
Sucking	×	×	×	×									
Palmar-mental	×	×	×										
Palmar-mandibular	×	×	×	×									
Palmarg rasping	×	×	×	×	×								
Babinski	×	×	×	×									
Plantarg rasp					×	×	×	×	×	×	×	×	×
Tonicn eck	×	×	×	×	×	×	×						
PosturalR eflexes													
Labyrinthiner ighting			×	×	×	×	×						
Opticalr ighting							×	×	×	×	×	×	×
Pull-up				×	×	×	×	×	×	×	×	×	×
Parachutea ndp ropping					×	×	×	×	×	×	×	×	×
Neckr ighting	×	×	×	×	×	×	×						
Bodyr ighting							×	×	×	×	×	×	×
Crawling	×	×	×	×									
Stepping	×	×	×	×	×								
Swimming	×	×	×	×	×								

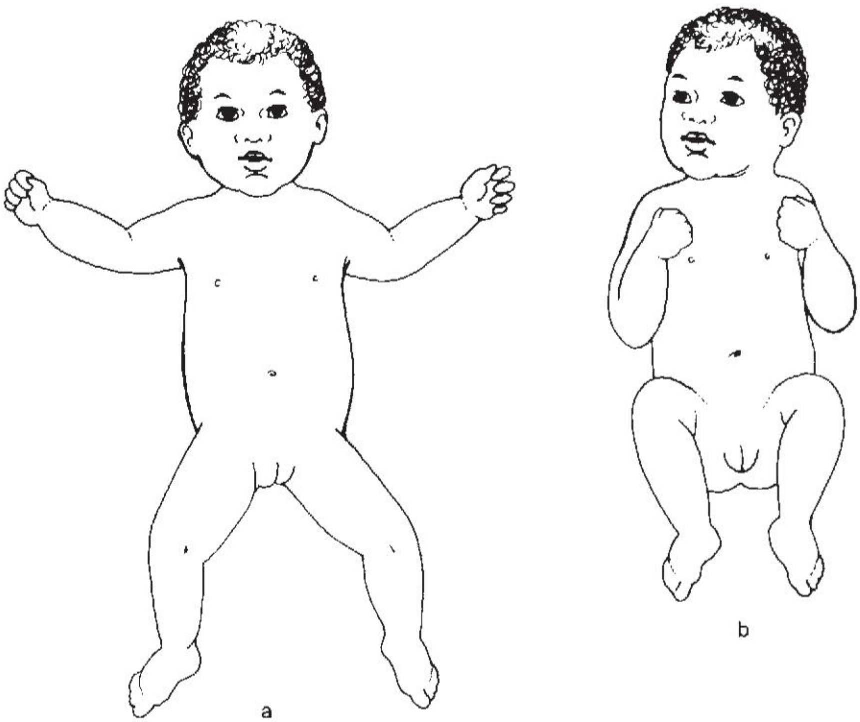

Figure 7.1
The Moro reflex: (a) extension phase, (b) flexion phase.

may even be self-induced by a loud noise or the infantÕs cough or sneeze. In the Moro reßex, there is a sudden extension and bowing of the arms and spreading of the Þngers. The legs and toes perform the same actions, but less vigorously. The limbs then return to a normal ßexed position against the body (Figure 7.1). The startle reßex is similar in all ways to the Moro reßex except that it involves ßexion of the limbs without prior extension.

The Moro reßex is present at birth and during the following six months. The Moro reßex has been one of the most widely used tools in the neurological examination of the young infant. The reaction is most pronounced during the infantÕs Þrst few weeks. The intensity of the response gradually decreases until it is Þnally characterized by a jerking motion of the body in response to the stimulus (startle reßex). Persistence of the reßex beyond the sixth month may be an indication of neurological dysfunction. An asymmetrical Moro reßex may indicate ErbÕs palsy or an injury to a limb.

Search and Sucking Reflexes

The search, or rooting, and sucking reßexes enable the newborn to obtain nourishment from its mother. Stimulation of the area around the mouth (search reßex) will result in the infantÕs turning its head toward the source of stimulation. The search reßex is strongest during the Þrst three weeks and gradually gives way to a directed head turning response that becomes reÞned and appears to be a purposeful behavior to bring the mouth into contact with the stimulus. The search reßex is most easily obtained when the infant is hungry, sleeping, or in his or her normal feeding position. Stimulation of the lips, gums, tongue, or hard palate will cause a sucking motion (sucking reßex) in an attempt to ingest nourishment. The sucking action is usually rhythmically repetitive. If it isnÕt, gentle movement of the object within the mouth will produce sucking. The sucking reßex has two phases, the expressive phase and the suction phase.

During the *expressive phase* of sucking, the nipple is squeezed between the tongue and palate. During the *suction phase*, negative pressure is produced in the mouth cavity. This reßex is elicited daily during the feeding times of a healthy neonate. Additionally, when high-risk newborns are stimulated to elicit the sucking and swallowing reßexes, it has been beneÞcial in reducing the need for intravenous feeding.

Both of these reßexes are present in all typically developing newborns. The search reßex may persist until the end of the Þrst year; the sucking movement generally disappears as a reßex by the end of the third month but persists as a voluntary response.

Hand-Mouth Reflexes

Two hand-mouth reßexes are found in the newborn. The *palmar-mental reflex,* elicited by scratching the base of the palm, causes contraction of the chin muscles, which lift the chin up. This reßex has been observed in newborns but disappears relatively early.

The *palmar-mandibular reflex,* or *Babkin reflex,* as it is sometimes called, is elicited by applying pressure to the palms of both hands. The responses usually include mouth opening, closing of eyes, and ßexing the head forward. This reßex begins decreasing during the Þrst month after birth and usually is not visible after the third month.

Palmar Grasping Reflex

During the Þrst two months, the infant usually has its hands closed tightly. Upon stimulation of the palm, the hand will close strongly around the object without use of the thumb. The grip tightens when force is exerted against the encircling Þngers. The grip is often so strong that the infant is able to support his or her weight when suspended(Figure7 .2).

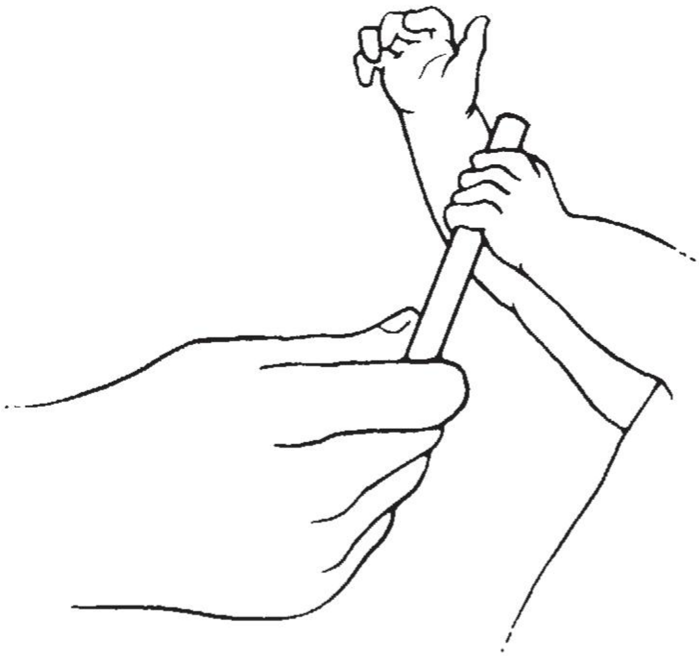

Figure 7.2
The palmar grasping reflex.

The grasping reßex is normally present at birth and persists during the Þrst four months. The intensity of the response tends to increase during the Þrst month and slowly diminish after that. Weak grasping or persistence of the reßex after the Þrst year may be a sign of delay in motor development or of hemiplegia, if it occurs on only one side.

Babinski and Plantar Grasping Reflexes

In the newborn the Babinski reßex is elicited by a stroke on the sole of the foot. The pressure causes an extension of the toes. As the neuromuscular system matures, the Babinski reßex gives way to the plantar reßex, a contraction of the toes upon stimulation of the sole of the foot (Figure 7.3).

The Babinski reßex is normally present at birth but gives way around the fourth month to the plantar grasp reßex, which may persist until about the twelfth month. The plantar grasp reßex may be most easily elicited by pressing the thumbs against the ball of the infantÕs foot. Persistence of the Babinski reßex beyond the sixth month may be an indication of a developmental lag.

Asymmetrical and Symmetrical Tonic Neck Reflexes

The asymmetrical tonic neck reßex is probably the most widely researched reßex in the therapeutic literature. To elicit it, the infant is placed by a trained examiner in a supine position, and the neck is turned so that the head is facing toward either side. The arms assume a position similar to the fencerÕs ÒEn garde.Ó That is, the arm extends on the side of the body toward which the head is turned, and the other arm assumes an acute ßexed position. The lower limbs assume a position similar to the arms. The symmetrical tonic neck reßex may be elicited from a supported sitting position. Extension of the head and neck will produce extension of the arms and ßexion of the legs. If the head and neck are ßexed, the arms ßex and the legs extend(Figure 7.4).

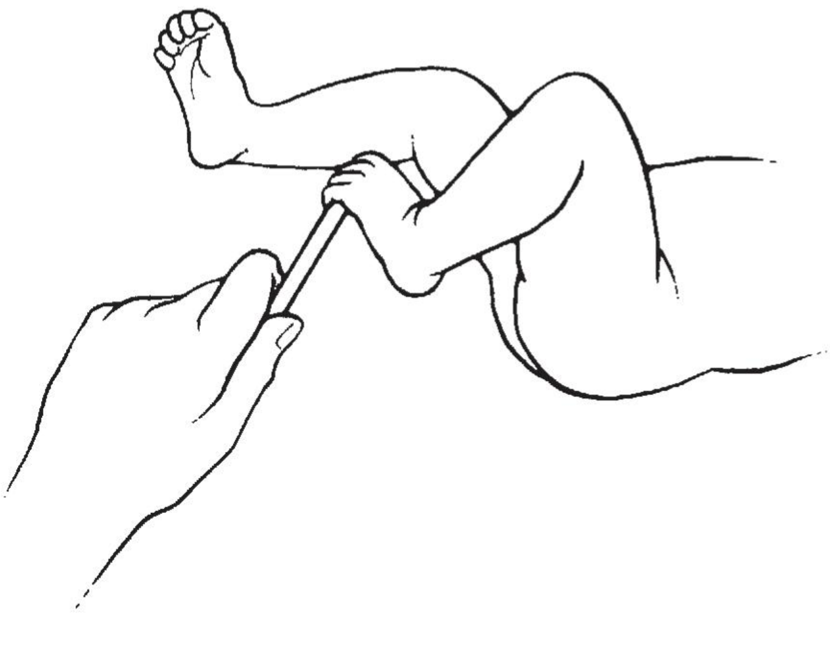

Figure 7.3
The plantar grasping reflex.

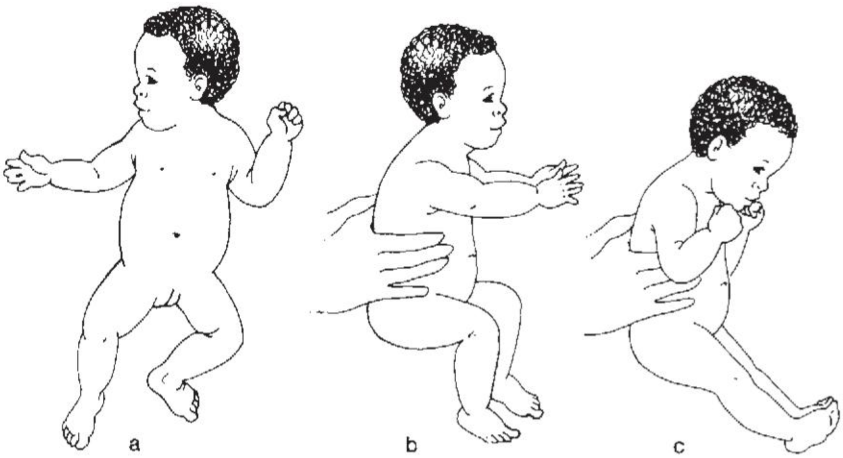

Figure 7.4
(a) The asymmetrical tonic neck reflex and (b & c) the symmetrical tonic neck reflex.

Both tonic neck reßexes may be observed in most premature infants, but they are not an obligatory response in newborns (i.e., they do not occur each time the infantÕs head is turned). However, the 3- or 4-month-old infant assumes the asymmetrical position about 50% of the time and then this response gradually fades away. Persistence beyond the sixth month may be an indication of lack of control over lower brain centers by higher ones.

Persistence of the asymmetrical tonic neck reßex into the early childhood years can prevent the child from developing motor tasks such as body rolling, body midline crossing, eye-hand coordination, and various swim strokes. Children and adults with severe cerebral palsy often exhibit a persistent asymmetrical tonic neck reßex (Sherrill, 2004).

Postural Reflexes

Postural reßexes resemble later voluntary movements. Postural reßexes automatically provide for an individualÕs maintenance of an upright position in relation to his or her environment. They are found in all normal infants during the early postnatal months of life and may, in a few cases, persist through the Þrst year. The following sections discuss postural reßexes of particular interest to the student of motor development. These reßexes are associated with later voluntary movement behavior and should be carefully studied by all concerned with the development of voluntary patterns of movement. (The approximate times of appearance and inhibition of these reßexes are also found in Table 7.1 on page 124.)

Concept 7.6

Postural reflexes resemble, and may be linked to, later voluntary movements.

Labyrinthine and Optical Righting Reflexes

The labyrinthine and the optical righting reßexes may be elicited when the infant is held in an upright position and is tilted forward, backward, or to the side. The child will respond by attempting to maintain the upright position of the head by moving it in the direction opposite to the one in which its trunk is moved. For example, if the baby is held in a prone position and tilted downward, it will respond by raising the head upward (Figure 7.5). The optical righting reßex is the same as the labyrinthine reßex except that the eyes can be observed to follow the upward lead

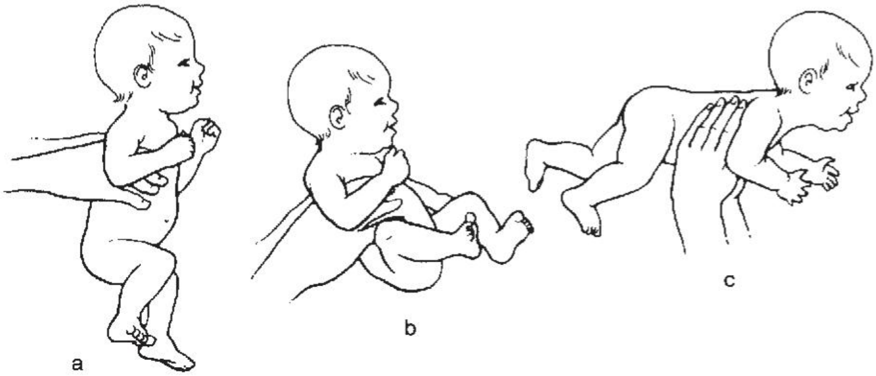

Figure 7.5
The labyrinthine righting reflexes from three positions: (a) upright, (b) tilted backward, and (c) prone.

Figure7 .6
The pull-up reflex.

of the head. In the labyrinthine righting reßex, impulses arising in the otolith of the labyrinth cause the infant to maintain its head in proper alignment to the environment even when other sensory channels (i.e., vision or touch) are excluded. The labyrinthine righting reßex makes its Þrst appearance around the second month and persists to about the sixth month, when vision generally becomes an important factor. The reßex continues into the Þrst year as the optical righting reßex. The optical righting reßex, and its more primitive cousin, the labyrinthine righting reßex, help the infant achieve and maintain an upright head and body posture and contribute to the infant©forward movement around the end of the Þrst year.

Pull-Up Reflex

The pull-up reßex of the arms is an involuntary attempt on the part of the infant to maintain an upright position. When the infant is in an upright sitting position and held by one or both hands, it will ßex its arms in an attempt to remain upright when tipped backward. It will do the same thing when tipped forward. The reßexive pull-up reaction of the arms usually appears around the third or fourth month and often continues through the Þrsty ear(Figure7 .6).

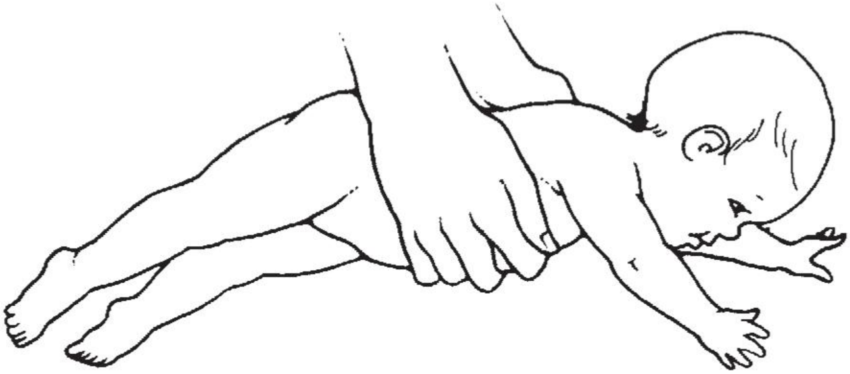

Figure7 .7
The parachute reflex.

Parachute and Propping Reflexes

Parachute and propping reactions are protective movements of the limbs in the direction of the displacing force. These reßexive movements occur in response to a sudden displacing force or when balance can no longer be maintained. Protective reßexes depend on visual stimulation and thus do not occur in the dark. They may be a form of a startle reßex.

The forward parachute reaction may be observed when the infant is held vertically in the air and then tilted toward the ground. The infant extends the arms downward in an apparent attempt to cushion the anticipated fall (Figure 7.7). The downward parachute reactions may be observed when the baby is held in an upright position and rapidly lowered toward the ground. The lower limbs extend, tense, and abduct. Propping reßexes may be elicited by pushing the infant off balance from a sitting position either forward or backward. The forward and downward parachute reactions begin to occur around the fourth month. The sideways propping reaction is Þrst elicited around the sixth month. The backward reaction is Þrst seen between the tenth and twelfth months. Each of these reactions tends to persist beyond the Þrst year and is necessary before the infant can learn towa lk.

Neck and Body Righting Reflexes

The neck righting reßex can be observed when the infant is placed in a supine position with the head turned to one side. The remainder of the body moves reßexively in the same direction as the head. First the hips and legs turn into alignment, followed by the trunk. In the body righting reßex the reverse occurs. When tested from a side-lying position with the legs and trunk turned in one direction, the baby will turn its head reßexively in the same direction and right the body in alignment with the head (Figure 7.8 on page 131). The neck righting reßex disappears around 6 months of age. The body righting reßex emerges around the sixth month and persists to about 18 months of age. The body righting reßex forms the basis for voluntary rolling that occurs from the end of the Þfth month onward.

Crawling Reflex

The crawling reßex can be seen when the infant is placed in a prone position and pressure is applied to the sole of one foot. It will reßexively crawl, using both its upper and lower limbs. Pressure on the soles of both feet will elicit a return of pressure by the infant. Pressure on the sole of one foot will produce returned pressure and an extensor thrust of the opposite leg (Figure 7.9 on page 131).

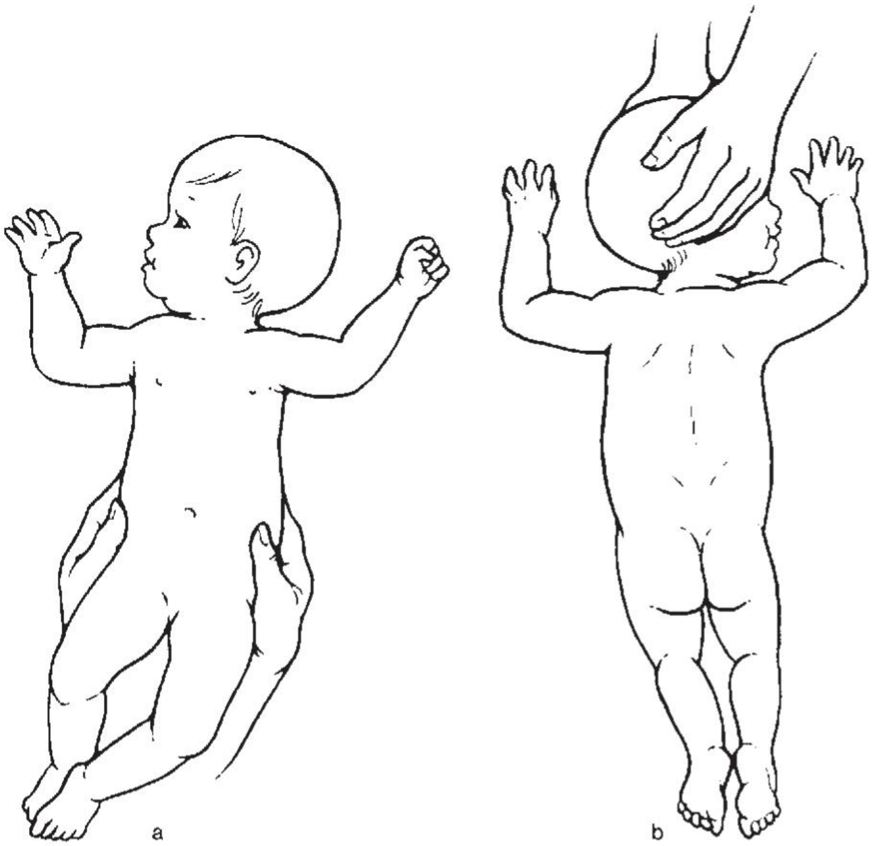

Figure7 .8
(a) The neck righting reflex and (b) the body righting reflex.

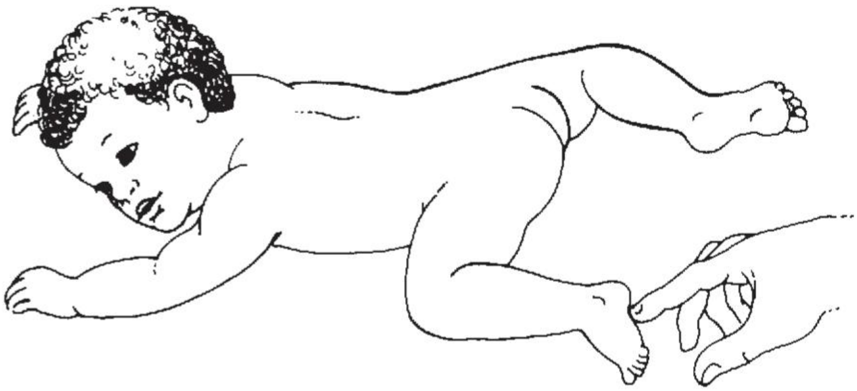

Figure 7.9
The crawling reflex.

DEVELOPMENTAL DILEMMA

Look! Baby's Already Starting to Walk!

Parents of a newborn are often intent on observing every move that their baby makes, especially during the eventful first year. One of the most heralded first major milestones is learning how to stand and walk independently. Typical variation ranges from about 9–18 months of age with the average being around 12.

Often, parents begin holding baby in a supported upright position shortly after birth and are amazed to see that he locks out at the hip and knee joints and appears to make real efforts to stand and walk. Calls are made to family and friends that baby is "starting to walk," and because it is so soon he must be demonstrating the first of what will certainly be many advanced behaviors. Ah, such proud parents.

Gathered with several onlookers several weeks later, mom and dad are chagrined when baby fails to demonstrate his early "walking" skills. In fact, when held upright and feet placed on a hard surface, he acts more like a limp wet noodle than their superbaby trying to stand and walk.

The primary stepping reflex appears shortly after birth and persists through the first four or five months. It is in no way a voluntary motor activity because it is subcortically controlled. It may, however, provide the infant with valuable information to be used later as higher brain centers mature and the body's musculature becomes sufficiently strong to support voluntary standing and walking.

Using the primary stepping reflex for early "practice" with walking has been shown to promote accelerated voluntary walking behaviors in infants. Practice appears to improve limb strength and asymmetrical coordination. It may, however, if overdone, put undue strain on bones and joints. Hence, the dilemma: Under what conditions is practice in early stepping behavior advised and under what conditions might it be unwise? Why?

The crawling reßex is generally present at birth and disappears around the third or fourth month. There is a lag between reßexive crawling and voluntary crawling, which appears around the seventh month.

Primary Stepping Reflex

When the infant is held erect, with its body weight placed forward on a ßat surface, it will respond by ÒwalkingÓ forward. This walking movement involves the legs only (Figure 7.10 on page 133). The primary stepping reßex is normally present during the Þrst six weeks and disappears by the Þfth month. Zelazo (1976) and Bower (1976) studied how early and persistent practice of the primary stepping reßex affects the onset of voluntary walking behavior. The results of these investigations revealed that the age of independent walking was accelerated through conditioning of the stepping reßex in the experimental group; the control group did not show accelerated development. Building on these Þndings, Thelen (1986a) was able to elicit a stepping reßex in infants several months after it should have been inhibited but prior to the onset of voluntary walking. She suggested that the conditioning of the reßex improves the strength in the limbs exercised, thus becoming a key to early voluntary walking. Several investigations have used this seminal work to explore the facilitation of voluntary walking in infants with Down syndrome (Ulrich and Ulrich, 1995; Ulrich et al., 1995; Ulrich et al., 1997; Ulrich et al., 2001).

Swimming Reflex

When placed in a prone position in or over water, the infant will exhibit rhythmical extensor and ßexor swimming movements of the arms and legs. The movements are well organized and appear more advanced than any of the other locomotor reßexes. McGraw (1939) Þlmed reßexive swimming movements in the human infant as early as the eleventh day following birth. These involuntary movements

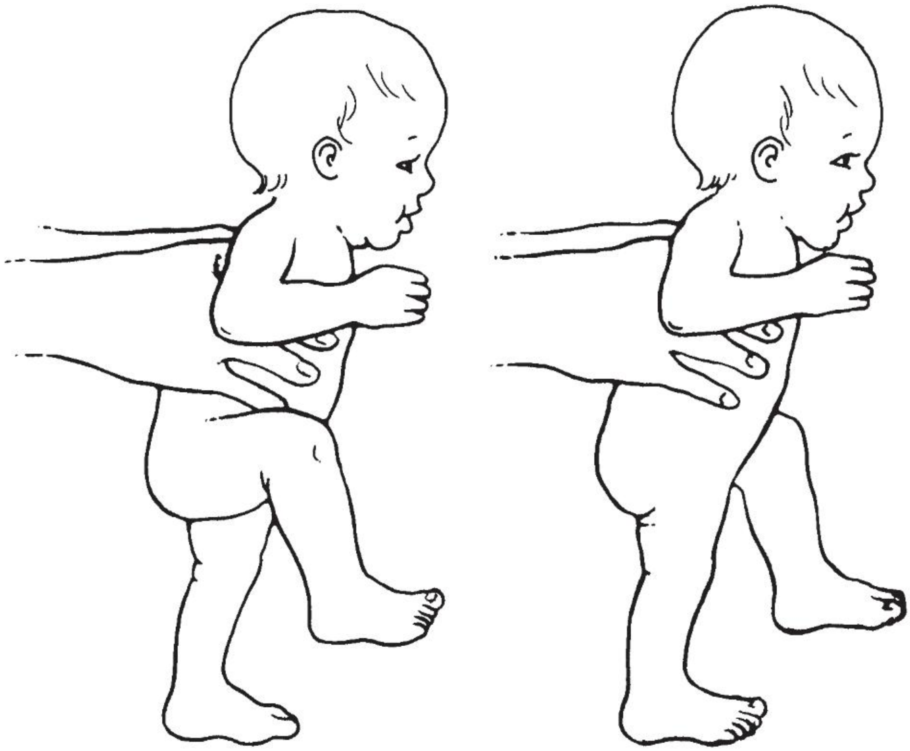

Figure7 .10
The primary stepping reflex.

generally disappear around the fourth month. McGraw discovered that a breath-holding reßex is elicited when the infantÕs face is placed in the water and that the swimming movements are more pronounced from this position. McGraw (1954) has since speculated on the theory that the infantÕs swimming reßex is a precursor to walking. ÒBasically the neuromuscular mechanisms which mediate the reßexive swimming movements may be essentially the same as those activated in the reßexive crawling and stepping movements of the infantÓ (p. 360). It is interesting to reßect on the relationship among the crawling, stepping, and swimming reßexes.

Rhythmical Stereotypies

Researchers have been interested in the many intriguing questions concerning infant reßexes for several decades. This research has important implications for the diagnosis of central nervous system disorders and for the physical and occupational therapist working with individuals who display various pathological conditions. Furthermore, the study of the origin of reßexes and their relationship to later voluntary behaviors is forging new inroads into learning theory and how the human being organizes itself for the learning of new movement skills.

CONCEPT 7.7

Infant rhythmical stereotypies provide evidence that human motor development is a self-organizing system that strives for increased motor control.

Only in the last two decades have investigators gone beyond cataloging and describing infant reßexive behaviors to attempt to examine the underlying mechanisms. Esther Thelen is among the Þrst to attempt to answer the many questions raised by the stereotypical behaviors of the infant. She studied **rhythmical stereotypies** in normal human infants to classify these movements and explain their occurrences. (*Stereotypies* are rhythmical behaviors performed over and over for their own sakes.) In children and adults, stereotypies are regarded as evidence of abnormal behavior, but in infants they are normal.

Thelen (1979, 1981, 1996) observed and cataloged the rhythmical stereotypies of normal infants from 4 weeks to 1 year of age. Her observations revealed forty-seven stereotypical behaviors, which have been subdivided into four groups: (1) movements of the legs and feet; (2) movements of the torso; (3) movements of the arms, hands, and Þngers; and (4) movements of the head and face. According to Thelen (1979), ÒThese behaviors showed developmental regularities as well as constancy of form and distribution. Groups of stereotypies involving particular parts of the body or postures had characteristic ages of onset, peak performance, and declineÓ (p. 699).

Rhythmic movements of given body systems tended to increase just before the infant gained voluntary control of that system. Therefore, the maturational level of the infant appears to control rhythmical stereotypies. Thelen and her colleagues (Thelen et al., 1985; Thelen et al., 1987) have argued that the presence of stereotypical behaviors in normal human infants is evidence of a self-organizing central motor program in control of infant motor development.

Legs and Feet

Thelen (1979, 1985) found that rhythmical kicking movements of the legs and feet were the earliest stereotypies observed. The majority of rhythmical kicking took place when infants were in either prone or supine positions. The supine position afforded infants the greatest amount of freedom with ßexibility at both the hip and knee joints. When kicking from this back-lying position, the babiesÕ legs were bent slightly at the hips, knees, and ankles with moderate outward rotation at the hips. From this position the infants could alternately kick the legs in what resembled a ÒbicyclingÓ action. From the prone position alternate leg kicking was more restricted and occurred only from the knee joint. Thelen noted that stereotypies of the legs and feet began around 4 weeks of age, earlier than for arms, and reached their peak occurrence between 24 and 32 months of age. Other forms of kicking discovered were foot rubbing from a related position and single leg kicking from both prone and supine positions.

Torso

Thelen (1979) also observed several rhythmical stereotypies of the torso. The most common was from a prone position. The infant arched the back, lifted the arms and legs from the supporting surface, and rhythmically rocked back and forth in an airplane-like position. Another frequently observed stereotypy of the torso occurred from a hands-and-knee prone creeping position. From this position the infant moved the body forward by extending the upper position of the leg and keeping the lower leg stationary. The arms remained extended throughout but moved forward on the backward thrust of the legs.

Other common, but less frequently observed, rhythmical stereotypies of the torso included rhythmical actions from sitting, kneeling, and standing postures. From either a supported or unsupported sitting position, the infant rhythmically rocked the torso forward and back. Rhythmical stereotypies from a kneeling position included rocking back and forth, side to side, and up and down. Standing stereotypies were common, and generally occurred from a support-standing position. The infant bent at the knees and performed a rhythmical up-and-down bouncing movement. Infants might also rhythmically rock forward and back and from side to side.

Arms, Hands, and Fingers

Rhythmical stereotypies of the arms, hands, and Þngers were observed in all of the infants sampled by Thelen. Waving (actions without an object) and banging (actions with an object in the infantÕs grasp) were the most frequently observed. Both were the same motor pattern and involved rhythmical movement in a vertical action from the shoulder. Banging differed from waving only in that the infant made contact with the surface on the downward action. Rhythmical clapping of the hands in front of the body was another common stereotypy, as in arm sway. The arm sway stereotypy is elicited, however, only when the infant is grasping an object and involves shoulder-initiated action across the front of the body.

Head and Face

Rhythmical stereotypies of the head and face, according to Thelen (1979), are much less frequent. They involve actions such as rhythmical head shaking from side to side (ÒnoÓ) and up and down (ÒyesÓ). Rhythmical sticking out of the tongue and drawing it back was routinely observed, along with nonnutritive sucking behaviors.

Of the forty-seven rhythmical stereotypies observed by Thelen, movements of the legs and feet were the most common, began the earliest, and peaked between 24 and 32 weeks of age. Arm and hand stereotypies were also common but peaked somewhat later, between 34 and 42 weeks. Torso stereotypies, although common, are less frequent than movements of the legs and feet and the hands and arms. Furthermore, torso stereotypies from sitting, kneeling, or standing positions tend to peakl atert hant he others.

SUMMARY

Primitive reßexes, under the control of subcortical brain layers, are observed in the fetus from about the eighteenth week of gestation. Generally, reßexes serve the double function of helping the neonate to secure nourishment and protection. Many of the movements represent initial methods of gaining information about the infantÕs environment.

As neurological development proceeds in the normal fetus, and later in the normal neonate, reßexes appear and disappear on a fairly standard, though informal, schedule. The presence of a primitive or postural reßex is evidence of subcortical control over some neuromuscular functions. Although cortical control soon dominates, the function of the subcortex is never completely inhibited. Throughout life, it maintains control over such activities as coughing, sneezing, and yawning, as well as over the involuntary life processes. The cortex mediates more purposeful behavior, whereas subcortical behavior is limited and stereotyped.

Although it is not yet possible to determine whether a direct relationship between reßexive behavior and later voluntary movement exists, it is safe to assume that there is at least an indirect link. This link may be associated with the ability of the developing cortex to store information received from the sensory end-organs regarding the performance of the involuntary movement. Or it may be due to improved strength in the involuntarily (reßexively) exercised body part.

QUESTIONS FOR REFLECTION

1. What are the major primitive and postural reßexes of the newborn?
2. What does the physician look for when testing a newbornÕs reßex responses?
3. In what ways do the information encoding and the information decoding stages within the reßexive phase of motor development differ?
4. What are rhythmical stereotypies and why are they thought to be important in the motor development of infants?
5. Are infant reßexes related to later voluntary behaviors seen in the rudimentary movement phase of motor development and beyond?

Critical Readings

Sherrill, C. (2004). *Adapted Physical Activity, Recreation and Sport: Crossdisciplinary and Lifespan,* 6th ed. (Chapter 10). St. Louis: McGraw-Hill.

Snow, C. W., & McGaha, C. G. (2003). *Infant Development*, 3rd ed. (Chapter 6). Upper Saddle River, NJ: Prentice Hall.

Thelen, E. (1996). Normal infant stereotypies: A dynamic systems approach. In R. L. Sprague & K. M. Newell (Eds.) *Stereotyped Movements: Brain and Behavior Relationships.* (pp. 139Ð165).Washington DC: American Psychological Association.

Thelen, E. (1986). Treadmill-elicited stepping in seven-month-old infants. *Child Development, 57*,1498Ð1506.

Ulrich, B. D., Ulrich, D. A., Angulo-Barroso, R., & Yun, J. K. (2001). Treadmill training in infants with Down syndrome: Evidence-based developmental outcomes. *Pediatrics, 108*,e84.

Web Resources

www.apta.org

Homepage of the American Physical Therapy Association. The APTA is a professional organization whose goal is to foster advancements in physical therapy practice, research, and education. Site provides news, government affairs, member groups, publications, and a job/career center.

www.isisweb.org/main.htm

Homepage for the International Society on Infant Studies. ISIS is Òdevoted to the promotion and dissemination of the research on the development of infants.ÓSite contains a description of the society, latest news, and newsletter.

www.physicaltherapist.com

This webpage is dedicated to serve physical therapists through message boards, classiÞed ads, school listings, clinical listings, and a job search feature.

http://www.mc.vanderbilt.edu/vumcdiglib/databases.html?diglib=4

Vanderbilt ChildrenÕs Hospital digital library website. Site contains numerous resources such as databases, electronic journals, electronic books, EBM resources, etc.

CHAPTER 8

Rudimentary Movement Abilities

KEY TERMS

Reflex inhibition stage
Precontrols tage
Stability
Locomotion
Manipulation
Crawling
Homolateralp attern
Creeping
Contralateralp attern
Earlyi ntervention
Hyponatremia
Giardia

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Describe intertask "motor milestones" that lead to upright locomotion and visually guidedr eaching
- Distinguishb etweent her eflex inhibition and the precontrol stages within the rudimentary movement phase of development
- Discuss historical and contemporary study of infant motor development
- List and describe the developmental sequence of acquisition of rudimentary stability, locomotor, and manipulative abilities
- Distinguishb etween *creeping* and *crawling*a nd describe the developmental process of each
- Discuss the interaction between maturation and experience in the acquisition of rudimentary movement abilities
- Devise your rudimentary movement infant observationala ssessmenti nstrument

KEY CONCEPT

Mastery of the rudimentary movement abilities of infancy is a reflection of increased motor control and movement competence, brought about by factors within the task and the environment, as well as within the individual.

We are all products of specific genetic structures, and the total of the experiences we have had since conception. As such, a child is not a blank slate, ready to be molded and shaped to our whims or a precut pattern. Research has made it abundantly clear that infants are able to process a great deal more information than we suspected. Infants think and use movement as a purposeful, though initially imprecise, way of gaining information about their environments. Each child is an individual, and no two individuals will respond in exactly the same manner. The child's hereditary and experiential background, as well as the specific demands of the movement tasks, have a profound effect on the rate of attainment of the rudimentary movement abilities of infancy.

It is important to study motor development, beginning with the early movement experiences of infancy, to gain a better understanding of the development that takes place before children enter school and to learn more about the developmental concept of how humans learn to move.

Gaining control over musculature, learning to cope with the force of gravity, and moving in a controlled manner through space are major developmental tasks facing the infant. During the neonatal period, movement is ill defined and poorly controlled. Reflexes are gradually inhibited and the **reflex inhibition stage** begins (see Figure 3.1, p. 50). This period stretches throughout most of the infant's first year. The infant gradually moves toward controlled rudimentary movement that represents a monumental accomplishment in suppressing reflexes and integrating the sensory and motor systems into controlled purposeful movement.

As the primitive and postural reflexes of the previous phase begin to fade, higher brain centers take over many of the skeletal muscle functions of lower brain centers. The reflex inhibition stage essentially begins at birth. From the moment of birth the newborn is bombarded by sight, sound, smell, tactile, and kinesthetic stimulation. The task is to bring order to this sensory stimulation. Initial reflexive responses are inhibited throughout the first year until around the first birthday, when the infant displays remarkable progress in bringing a semblance of control to his or her movement.

The period from about 12 months to between 18 and 24 months represents a time for practice and mastery of the many rudimentary tasks initiated during the first year. The infant begins to bring movements under control during this precontrol period. The **precontrol stage** spans roughly the period between the first and second birthdays. During this stage the infant begins to gain greater control and precision in movement. Differentiation and integration of sensory and motor processes become more highly developed, and the rate limiters of early infancy become less pronounced.

As the infant makes crude but purposeful attempts at a variety of movement tasks, he or she should be encouraged. An environment that provides sufficient stimulation through abundant opportunities for practice and positive encouragement may prove beneficial in hastening development of the rudimentary stability, locomotor, and manipulative tasks that follow. The question, however, should be asked: What are the benefits of early motor skill acquisition? The answer is clear, and it is possible to build a strong case for encouraging early motor skill acquisition in normally developing infants (Nash, 1997) as well as in infants with developmental disabilities (Greenspan, 1997).

STUDY OF INFANT MOTOR DEVELOPMENT

The study of the rudimentary movement abilities of infancy received its impetus in the 1930s and 1940s, when a wealth of information was obtained from the observations of developmental psychologists.

Many of these studies have become classics and have withstood the tests of time because of their careful controls and thoroughness. The works of H. M. Halverson, Mary Shirley, Nancy Bayley, and Arnold Gesell are particularly noteworthy.

The work of H. M. Halverson (1937) is probably the most comprehensive on the sequence of the emergence of voluntary grasping behavior during infancy. Through film analysis of infants from 16 to 52 weeks of age, he described three distinct stages of approach toward a cube and the development of the use of fingers-thumb opposition in grasping behavior.

Mary Shirley's (1931) pioneering study of twenty-five infants from birth to age 2 enabled her to describe a sequential developmental progression of activities leading to upright posture and a walking gait. She noted that "each separate stage was a fundamental step in development and that every baby advanced from stage to stage in the same order" (p. 98). She also noted that although the sequence was fixed, individual differences were expressed in variations in the rates of development between infants.

Nancy Bayley (1935) conducted an extensive study similar to that of Shirley. As a result of her observations of infants, she was able to describe a series of emerging locomotor abilities progressing from reflexive crawling to walking down a flight of stairs using an alternate foot pattern. Based on this information Bayley developed a cumulative scale of infant motor development that has been widely used as a diagnostic tool to determine an infant's developmental status.

Arnold Gesell (1945) conducted extensive studies of infant motor development. He viewed posture (i.e., stability) as the basis of all forms of movement. Therefore, according to Gesell, any form of locomotion or infant manipulation is a closely related series of sequential postural adjustments. The sequence of motor development is predetermined by innate biological factors that cut across all social, cultural, ethnic, and racial boundaries. This common base of motor development during the early years of life has caused many experts to speculate that some voluntary movements (particularly locomotor movements) are phylogenetic (Eckert, 1973) and that, because these movements are maturationally based, they are not under voluntary developmental control (Hellebrandt et al., 1961). This view has often led to the erroneous assumption that infants and particularly young children acquire movement abilities at about the same chronological age solely by the action of neural maturation and with little dependence on experience.

CONCEPT 8.1

The sequence of infant motor development is predictable, but the rate is variable.

Although the sequence of skill acquisition is generally invariant during infancy and early childhood, the rate of acquisition differs from child to child. This causes one to hypothesize that early motor development is not only a function of neurological maturation but also a function of a self-organizing system involving the requirements of the movement task, the conditions of the immediate environment, and the biology of the individual. As with the reflexive phase, neural maturation is only one of a number of factors influencing the developmental rate of children's rudimentary movement abilities. In accordance with the Triangulated Hourglass Model of motor development presented in chapter 3, it is time to look beyond neural maturation as the sole means of explaining infant motor development. Researchers are now looking more closely at the transactional processes embodied in the task, the individual, and the environment through a constraints perspective (Alexander et al., 1993; Getchell & Gagen, 2006; Newell, 1992; Thelen, 1998; Thelen et al., 1987).

From the moment of birth the infant is in a constant struggle to gain mastery over the environment to survive. During the earliest stages of development, the infant's primary interaction with the environment is through the medium of movement. The infant must begin to master three primary categories of movement for survival and effective and efficient interaction with the world. First, the infant must establish and maintain the relationship of the body to the force of gravity to achieve an upright sitting posture and an erect standing posture (**stability**). Second, the child must develop basic abilities to move through the environment (**locomotion**). Third, the infant must develop the rudimentary abilities of reach, grasp, and release to make meaningful contact with objects (**manipulation**).

CONCEPT 8.2

Variations in the rate of infant motor development lend support to the proposition that development is a dynamic process within a self-organizing system.

The rudimentary movement abilities in the infant are the building blocks for more extensive development of the fundamental movement skills in early childhood and the specialized movement skills of later childhood and beyond. These so-called rudimentary movement abilities are highly involved tasks for the infant. The importance of their development must not be overlooked or minimized. The question that arises is: Are there identifiable constraints that serve to enhance or limit the development of the rudimentary movement abilities? The answer is that both affordances and rate limiters found in the biology of the individual, the requirements of the movement task, and the conditions of the learning environment impact infant development. Although biology plays a powerful role during this phase, rudimentary movement abilities are not genetically determined to the point that they are not susceptible to modification. Early enrichment does seem to influence later development, but further information is needed about the type, timing, degree, and duration.

STABILITY

The infant is in a constant struggle against the force of gravity to achieve and maintain an upright posture. Establishing control over the musculature in opposition to gravity is a process that follows a predictable sequence in all infants. The events leading to an erect standing posture begin with gaining control over the head and neck and proceed down to the trunk and the legs. Operation of the cephalocaudal principle of development is generally apparent in the infant's sequential progress from a lying position to a sitting posture and eventually to an erect standing posture. Table 8.1 provides a summary of the developmental sequence and the approximate age of onset of selected rudimentary stability abilities.

CONCEPT 8.3

Stability is the most basic of the three categories of movement because all voluntary movement involves an element of stability.

Control of the Head and the Neck

At birth the infant has little control over the head and neck muscles. If the infant is held erect at the trunk, the head will drop forward. Around the end of the first month, the infant gains control over these muscles and is able to hold the head erect when supported at the base of the neck. By the end of the first month, the infant should be able to lift the chin off the crib mattress when lying in a prone position. By the fifth month the infant should be able to lift the head off the crib mattress when lying in a supine position.

Control of the Trunk

After infants have gained mastery of the head and neck muscles, they begin to gain control of the muscles in the thoracic and lumbar regions of the trunk. The development of trunk control begins around the second month. Control of the trunk muscles may be observed if you hold the infant off the ground by the waist and note the ability to make postural adjustments necessary to maintain an erect position.

By the end of the second month, the infant should be capable of lifting the chest off the floor

TABLE 8.1 Developmental Sequence and Approximate Age of Onset of Rudimentary Stability Abilities

StabilityT asks	Selected Abilities	Approximate Age of Onset
Controlo f heada ndn eck	Turns to one side	Birth
	Turns to both sides	1 week
	Held with support	First month
	Chin off contact surface	Second month
	Good prone control	Third month
	Good supine control	Fifth month
Control oft runk	Lifts head and chest	Second month
	Attempts supine-to-prone position	Third month
	Success in supine-to-prone roll	Sixth month
	Prone-to-supine roll	Eighth month
Sitting	Sits with support	Third month
	Sits with self-support	Sixth month
	Sits alone	Eighth month
	Stands with support	Sixth month
Standing	Supports with handholds	Tenth month
	Pulls to supported stand	Eleventh month
	Stands alone	Twelfth month

when placed in a prone position. After the infant can lift the chest, he or she begins to draw the knees up toward the chest and then kick them out suddenly as if swimming. This usually occurs by the sixth month. Another indication of increasing control over the trunk muscles is the ability to turn over from a supine to a prone position. This is generally accomplished around the sixth month and is easily done by flexing the hips and stretching the legs out at right angles to the trunk. Mastery of the roll from a prone to a supine position usually occurs somewhat later.

Sitting

Sitting alone is an accomplishment that requires complete control over the entire trunk. The infant of 4 months is generally able to sit with support in the lumbar region. The infant has control over the upper trunk but not the lower portion. During the next month or two the infant gradually gains control over the lower trunk. The first efforts at sitting alone are characterized by an exaggerated forward lean to gain added support for the lumbar region. Gradually, the ability to sit erect with a limited amount of support develops. By the seventh month, the infant is generally able to sit alone completely unsupported. At this juncture he or she has now gained control over the upper half of the body (Figure 8.1). At the same time that the infant is learning to sit alone, he or she is developing control over the arms and hands—a further example of the cephalocaudal and proximodistal principles of development in operation described earlier in the text.

Standing

Achievement of an erect standing posture represents a developmental milestone in the infant's quest for stability. It is an indication that control over the musculature has been gained to the extent that the force of gravity can no longer place such demanding restraints on movement. The infant is now on the verge of achieving upright locomotion (walking), a feat heralded by parents and

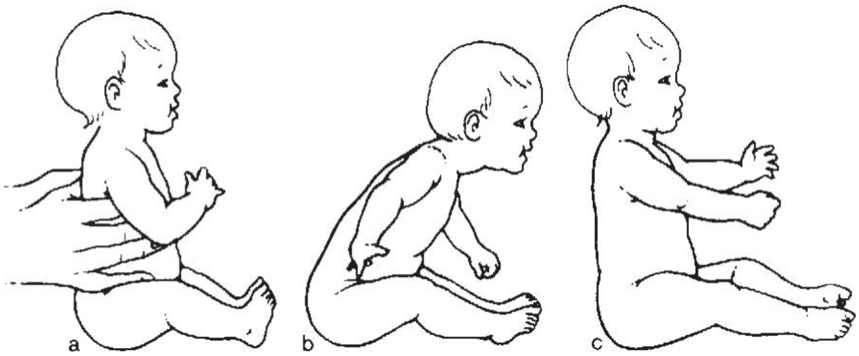

Figure8 .1
Three stages in achieving independent sitting: (a) third month, (b) sixth month, and (c) eighth month.

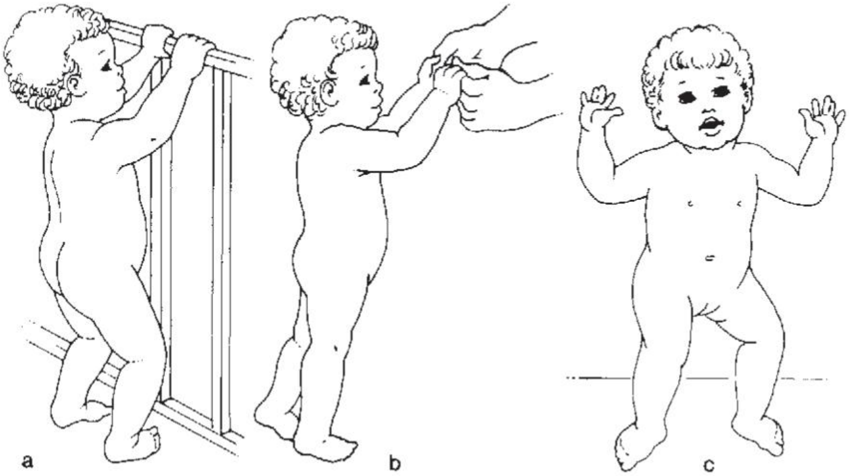

Figure8 .2
Three stages in gaining a standing posture: (a) sixth month, (b) tenth month, and (c) twelfth month.

pediatricians as the infant's most spectacular task of motor development.

The first voluntary attempts at standing occur around the fifth month. When held under the armpits and brought in contact with a supporting surface, the infant will voluntarily extend at the hip, straighten and tense the muscles of the legs, and maintain a standing position with considerable outside support. Around the ninth or tenth month, infants are able to stand beside furniture and support themselves for a considerable time. Gradually, the infant begins to lean less heavily on the supporting object and can often be seen testing balance completely unsupported for a brief instant. Between the eleventh and twelfth months the infant learns to pull to a stand by first getting to the knees and then pushing with the legs while the upward extended arms pull down. Standing alone for extended periods generally takes place with walking alone and does not appear separately in most babies. The onset of an erect standing posture normally occurs somewhere between 11 and 13 months (Figure 8.2). At this point the infant has gained considerable control over the musculature and can accomplish the difficult task of rising from a lying position to a standing position completely unaided.

From a developmental perspective it is important to note that movement patterns demonstrated by infants and toddlers when moving from a supine to a standing position do change as the child grows older (Marsala and VanSant, 1998).

Locomotion

The infant's movement through space depends on emerging abilities to cope with the force of gravity. Locomotion does not develop independently of stability; it relies heavily on it. The infant will not be able to move about freely until the rudimentary developmental tasks of stability are mastered. The following are discussions of the most frequent forms of locomotion engaged in by the infant while learning how to cope with the force of gravity. These forms of locomotion are also summarizedi n Table8. 2.

Concept 8.4

Development of rudimentary locomotor abilities provides the infant with a means for exploring a rapidly expanding world.

Crawling

The crawling movements of the infant are the first attempts at purposeful locomotion. **Crawling** evolves as the infant gains control of the muscles of the head, neck, and trunk. In a prone position and using a **homolateral pattern,** the infant may reach for an object in front of her, raising her head and chest off the floor. On coming back down, the outstretched arms pull her back toward the feet. The result of this combined effort is a slight sliding movement forward (Figure 8.3). The legs are usually not used in these early attempts at crawling. Crawling generally appears in the infant by the sixth month but may appear as early as the fourth month.

Creeping

Creeping evolves from crawling and often develops into a highly efficient form of locomotion for the infant. Creeping differs from crawling in that the legs and arms are used in opposition to one another. The infant's first attempts at creeping are characterized by deliberate movements of one limb at a time. As the infant's proficiency increases, movements become synchronous and more rapid. Most efficient creepers use a **contralateral pattern** (right arm and left leg). There is some evidence that suggests that infants who had skipped crawling and moved directly to creeping were less efficient

Table 8.2 Developmental Sequence and Approximate Age of Onset of Rudimentary Locomotor Abilities

Locomotor Tasks	Selected Abilities	Approximate Age of Onset
Horizontal movements	Scooting	Third month
	Crawling	Sixth month
	Creeping	Ninth month
	Walking on all fours	Eleventh month
Uprightg ait	Walks with support	Sixth month
	Walks with handholds	Tenth month
	Walks with lead	Eleventh month
	Walks alone (hands high)	Twelfth month
	Walks alone (hands low)	Thirteenth month

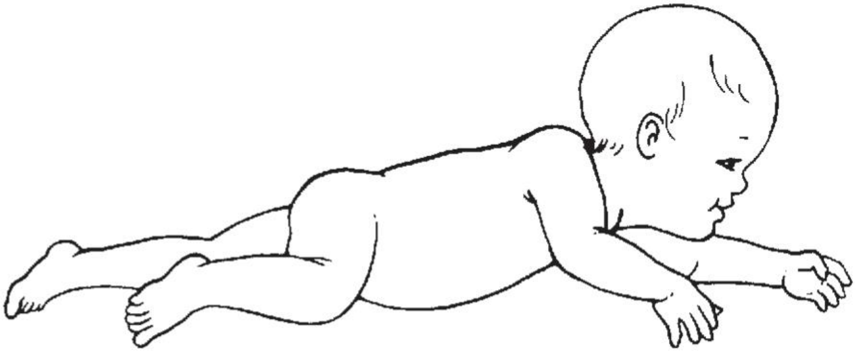

Figure8 .3
Crawling.

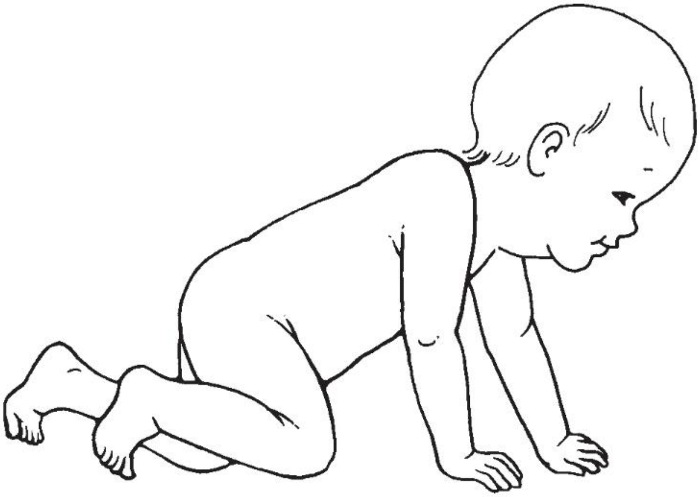

Figure8 .4
Creeping.

in their creeping movements than those who experienced crawling initially (Adolph, Vereijken, and Denny, 1998). See Figure 8.4 for a visual representation of contralateral creeping.

Upright Gait

The achievement of upright gait or walking depends on the infant's stability. The infant must first be able to control the body in a standing position before tackling the dynamic postural shifts required of upright locomotion. The infant's first attempts at independent walking generally occur somewhere between the tenth and fifteenth months and are characterized by a wide base of support, the feet turned outward, and the knees slightly flexed. These first walking movements are not synchronous and fluid. They are irregular, hesitant, and unaccompanied by reciprocal arm movements. It has been demonstrated that as they attempt to walk, infants exhibit cocontraction patterns in the various muscle groups of the lower body. Agonist and antagonist muscle groups are activated at the same time in an attempt to maintain body stability

DEVELOPMENTAL DILEMMA

Creeping Facilitates Neurological Organization. Or Does It?

There has been considerable speculation about the importance of creeping in the infant's motor development and the "proper" method of creeping. The neurological organization rationale often referred to as neurological patterning, placed great importance on proper creeping and crawling techniques as a necessary stage in achieving cortical hemispherical dominance.

According to the dominance rationale, one side of the cortex is necessary for proper neurological organization. Faulty organization, it is hypothesized, will lead to motor, perceptual, and language problems in the child and adult.

For years, neurologists, pediatricians, and researchers in the area of child development have vigorously attacked this hypothesis. Unfortunately, it still continues to come up as a topic of discussion concerning infant stimulation programs even though in 1982 and again in 1999 the American Academy of Pediatrics stated that neurological patterning treatment programs offer no special merit and the claims of its proponents remain unproven. In fact, the Academy is emphatic in condemnation of neurological patterning treatments, saying: "This treatment is based on an outmoded and oversimplified theory of brain development. Current information does not support the claims of proponents that this treatment is efficacious, and its use continues to be unwarranted."

Brain development is complex, and early motor development during infancy plays a yet undetermined but important role. Current data, however, simply do not support claims made by adherents to hemispherical dominance theory and patterning advocates who insist that "proper" creeping is necessary for proper brain organization.

(Okamoto & Okamoto, 2001). While central nervous system maturation is extremely important to the advent of walking, other individual-oriented factors such as the elastic qualities of the muscles, anatomical properties of the bones and joints, and the energy delivered to the moving limbs serve as critical interactive systems (Thelen, 1992). Additional environmental factors such as parental encouragement and assistance and availability of furniture handholds may contribute to the timing of when independent walking appears.

Shirley (1931) identified four stages that the infant passes through in learning how to walk unaided: "(a) an early period of stepping in which slight forward progress is made (3–6 months); (b) a period of standing with help (6–10 months); (c) a period of walking when led (9–12 months); (d) a period of walking alone (12–15 months)" (p. 18). As the infant passes through each of these stages and progresses toward a mature walking pattern, several changes occur. First, the speed of walking accelerates and length of the step increases. Second, the width of the step increases until independent walking is well established, and then decreases slightly. Third, the eversion of the foot gradually decreases until the feet are pointing straight ahead. Fourth, the upright walking gait gradually smooths out, the length of the step becomes regular, and the movements of the body become synchronous. Shortly after independent walking has been achieved, the toddler will experiment with walking sideways, backward (Eckert, 1973), and on tiptoes (Bayley, 1935).

MANIPULATION

As with stability and locomotion, the manipulative abilities of the infant evolve through a series of stages. In this section, only the most basic aspects of manipulation—reaching, grasping, and

TABLE 8.3 Developmental Sequence and Approximate Age of Onset of Rudimentary Manipulative Abilities

ManipulativeT asks	Selected Abilities	Approximate Age of Onset
Reaching	Globular ineffective reach	First to third month
	Definite corralling reach	Fourth month
	Controlled reach	Sixth month
Grasping	Reflexive grasp	Birth
	Voluntary grasp	Third month
	Two-hand palmar grasp	Third month
	One-hand palmar grasp	Fifth month
	Pincerg rasp	Ninth month
	Controlled grasp	Fourteenth month
	Eats without assistance	Eighteenth month
Releasing	Basic release	Twelfth to fourteenth month
	Controlled release	Eighteenth month

releasing—will be considered. As with the sections on stability and locomotion, the manipulative abilities of the infant may be susceptible to early appearance even though the process is influenced greatly by maturation. If the child is maturationally ready, she will benefit from early opportunities to practice and perfect rudimentary manipulative abilities.

The following are the three general steps in which the infant engages during the acquisition of rudimentary manipulative abilities. Table 8.3 provides a summary of the developmental sequence and approximate age of onset of rudimentary manipulativea bilities.

CONCEPT 8.5

The emergence of rudimentary manipulative abilities provides the developing infant with the first meaningful contact with objects in the immediate environment.

Reaching

During the first 4 months, the infant does not make definite reaching movements toward objects, although she may attend closely to them visually and make globular encircling motions in the general direction of the object. Around the fourth month she begins to make the fine eye and hand adjustments necessary for contact with the object. Often the infant can be observed making alternating glances between the object and the hand. The movements are slow and awkward, involving primarily the shoulder and elbow. Later the wrist and the hand become more directly involved. By the end of the fifth month, the child's aim is nearly perfect, and she is now able to reach for and make tactual contact with objects in the environment. This accomplishment is necessary before she can take hold of the object and grasp it in the hand. Some factors demonstrated to influence the accuracy of infant reaching include the speed of the movement (Thelen, Corbetta, and Spencer, 1996) and the position or posture of the infant's body when reaching (i.e., supine, sitting, standing, walking) (Corbetta & Bojczyk, 2001; Rochat, 1992; Savelsbergh & van der Kamp, 1994).

Grasping

The newborn will grasp an object when it is placed in the palm of the hand. This action, however, is entirely reflexive until about the fourth month. Voluntary grasping must wait until the sensorimotor mechanism has developed to the extent that efficient reaching and meaningful contact can take place. Halverson (1937) identified several stages in the development of prehension. In the first stage, a 4-month-old infant makes no real voluntary effort at tactual contact with an object. In the second stage, the 5-month-old infant is capable of reaching for and making contact with the object. He is able to grasp the object with the entire hand, but not firmly. In the third stage, the child's movements are gradually refined so that by the seventh month the palm and fingers are coordinated. The child is still unable to effectively use the thumb and fingers. In the fourth stage, at about 9 months of age, the child begins use of the forefinger in grasping. At 10 months of age reaching and grasping are coordinated into one continuous movement. In the fifth stage, efficient use of the thumb and forefinger comes into play at around 12 months of age. In the sixth stage, when the child is 14 months old, prehension abilities are much like those of adults. Environmental factors that appear to influence the quality of the grasping movement include the size, weight, texture, and shape of the object being held (Case-Smith, Bigsby, and Clutter, 1998; Siddiqui, 1995).

The developmental progression of reaching and grasping is complex. Landreth (1958) stated that six component coordinates appear to be involved in the development of prehension. Eckert (1987) neatly summed up these six developmental acts in the following statement:

> These acts involve transitions and include: (1) the transition from visually locating an object to attempting to reach for the object. Other transitions involve: (2) simple eye-hand coordination, to progressive independence of visual effort with its ultimate expression in activities such as piano playing and typing; (3) initial maximal involvement of body musculature to a minimum involvement and greater economy of effort; (4) proximal large muscle activity of the arms and shoulders to distal fine muscle activity of the fingers; (5) early crude raking movements in manipulating objects with the hands to the later pincer-like precision of control with the opposing thumb and forefinger; and (6) initial bilateral reaching and manipulation to ultimate use of the preferred hand. (pp. 122–123)

Releasing

The frantic shaking of a rattle is a familiar sight when observing a 6-month-old infant at play. This is a learning activity usually accompanied by a great deal of smiling, babbling, and obvious glee. Minutes later, however, the same infant may be observed shaking the rattle with obvious frustration and apparent rage. The reason for this abrupt shift in moods may be that at 6 months of age the infant has yet to master the art of releasing an object from the grasp. The child has succeeded in reaching for and grasping the handle of the rattle but is not maturationally able to command the flexor muscles of the fingers to relax their grip on the object on command. Learning to fill a bottle with stones, building a block tower, hurling a ball, and turning the pages of a book are seemingly simple examples of a young child's attempts to learn to release, but when compared with earlier attempts at reaching and grasping, these are indeed remarkable advances. By the time the child is 14 months old, she has mastered the rudimentary elements of releasing objects from her grasp. The 18-month-old has well-coordinated control of all aspects of reach, grasp, and release (Halverson, 1937).

As the infant's mastery of the rudimentary abilities of manipulation (reach, grasp, and release) are developing, the reasons for handling objects are revised. Instead of manipulating objects simply to touch, feel, or mouth them, the child now becomes involved in the process of manipulating objects to learn more about the world in which he lives. The manipulation of objects becomes directed by appropriate perceptions to achieve meaningful goals (Figure8. 5).

The development of locomotor, stability, and manipulative movement abilities in infants is influenced by both maturation and learning. These two facets of development are interrelated, and it is through this interaction that the infant develops and refines rudimentary movement abilities. These

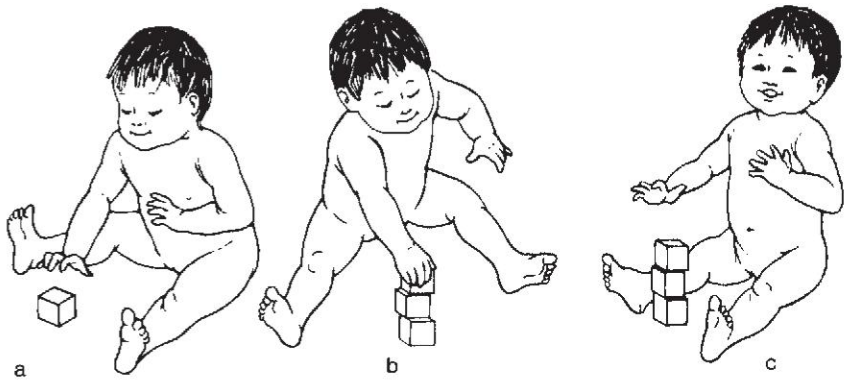

Figure8 .5
Rudimentary (a) reaching, (b) grasping, and (c) releasing.

movement abilities are necessary stepping-stones to the development of fundamental movement patterns and specialized movement abilities.

Special Programs for Infants

For years parents, pediatricians, therapists, and educators have recognized the importance of providing infants with a stimulating and enriching environment in which to grow and develop. This is particularly evident with developmentally delayed or at-risk infants. This awareness led to the passage of Public Law 99-457 in 1986, its reauthorization in Public Law 108-446 in 2000, and finally IDEA, the Individuals with Disabilities Education Act of 2004 (Houston-Wilson, 2011), which mandates **early intervention** services for infants and toddlers with disabilities. One of the stipulations of this legal action is that an individualized family service plan (IFSP) is devised by a multidisciplinary team to provide structure and evaluation to a strategy for facilitating healthy development and reducing or eliminating the potential for developmental delays. Successful implementation of such plans is contingent on the intensity and quality of the intervention program (Houston-Wilson, 2011). Additionally, the theoretical foundation on which the intervention activities are based should be well developed.

Enriching movement experiences are often a major part of the IFSP of an infant at-risk. Moving about and interacting with the environment is one of the primary means by which infants develop cognitively. A recent and unique early intervention strategy on the horizon is the facilitation of independent walking in infants with developmental delays using a treadmill training paradigm. Based on the theoretical studies of Esther Thelen (1985, 1986a), Beverly and Dale Ulrich have pursued a line of research that has resulted in a procedure that can facilitate the onset of independent walking in infants with Down syndrome (Ulrich et al., 2001; Ulrich and Ulrich, 1995; Ulrich, Ulrich, and Collier, 1992; Ulrich, Ulrich, Collier, and Cole, 1995). Their technique involves supporting the infant upright on a small, motorized treadmill (see Figure 8.6). As the belt begins to move, the infants display a well-coordinated, alternating stepping pattern even though they are unable to walk independently. As a result of stepping practice sessions on the treadmill, infants with Down syndrome walked independently months sooner than their counterparts who did not have practice. These findings may be the result of a number of factors including the strengthening and stabilizing of the walking movement pattern, an increase in leg strength, and the improvement of body mechanisms associated with balance and posture (Ulrich and Ulrich, 1999). While progress is still being made in the treadmill design and procedures, treadmill training represents an early intervention strategy that shows great promise for infants with Down syndrome or other developmental disabilities such as cerebral palsy and spina bifida.

Figure8 .6
Infantt readmill.

INTERNATIONAL PERSPECTIVES

Infant Swaddling: Renewal of a Centuries-Old Practice

Prior to the eighteenth century, infant swaddling, sometimes referred to as bundling, with or without a cradle board was an almost universally accepted practice. Swaddling is still commonly practiced in some countries in the Middle East and South America and has gained renewed popularity in the United States, Great Britain, and the Netherlands. The duration and method of swaddling varies greatly across cultures, ranging from the entire first 12 months to as little as 12 weeks. Care needs to be taken in the method of swaddling so as not to do so in a manner that promotes hip dysplasia, which can occur when the infant is placed daily in a leg extension and adduction position.

Although swaddling can be done in a variety of ways, in all cases movement on the part of the infant is restricted. Therefore, one might speculate that a swaddled infant's motor development might be delayed in some manner. An exhaustive review of swaddling studies did not support this hypothesis. In 2007 vonSlevwen and colleagues concluded that infant swaddling has no known negative outcomes or delays in achieving the common motor milestones of infancy. In fact, some studies have suggested that swaddling actually promotes neuromuscular development and motor organization, especially in preterm infants. Furthermore, a nationwide study in New Zealand revealed that swaddled infants placed in a supine position were significantly less prone to sudden infant death syndrome (SIDS), and tolerated supine sleeping better when swaddled.

The reemergence of swaddling in many cultures across the globe is just another example of common child-rearing practices of generations ago being rethought and revived. The same has occurred in the resurgence of vaginal births, breast feeding, and infant stimulation programs.

Another body of research that has emerged over the last ten years is the area of enhancing brain development or recovering from brain injury by attempting complex motor tasks in environmentally enriched settings (Ivanco and Greenough, 2000; Jones and Greenough, 1996; Jones, Klintsova, Kilman, Sirevaag, and Greenough, 1997; Kleim, Pipitone, Czerlanis, and Greenough, 1998). While these studies involved the use of rats as subjects, they lay the groundwork for later theoretical and application research with human beings. This represents the potential for exciting outcomes not only with infants but also across the life span.

Professionals working with infants in physical activity settings will find *Active Start: A Statement of Physical Activity Guidelines for Children from Birth to Age 5* (NASPE, 2009) helpful. Incorporation of the five guidelines that follow will do much to ensure programs for infants that are developmentally appropriate, safe, and enjoyable for both baby and caregiver.

Guideline 1. Infants should interact with caregivers in daily physical activities that are dedicated to exploring movement and the environment.

Guideline2 . Caregivers should place infants in settings that encourage and stimulate movement experiences and active play for short periods of time several times a day.

Guideline3 . Infants' physical activity should promote skill development in movement.

Guideline4 . Infants should be placed in an environment that meets or exceeds recommended safety standards for performing large-muscle activities.

Guideline 5. Those in charge of infants' well-being are responsible for understanding the importance of physical activity and should promote movement skills by providing opportunities for structured and unstructured physical activity. ( )

CONCEPT 8.6

Developmental stimulation programs for at-risk infants have the potential for enhancing later development.

Infant Aquatic Programs

Infant aquatic programs are a popular activity in the United States. Most communities with swimming facilities offer some form of aquatics for babies. Parents enroll their children in infant swimming programs for varying reasons. Some want to "drownproof" their children. Others want babies to learn how to swim in the belief that this is a "critical period" for developing swimming skills. Still others enroll their babies for the sheer pleasure of interacting in a different medium and enhancing the bonding process. Although each of these reasons may have merit, aquatic programs for infants should be approached with caution.

CONCEPT 8.7

Infant aquatic programs may be beneficial in providing additional stimulation and promoting parent-child interaction, but they involve potential dangers that must be acknowledged.

Langendorfer (1987) points out that "regardless of age or skill, *no* person is completely water safe!" (p. 3). Parents who attempt to drownproof their children need to be alerted that this is not possible and that constant vigilance is necessary when children are near the water. Langendorfer further indicated that there is no evidence to suggest that infant swimming enhances later development. The notion of a narrowly defined critical period for learning how to swim is not supported by available research.

Other problems associated with infant swim programs are hyponatremia (or infant water intoxication) and giardia. **Hyponatremia** is a rare but serious condition activated by swallowing excessive amounts of water, which reduces the body's serum sodium level. Symptoms include lethargy, disorientation, weakness, nausea, vomiting, seizures, coma, and death. **Giardia,** a problem much more common to infant swimming classes, is an intestinal parasite that may be transmitted between infants. It causes severe and prolonged diarrhea.

As a result of the misinformation about infant aquatics and potential problems, the American Academy of Pediatrics (2000, reaffirmed and revised 2010) offers a series of recommendations, which include the following:

- Children are generally not developmentally ready for formal swimming lessons until after their fourth birthday.
- Aquatic programs for infants and toddlers should not be promoted as a way to decrease the risk of drowning.
- Parents should not feel secure that their child is safe in water or safe from drowning after participation in such programs.
- Whenever infants and toddlers are in or around water, an adult should be within an arm's length, providing "touch supervision."
- All aquatic programs should include information on the cognitive and motor limitations of infants and toddlers, the inherent risks of water, the strategies of prevention of drowning, and the role of adults in supervising and monitoring the safety of children in and around water.
- Hypothermia,w ateri ntoxication,a nd communicable diseases can be prevented by following existing medical guidelines and do not preclude infants and toddlers from participating in otherwise appropriate aquatic experiencep rograms.

Motor Assessment in Infancy

Medical and allied health professionals routinely conduct motor assessments of infants and toddlers. With the passage of Public Law 99-457 (1986) by the federal government, which amended the 1975 Education of the Handicapped Act by expanding services to children with developmental disabilities from birth to 2 years of age, education professionals began to play a greater role in the assessment of the very young. The American Academy of Pediatrics (2001) points out the value of screening infants and young children and notes the availability of a number of screening instruments.

One of the first assessments administered to infants is the Apgar screening test. Virginia Apgar (1953) developed the Apgar screening test as a quick and reliable method of assessing the newborn immediately after birth. An Apgar rating is made one minute after birth with subsequent ratings given five or more minutes after delivery. Infants are assigned a value of 0, 1, or 2 for each of the following items: (1) heart rate, (2) respiratory effort, (3) reflexive irritability, (4) muscle tone, and (5) color. The maximum total score is 10. Infants with low Apgar ratings generally require immediate attention if they are to survive. Apgar scores appear to be reliable. The test was standardized by Apgar and James (1962) on 27,715 infants. The standardization showed that infants with the lowest Apgar scores had the highest mortality rates and that the device was useful in predicting infant mortality.

Other infant and toddler assessment instruments include the *Denver Developmental Screening Test–Denver II,* the *Bayley Scales of Infant Development—Second Edition,* and the *Peabody Developmental Motor Scales—Second Edition.* These instruments provide a variety of measurements related to fine and gross motor development. Descriptions of these and other infant/toddler assessment instruments can be found in reviews by Zittel (1994) and Burton and Miller (1998).

Summary

During infancy the child's primary concerns are with self-gratification. Primitive reflexes serve the infant well in meeting basic survival needs, but as the child develops, other needs emerge. Among them is the characteristic need to "know." Development proceeds in a predictable sequence but at varying rates as control is gained first over head and trunk and then over the limbs. Sitting enables the infant to more effectively use the arms for exploration. Manipulative skills, including mouthing, allow use of the sensorimotor mechanisms to gain information. Movements become the symbols of the child's thought process because language is limited.

The motor achievements of the normal human infant are not only a function of neurological maturation but also a function of a self-organizing system. Biology plays an important role in the predictable sequence of motor development. There is, however, considerable normal variation in the rate of development. Although neuromuscular maturation must occur for the infant to progress to the next developmental level, several environmental and task demand factors (constraints) determine the rate. Environments that provide stimulation and opportunities for exploration encourage early acquisition of rudimentary movement patterns. Crawling, for example, is often the outgrowth of an ocular following pattern, while standing and an upright gait are reinforced by the presence of handholds in the child's environment.

Questions for Reflection

1. What are the differences and the similarities between the reflex inhibition and the precontrol stages of motor development?
2. What are the intertask motor milestones that lead to upright locomotion and visually guided reaching?
3. In what key ways does study of infant motor development today differ from that of only 30 to 40 years ago?
4. What is the controversy concerning infant crawling and neurologic organization?
5. Infant stimulation programs have become quite popular for typically developing infants as well as those at risk. Why and what commonsense guidelines need to be followed?

Critical Readings

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Web Resources

www.kines.umich.edu/group/developmental-neuromotor-control-laboratory

University of Michigan's Developmental Neuromotor Control Laboratory. The laboratory is directed by Dr. Beverly Ulrich. The site contains thumbnail sketches of several research projects currently underway, including infant motor development studies.

www.growingchild.com/milestones.html

Growing Child newsletter page lists the developmental milestones from six months to six years. Page includes subscription information, brain development facts, and customer services.

www.isisweb.org/main.htm

Homepage for the International Society on Infant Studies. ISIS is "devoted to the promotion and dissemination of the research on the development of infants." Site contains a description of the society, latest news, and newsletter.

www.srcd.org

Society for Research in Child Development homepage. The society is an international professional association focused on human development. The site includes news for members, job opportunities, suggested publications, summaries of journal articles, and information on becoming a member of the society.

library.med.utah.edu/pedineurologicexam/html/home_exam.html

University of Utah website on the pediatric neurologic examination. Contains short and very well done videos of the infant neurological examination from birth to 24 months.

www.aahperd.org/naspe/standards/nationalGuidelines/ActiveStart.cfm

Active Start: A Statement of Physical Activity Guidelines from Birth to Age 5 (2nd ed.). Full version available in print. Online version provides guidelines for infants, toddlers, and preschoolers. Full version with practical suggestions for parents and caregivers available in print.

www.zerotothree.org

Homepage for the National Center for Infants, Toddlers and Families. Click on *On the Move: The Power of Movement in Your Child's First Three Years* for up-to-date, parent-friendly information on physical activity and play for the very young.

CHAPTER

9 INFANT PERCEPTION

KEY TERMS

Perception
Sensations
Habituation
Dishabituation
Evokedp otentials
Consensualpupi llaryr eflex
Visuala cuity
Accommodation(v isual)
Peripheralv ision
Binocularv ision
Tracking
Bifovealfi xation
Fusion
Stereopsis
Saccades
Depthp erception
Chromatici ntensity
Colorper ception
Formp erception
Auditoryp erception
Olfactoryp erception
Gustatoryp erception
Tactilep erception

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Discuss changes in perceptual functioning duringi nfancy
- Describe various methods of studying infant perception
- Discuss developmental aspects of infant visual perception
- Describe developmental changes in visual acuity, accommodation, and peripheral vision
- Distinguish between the terms *binocularity, fixation,* and *tracking*
- Discuss the visual-cliff experiments and draw conclusions about infant depth perception
- Debate the question concerning infants' perception of color
- Trace the developmental aspects of form perception
- Describe various aspects of infant auditory, olfactory,a ndg ustatoryp erception

KEY CONCEPT

Perceptual development is intricately entwined with infant motor development, resulting in an interdependent perceptual-motor system.

From the moment of birth, infants begin the process of learning how to interact with the environment. This interaction is a perceptual as well as a motor process. **Perception** refers to any process in which sensory information or sensations are interpreted or given meaning regarding what is occurring about ourselves. *Perceptual-motor* refers to the process of organizing incoming information with stored information that leads to an overt act or motor performance. All voluntary movement involves an element of perception. Students of motor development should be concerned with perceptual development because of the important link between perceptual and motor processes. Santrock (2009) points out that in viewing development through a dynamic systems perspective perceptual development and motor development are coupled and not isolated from each other. Therefore people perceive in order to experience movement and move in order to experience perception.

To gain immediate information about the outside world, we must rely on our various senses. Newborns receive all sorts of stimulation (visual, auditory, olfactory, gustatory, tactile, and kinesthetic) through the various sense modalities. They make responses to these stimuli, but these responses have limited utility. Only when sensory stimuli can be integrated with stored information do these **sensations** take on meaning for the infant and truly warrant being called perceptions.

Newborns attach little meaning to sensory stimuli. For example, light rays impinging on the eyes register on the retinas and are transmitted to appropriate nerve centers in the sensory areas of the cortex. The newborn's reaction is simple (sensation)—if the light is dim the pupils dilate, and if the light is bright the pupils constrict and some of the stimulation is obscured (*consensual pupillary reflex*). Soon the neonate blinks as the stimulus approaches. These simple reflex actions persist throughout life, but in a short time the infant begins to attach meaning to the visual stimuli received. Soon a certain face becomes "mother." An object is identified as having either three or four sides. The infant attends to certain stimuli and begins to apply basic meaning to them with the powers of visual perception.

CONCEPT 9.1

In infancy, development of the perceptual system is more rapid than that of the motor system.

As with the development of movement abilities in the infant, the development of perceptual abilities is a matter of experience and maturation. Maturation plays an important role in the development of increased acuity of perception, but much improvement in acuity is due to experience. Learning opportunities afforded children, adolescents, and adults enhance the sophistication of their perceptual modalities within their genetic potential. Similarly, only through experience will the infant be able to acquire many perception capabilities. The infant's perceptual development is basic to later functioning and, as we will see, is intricately intertwined with the motor system.

METHODS OF STUDYING INFANT PERCEPTION

In the study of infant perceptual abilities a number of techniques are used to determine infants' responses to various stimuli. Because they cannot verbalize or fill out questionnaires, indirect techniques of naturalistic observation are used as the primary means of determining what infants can see, hear, feel, and so forth. Each of these methods compares an infant's state prior to introduction of the stimulus with its state during or immediately following the stimulus. The difference between the two measures provides the researcher with an indication of the level and duration of the response to

DEVELOPMENTAL DILEMMA

Studying Infant Perception: A Communications Dilemma

Infants cannot provide us with the verbal feedback necessary for us to know conclusively what their response to a particular perceptual stimulus means. Without speech, for example, we cannot be certain what their response to mother's face versus a stranger's face really means. To try to know what the infant is perceiving, researchers have devised several techniques that they "think" are accurate markers of the infant's visual, auditory, gustatory, olfactory, and tactile perception, including the following, which are explained further in this chapter:

- Naturalistico bservation
- Filma nalysis
- Changes in heart and respiration rates
- Nonnutritive sucking
- Habituation-dishabituation
- Evoked potentials

The dilemma lies in the knowledge that no matter what technique is used, researchers still have only an indirect measure of the infant's perceptual response to a given stimuli. We can take heart, however, because the preponderance of research conducted over the past 50 years leans strongly toward perception, in all its forms, being a developmental phenomenon, a phenomenon that in the typically developing infant moves from crude simple abilities to more complex abilities to discriminate in perceptual qualities such as color, form, taste, smell, and touch.

the stimulus. For example, if a uniformly moving pattern of some sort is passed across a neonate's visual field, repetitive following movements of the eyes occur. The occurrence of these eye movements provides evidence that the moving pattern is perceived at some level by the newborn. Similarly, changes in the infant's general level of motor activity—turning the head, blinking the eyes, crying, and so forth—have been used by researchers as visual indicators of the infant's perceptual abilities.

Such techniques, however, have limitations. First, the observation may be unreliable in that two or more observers may not agree that the particular response occurred, or to what degree it occurred. Second, responses are difficult to quantify. Often the rapid and diffuse movements of the infant make it difficult to get an accurate record of the number of responses. The third, and most potent, limitation is that it is not possible to be certain whether the infant's response was due to the stimulus presented or simply to a change from no stimulus to a stimulus. The infant may be responding to aspects of the stimulus different from those identified by the investigator. Therefore, when observational assessment is used as a technique for studying infant perceptual abilities, care must be taken not to overgeneralize from the data or to rely on one or two studies as conclusive evidence of a particular perceptual quality of the infant.

CONCEPT 9.2

The ability to generalize from conclusions reached in observational studies of infant perceptual development, even though the study techniques are sophisticated, is limited at best.

Observational assessment techniques have become much more sophisticated, reducing the limitations just presented. Film analysis of the infant's responses, heart and respiration rate monitors, and nonnutritive sucking devices are used as effective tools in understanding infant perception. Film analysis permits researchers to carefully study the infant's responses over and over and in slow motion. Precise measurements can be made of the length and frequency of the infant's attention between two stimuli. Heart and respiration rate monitors provide the investigator with the number of heartbeats or breaths taken when a new stimuli is presented. Numerical increases are used as quantifiable indicators of heightened interest in the new stimulus. Increases in *nonnutritive sucking* were first used as an assessment measure by Siqueland and DeLucia (1969). They devised an apparatus that connected a baby's pacifier to a counting device. As stimuli were presented, changes in the infant's sucking behavior were recorded. Increases in the number of sucks were used as an indicator of the infant's attention to, or preference for, a given visual display.

Two additional techniques of studying infant perception have come into vogue: habituation-dishabituation and evoked potentials. In the *habituation-dishabituation* technique, a single stimulus is presented repeatedly to the infant until there is a measurable decline (**habituation**) in whatever attending behavior is being observed. At that point a new stimulus is presented, and any recovery (**dishabituation**) in responsiveness is recorded. If the infant fails to dishabituate and continues to show habituation with the new stimulus, it is assumed that the baby is unable to perceive the new stimulus as different. The habituation-dishabituation paradigm has been used most extensively with studies of infant auditory and olfactory perception. **Evoked potentials** are electrical brain responses that may be related to a particular stimulus because of where they originate. Electrodes are attached to the infant's scalp. Changes in the electrical pattern of the brain indicate that the stimulus is getting through to the infant's central nervous system and eliciting some form of response.

Each of the preceding techniques provides the researcher with hard evidence that the infant can detect or discriminate between stimuli. With these sophisticated observational assessment and electrophysiological measures we know that the neonate of only a few days is far more perceptive than previously suspected. However, these measures are still only "indirect" indicators of the infant's perceptual abilities. Rigid adherence to a chronological age classification of these abilities is unwise. Moreover, perception in infants is viewed today clearly as a developmental phenomenon. Based on the volume of research on the topic, human infants are now seen as being perceptually competent (Bornstein, 2005).

Visual Perception

At birth, the infant's eyes have all of the parts necessary for sight and are almost completely formed. The fovea is incompletely developed, and the ocular muscles are immature. These two factors result in poor fixation, focusing, and coordination of eye movements. The blinking and lacrimal (tear formation) apparatuses are poorly developed at birth, and the neonate is unable to shed tears for one to seven weeks after birth. Also, it is debatable whether the newborn possesses color vision because of the amount of rhodopsin and iodopsin (visual purple) present in the rods and cones of the eye. Visual acuity, accommodation, peripheral vision, binocularity, fixation, tracking, color vision, and form perception develop rapidly during the early weeks and months following birth. Table 9.1 presents a list of the major developmental aspects of infant visual perception, along with the approximate age at which these abilities begin to emerge.

Concept 9.3

At birth, the eye is structurally complete but functionally immature.

Contrast Sensitivity

The visual apparatus is anatomically complete at birth, although it may be functionally immature. Vision is first used by the newborn in responding to various light intensities. At birth the newborn exhibits a **consensual pupillary reflex** in which the pupils dilate or constrict in response to the intensity of a localized light source. Hershenson (1964) found that 2- to 4-day-old infants looked at medium-intensity lights longer than at dim or high-intensity lights. Peeples and Teller (1975) found that 2-month-old infants could discriminate between bars of light against a black background almost as well as adults. The babies were able to detect differences in brightness of as little as 5 percent, whereas adults were able to make 1 percent discriminations. Additionally, it has frequently been observed that newborns tighten their eyelids

TABLE 9.1 Developmental Aspects of Selected Infant Visual Perceptual Abilities

VisualQ uality	Selected Abilities	Approximate Age of Onset
Sensitivity to Light	Consensual pupillary reflex (contraction and dilation of the pupils)	Birth
The visual apparatus is complete in the newborn and is first put to use by adjusting to varying intensities of the light source.		2 to 3 hours
	Strabismus	Birth to 14 days
	Turns head toward light source	Birth
	Closes eyes if light is bright	Birth
	Tightens eyelids when asleep	Birth
	More active in dim light than in bright light	Birth to 1 year
Visual Acuity	Organically complete visual apparatus	Birth
The length of focus increases daily as the eye matures.	Length of focus 4 to 10 in. (10.2–25.4 cm)	Birth to 1 week
	Length of focus about 36 in. (91.4 cm)	3 months
	Length of focus about 100 ft. (30.5 m)	1 year
Accommodation	Poor	Birth to 2 months
Accommodation depends on functional maturity of the lens.	Neara dultlike	2 to 4 months
Peripheral Vision	15 degrees from center	Birth to 2 weeks
Peripheral vision improves rapidly in a horizontal direction.	30 degrees from center	1 to 2 months
	40 degrees from center	5 months
Fixation	Fixates one eye on bright objects	Birth
Fixation is monocular and essentially reflexive during the first weeks.	Fixates both eyes on bright objects	2 to 3 days
	Turns head from one stationary bright surface to another	11 days
	Follows an object in motion, keeping the head stationary	23 days
	Directs eyes toward an object	10 weeks
Tracking	Horizontal	Saccadic pursuit begins at birth
Tracking is first saccadic and gradually smooths out. Develops far sooner than the motor component.	Vertical	Smooth pursuits begin by 2 months
	Diagonal	Sequence is fixed from birth to 2 months
	Circular	
Depth Perception	Monocular vision	Birth
Monocular vision at birth soon gives way to binocular vision and perception of depth.	Binocular vision	2 months
	Depthp erception	2 to 6 months
Color Discrimination and Preference	Colorv ision	Birth?
Inconsistent evidence. Color vision may be present at birth depending on the amount of rhodopsin and iodopsin present.	Colorpe rception	10 weeks
	Prefers shape to color	15 days
	Colord iscrimination	3 months
Form Perception	Prefers patterned objects to plain	Neonate
Discrimination begins early and develops rapidly in complexity. The human face is the favorite object.	Imitates facial gestures	Neonate
	Prefers human face	Neonate
	Size and shape constancy	2 months
	Discriminates between two- and three-dimensional figures	3-6 months

when asleep in brightly lit rooms, and they tend to be more active in dim light than in bright. Perhaps this helps explain why infants are frequently more active at night than during the daylight hours.

CONCEPT 9.4

Visual perceptual abilities develop rapidly during the first six months following birth.

Visual Acuity, Accommodation, and Peripheral Vision

The eye grows and develops rapidly during the child's first two years. In the infant, the cornea is thinner and more spherical than in the adult. As a result, the cornea is more refractive and the infant tends to be slightly myopic at birth. Normal visual acuity is gradually achieved as the cornea rounds out and the lens flattens. The term **visual acuity** refers to the degree of detail that can be seen in an object. The newborn has a focal distance of about 4 to 10 inches (10.2–25.4 cm). The length of focus increases almost daily and is within the range of normal adult acuity by the time the infant is 6 to 12 months old (Aslin & Dumais, 1980; Cohen et al., 1979).

Accommodation, the ability of the lens of each eye to vary its curvature to bring the retinal image into sharp focus, improves with age. The study by Haynes et al. (1965) demonstrated that adultlike accommodation does not occur until around the fourth month. Banks (1980), in a replication of the Haynes study, found partial accommodation at one month and near adultlike focusing around the second month. These studies demonstrated that, until at least 2 months of age, infants are not able to bring objects into sharp focus.

Peripheral vision is the visual field that can be seen without a change in fixation of the eyes. Tronick's (1972) work suggests that the visual field of the 2-week-old is narrow (about 15 degrees from center), but expands to about 40 degrees from center by the fifth month. In line with Tronick (1972), Aslin and Salapatek (1975) found that 1- and 2-month-old infants had a visual field of about

INTERNATIONAL PERSPECTIVES

Beauty Is in the Eye of the Beholder. Or Is It?

The familiar saying "Beauty is in the eye of the beholder" poses an interesting question in terms of infants' interest in and attention to faces considered to be attractive and those considered to be unattractive. Can babies discriminate between the two? Langolis and colleagues (1987) conducted an interesting study in which that very question was asked, but may have raised more questions than answers.

The study was conducted with two sets of infants, one younger (2–3 months) and one older (6–8 months), and used a standard visual preference technique that required the infants to look at slides of women previously rated by other adults as "attractive" or "unattractive." Both study groups were presented with a variety of pairs of faces. The results showed that both the younger and the older babies preferred (i.e., looked longer at) the attractive face when presented with contrasting pairs of attractiveness (attractive/unattractive). However, when presented with similar pairs of attractiveness (attractive/attractive and unattractive/unattractive), only the older study group looked longer at the attractive facial combinations.

This study is provocative in that the authors claim that the results challenge the long-held notion that standards of attractiveness are culturally conditioned through gradual exposure to cultural standards of beauty and that perhaps beauty really is in the eye of the beholder. Given the vast worldwide cultural differences in what is considered to be attractive, it is interesting to contemplate how infants might or might not be acculturated into their society's standard of "beauty." Think about it. How would you design a research study with infants, children, adolescents, and adults to more fully understand the perception of beauty?

30 degrees from center. Normal adult peripheral vision is about 90 degrees from center to either side.

> **CONCEPT 9.5**
>
> Although myopic at birth, with a short focal distance and limited peripheral vision, the neonate responds to various light intensities.

Cohen et al. (1979) reported that "by 6 months of age both the infant's central and peripheral systems are quite mature" (p. 404). It appears, therefore, that visual acuity, accommodation, and peripheral vision improve dramatically as the eyes mature during early infancy. The interaction between these three developing systems is, at present, unknown.

Binocularity, Fixation, and Tracking

The topics of infant binocularity, fixation, and tracking have interested researchers for years. Prerequisite to efficient fixation and tracking behaviors is binocular vision. **Binocular vision** requires that the eyes work together in visually attending to a stationary object *(fixation)* or to a moving object **(tracking)**.

Binocular vision, according to the theoretical framework originally presented by Worth in 1915 as discussed by Aslin and Dumais (1980), occurs at three levels: bifoveal fixation, fusion, and stereopsis. For **bifoveal fixation** to occur, the fovea of the two eyes must be aligned and directed at the same instant toward the object of visual regard. If bifoveal fixation is absent, then fusion and stereopsis cannot occur.

> **CONCEPT 9.6**
>
> Binocular vision occurs at three levels: bifoveal fixation, fusion, and stereopsis.

Fusion is the second level of binocular vision. Fusion is a process in which the images on the two retinas are combined into a single visual percept. When looking at an object, each eye sends information to the retina and on to the brain from a different orientation. The two eyes are about 6 centimeters apart, so a direct line from each eye to the object is different. Krieg (1978) noted that the interocular distance between the two eyes increases by about 50 percent from birth to adulthood. Limited data suggest that infants have fusion by the fourth to sixth month of postnatal life (Aslin, 1977). Fusion is required for stereopsis to occur.

Stereopsis is the third level of binocularity and enables one to detect depth. Stereopsis is based on the extent of retinal disparity, or mismatch, between the two eyes and has been demonstrated in infants 3 months and older (Fox et al., 1980). Aslin and Dumais (1980) stated that "the presence of bifovealfi xation in infants does not guarantee that fusion and stereopsis are present" (p. 60). Therefore, although it is possible that these three levels of binocularity are hierarchical, it is also possible that they exist as three parallel functions interdependent upon one another. The primary developmental determinants of binocular vision, which makes fixation and tracking possible, are visual acuity, contrast sensitivity, accommodation, and the distance between the eyes (Aslin & Dumais, 1980).

Visual fixation is monocular at birth, probably because of the infant's poor visual acuity and contrast sensitivity. Also, visual-motor control of the two eyes is immature. These conditions improve rapidly during the first 6 months, suggesting improvement in the infant's ability to binocularly fixate (Atkinson & Braddick, 1982).

> **CONCEPT 9.7**
>
> Saccadic eye movements govern visual tracking by the young infant.

Binocular tracking is the most basic aspect of visual-motor pursuit. Tracking involves directing the eyes from one line of sight to another. These eye movements are either of a high velocity (saccadic) or slow velocity (smooth pursuit). **Saccades** are quick movements of the eyes that involve a redirection of focus from one object of regard to another.

Saccadic eye movements govern the object tracking of the very young infant. A series of saccadic movements are made as the infant tracks an object across the visual field. A variety of hypotheses are available for this as yet unexplained phenomenon (Aslin, 1984), but by the end of the second week of postnatal life the neonate is capable of making reliable saccadic tracking movements. Dayton and Jones (1964) were the first to demonstrate that the eye movements of the infant are totally saccadic until the end of the second month. However, Aslin (1981), using a very slow moving target, found evidence of smooth pursuits beginning by the sixth week of age. Although the exact timing of the onset of smooth pursuits is debatable, the sequence is clear. Smooth pursuits tracking behaviors first occur in a horizontal direction, followed by vertical, then diagonal, and finally circular (Field, 1976; Haith, 1966; Pratt, 1954).

Depth Perception

Perception of depth involves the ability to judge the distance of an object from oneself. Williams (1983) categorized **depth perception** into "static" and "dynamic" components. *Static depth perception* involves making depth or distance judgments with regard to stationary objects. *Dynamic depth perception* requires one to make distance judgments about moving objects.

CONCEPT 9.8

Perception of depth by the infant is a function of experience as well as maturation.

Static depth perception has been extensively investigated in infants through the now classic *visual-cliff* experiments by Gibson and Walk (1960) and Walk (1966). In these researchers' design, infants and animals capable of self-produced locomotion were encouraged to crawl across a thick sheet of glass that contained a variety of depth cues (Figure 9.1). The experiments concluded that mobile infants, even when coaxed, would not crawl across the "deep end" to their mothers. Svejda and Schmidt (1979) assessed the cardiac responses of prelocomotor infants (mean age of 6.9 months) and locomotor infants (mean age of 7.1 months) as they were lowered to the shallow or the deep side of the cliff. Prelocomotor infants exhibited little or no difference in heart rate levels when lowered to either side. However, locomotor infants showed significant increases in heart rate responses to both sides, but a "more marked acceleration" on the deep side. The results of this experiment tend to confirm the Held and Hein (1963) and Walk (1978) hypotheses that the development of depth perception is in part a function of experience. It also indicates that sensorimotor feedback through early locomotor experience is sufficient to account for a developmental shift on the visual cliff between prelocomotor and locomotor infants. Whether sensorimotor experiences are a necessary condition is still uncertain.

A number of investigations into dynamic depth perception have been conducted with infants in recent years. The reaching responses of young infants presented with moving stimuli have been carefully studied by von Hofsten (Gredebäck & von Hofsten, 2004; Jonsson & von Hofsten, 2003; Rosander & von Hofsten, 2004; von Hofsten, 1979, 1982). The results of his investigations clearly demonstrated that infants as young as 5 days of age make what appear to be purposeful, but poorly controlled, reaching movements toward moving objects. Dynamic depth perception appears to be present in rather sophisticated form by the fourth month of postnatal life. Von Hofsten (1986) stated that: "Thus it seems without doubt that shortly before four months of age the infant starts to be able to use also the purely visual mode of control whereby the seen position of the hand is related to the seen position of the object" (p. 174).

At this point the motor system lags behind the perceptual system. Movements toward an object, though purposeful, are crude, demonstrating poor integration between the visual and motor systems. Adultlike reaching behaviors do not appear until around the sixth month, when differentiation of muscle groups and integration with sensory systems begin to conjoin.

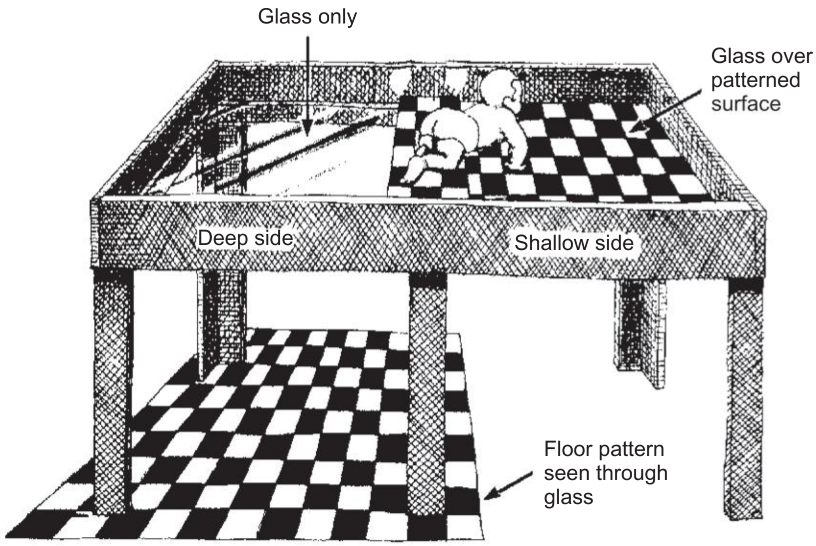

Figure9 .1
Thevi sualc liff.

Color Perception

A large number of studies have been conducted over the years to determine if infants perceive color and are able to distinguish among different colors. Much of the experimentation prior to the 1960s yielded confusing and often conflicting results. Out of this research, however, came the realization that the infant responds to the brightness (i.e., **chromatic intensity**) of the colors presented prior to responding to hue. Hershenson (1964) was the first to demonstrate this in infants, prompting a new wave of studies that attempted to control for the brightness factor. Kellman and Arterberry (1998) concluded that by about 2 or 3 months of age infants seem to have similar color vision to adults and have the ability to discriminate between a variety of colors. We do not know if infants younger than 10 weeks perceive color. The amount of *rhodopsin* and *iodopsin* present in the rods and cones may be insufficient for color vision. Similarly, we do not know categorically if the **color perception** of the infant is identical to that of adults, but limited evidence favors this notion. In 2003 Cohen and Cashon argued that:

> From an information-processing viewpoint, it is interesting that, like form perception even infants' color perception appears to go through a developmental pattern whereby infants begin by processing information at a lower level, and then, later, they begin to integrate that information and process it at a higher level. (p. 25)

CONCEPT 9.9

Infants tend to respond more to the chromatic intensity of color than to the actual hue.

Form Perception

A number of investigators have examined **form perception** in infants. Form perception is the ability to distinguish between shapes and to discriminate among a variety of patterns. Haith (1980) found that newborns placed in a darkened room would look for subtle shadows and edges. Moreover, Kessen et al. (1972), in a similar experiment, reported that newborns responded only to vertical high-contrast edges. However, Haith found that they could also respond to horizontal lines. Fantz et al. (1975) reported that newborns were able to perceive form and preferred curved lines over straight lines.

Salapatek (1975) reported that other researchers examining neonatal responses to squares, circles, and triangles found that the infants tended to fixate on a single line or edge at 1 month of age but spent much more time scanning the figures at 2 months of age. Salapatek drew three important conclusions from the abundance of research on form perception in the newborn:

> First, before 2 months of age visual attention appears to be captured by a single or limited number of features of a figure or pattern. Second, before approximately 1 to 2 months of age there is little evidence that the arrangement or pattern of figural elements plays any role in visual selection or memory. Third, before 1 to 2 months, there is little evidence that the line of sight is attracted by anything more than the greatest number or size of visible contour elements per unit area, regardless of type or arrangement of elements. (p. 226)

CONCEPT 9.10

Complexity governs the infant's visual attending behaviors, in that the infant prefers shape to color and prefers complex shapes to simpler ones.

Infants over 3 months of age appear to exhibit a variety of sophisticated abilities with regard to form perception. Cohen et al. (1979) reported that several investigators have determined that infants can discriminate one pattern from another even when the pattern is placed in a variety of arrangements. Furthermore, "the evidence is reasonably convincing that at some point within the first 6 months following birth infants can perceive multiple forms and can respond to, and prefer, a change in pattern arrangement" (Cohen et al., p. 412). Fantz (1963) found that 2-month-old infants prefer looking at the human face over all other simple stimuli. Cohen et al. reported that by 6 months of age infants can distinguish among two-dimensional photographs of human faces. Clearly, the ability of the infant to discriminate between shapes and patterns develops rapidly during this period and has reached rather sophisticated levels by the end of the first 6 months of postnatal life.

AUDITORY, OLFACTORY, GUSTATORY, AND TACTILE PERCEPTION

Available research data concerning the development of **auditory, olfactory, gustatory,** and **tactile perception** in the human infant are much less complete than for the visual modality. As with vision, the auditory abilities do not unfold exclusively without the influences of the environment. Environmental conditions influence the extent of development of audition. The ear is structurally complete at birth, and the infant is capable of hearing as soon as the amniotic fluid drains (usually within a day or two after birth). The fetus responds to sound before birth. Through the measurement of changes in heart rate it has been demonstrated that the fetus responds to its mother's speech and to musical notes (DeCasper et al., 1994; Lecanuet et al., 2000).

CONCEPT 9.11

Although less widely studied, infant auditory, olfactory, and tactile-kinesthetic perceptions also influence the process of motor development.

Research indicates that the newborn is less sensitive to sound than adults. Aslin et al. (1983) reported that the difference is at least 10 decibels. Sensitivity to sound improves with age, and infants as young as 6 months are more sensitive to high-frequency sounds than neonates (Trehub et al., 1980). Infant auditory perception may be adultlike by 2 years of age (Schneider et al., 1980). The infant can localize sounds at birth and reacts primarily to loudness and duration (Trehub et al., 1991). Crude pitch discriminations have been demonstrated by Leventhal and Lipsett (1964) as early as the first

4 days of postnatal life. Definite responses to tonal differences are seen around the third month, and the infant reacts with pleasure to a parent's voice by the fifth month (Leventhal & Lipsett, 1964).

The research on olfactory and gustatory perception is sparse. It is difficult to separate the developmental sequence of smell and taste because the nose and mouth are closely connected, and stimuli applied to one are likely to affect the other. The newborn does, however, appear to react to certain odors, although this may be due more to pain caused by the pungent odors than to smell. Lipsett et al. (1963) were the first to demonstrate that newborns less than 24 hours old made definite responses when exposed to a highly offensive odor. Engen and Lipsett (1965) showed that infants as young as 32 hours were able to discriminate between two different odors. McFarlane (1975) in studying infants less than a week old found that they could discriminate between the mother's breast pad and a clean pad, with a clear preference for mother's pad. Not one of the infants, however, could discriminate between his or her mother's breast pad and that of another. It may not be until the second week that recognition of mother's smell is developed. Newborns react to taste, preferring sweet tastes to sour ones and sour tastes to bitter ones. Mennella and Beauchamp (1996) point out that while the smell and taste sensory systems are functional during infancy, they mature postnatally and are therefore likely to be influenced by individual experiences.

The research on the tactile system of infants is limited, but there is certainly evidence that newborns respond reflexively to touch (i.e., search reflex, palmar grasp reflex). In addition, the newborn response to pain has been noted through the monitoring of various measures of stress.

Table 9.2 presents a summary of the major developmental aspects of infant auditory, gustatory, olfactory,a ndt actilep erceptions.

TABLE 9.2 Developmental Aspect of Selected Infant Auditory, Olfactory, Gustatory, and Tactile Abilities

PerceptualQ uality	Selected Abilities	Approximate Age of Onset
Auditory Perception	Responds to loud, sharp sounds	Neonatal
The ear is structurally complete at birth, and the newborn can respond to sound.	Ability to localize sounds	Birth
	Reacts primarily to loudness and duration	Birth
	Crude pitch discrimination	1 to 4 days
	Responds to tonal differences	3 to 6 months
	Reacts with pleasure to parent's voice	5 to 6 months
	Adultlike	24 months
Olfactory Perception	Responds to odors	Birth
The olfactory mechanism is structurally complete at birth, and the newborn responds crudely to various odors.	Reduced sensitivity upon repeated application of the stimuli (habituation)	Neonate
	Distinguishes between pleasant and unpleasant odors	2 to 3 days
	Shows preference for mother's odor	2 weeks
	Discrimination abilities improve with practice	Infancy
Gustatory Perception The newborn reacts to variation in sweet, sour, and bitter tastes.	Shows preference in tastes (prefers sweet to sour, sour to bitter)	Neonate
Tactile Perception The newborn reacts to a variety of tactile sensations by responding with reflexive movements.	Turns head when cheek is stroked, sucks when lips are stroked, curls fingers and toes when pressure is applied to those areas	Neonatal

Summary

The study of infant perception has intrigued researchers for years. We now know that the newborn, neonate, and young infant are much more perceptually aware and capable than previously thought. Newer techniques for observing and recording infant responses to various stimuli have been responsible for a shift in our assumptions about the perceptual capabilities of the very young. Observational assessment techniques that use film analysis, heart and respiration monitors, nonnutritive sucking devices, and electrical brain impulse recorders are making new inroads into our understanding of the perceptual world of the infant.

The visual world of the infant has been the most extensively studied perceptual modality. The newborn's eyes are structurally complete, but functionally immature. Rapid progress is seen in the acquisition of a vast array of visual perceptual abilities. Although it is difficult to pinpoint when these abilities emerge, it is possible to chart the sequence of acquisition of many visual perceptual abilities. (Generalized application of observations to all infants should be avoided, however.) The motor developmentalist is especially interested in the visual modality because of its close, often essential, link to voluntary movement. Much movement behavior is governed by our perceptions. Although the visual perceptual world of the infant develops rapidly, the motor system tends to lag behind. It is not until later infancy that the motor system begins to catch up and a matching of perceptual and motor data occurs.

These other sensory modalities (auditory, gustatory, olfactory, and tactile), although important, are less clearly understood in the infant. Furthermore, their link to the motor system, although significant, is less crucial than vision. Therefore, the matching of perceptual and motor data in the infant and young child will probably continue to be a topic of keen interest to researchers and educators.

Questions for Reflection

1. How are infant perceptual development and infant motor development linked?
2. What are the advantages and disadvantages of the various scientific methods of studying infant perception?
3. What are the primary developmental changes in infant visual acuity, accommodation, and peripheral vision?
4. What is the sequence of progression for typically developing infants in their acquisition of more mature visual, auditory, olfactory, and gustatory perceptual abilities?
5. What do the "visual cliff" experiments tell us about infant depth perception and how can this information be used to help ensure infant safety?

Critical Readings

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WEB RESOURCES

www.ecdgroup.com

The Consultative Group on Early Childhood Care and Development webpage. The group is involved in programming, research, policy-advocacy, monitoring and evaluation for young children (0–8 years) at risk in developing countries. Page contains news, events, resources, a library, networks, and membership information.

www.isisweb.org/view/0/index.html

Homepage for the International Society on Infant Studies. ISIS is "devoted to the promotion and dissemination of the research on the development of infants." Site contains a description of the society, latest news, and newsletter.

http://kidshealth.org/parent/growth/senses/sensenewborn.html

Linked from KidsHealth.org providing information about newborns and their senses. Article includes information on newborn sight, hearing, taste, smell, and touch.

cde.ca.gov/sp/cd/re/itf09percmotdev.asp

Homepage for the *Perceptual and Motor Development Domain* section of the **California Infant/Toddler Learning and Development Foundations**(2009).

http://www.zerotothree.org/child-development/brain-development/

The National Center for Infants, Toddlers and Families homepage contains a section on brain development. The site provides a "baby brain map" and tips on facilitating infant brain development.

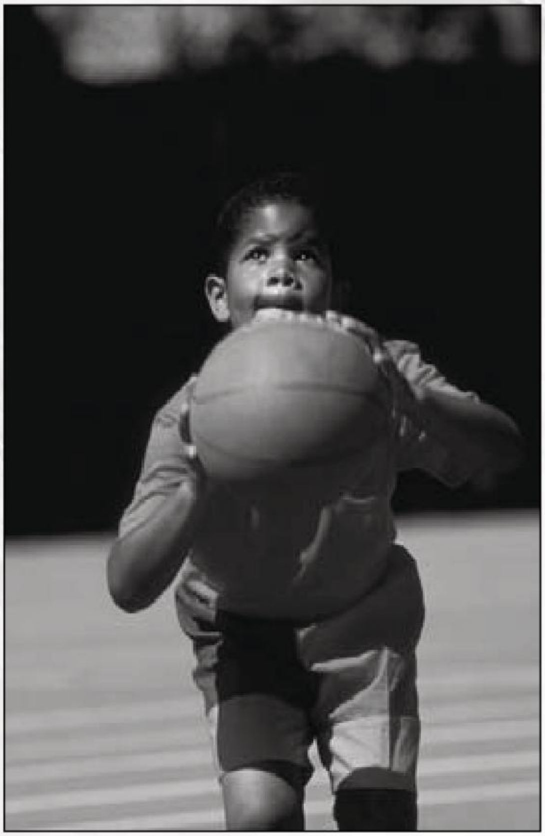
UNIT

III

Childhood

The childhood shows the man, as the morning shows the day.

—JohnM ilton



CHAPTER

10 Childhood Growth and Development

KEY TERMS

Myelination
Chronicm alnutrition
Growthr etardation
Hypertrophy
Atrophy
Endomorphic
Mesomorphic
Ectomorphic
Growthp latei njuries
Bonem ineralization
Seculart rend

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Describe and interpret the normal curve and displacement and velocity graphs during childhood
- Discuss secular trends in physical size and biologicalm aturation
- Discusst he influence of nutritional status on childhood growth processes
- Distinguishb etween *malnutrition* and *undernutrition* and discuss the causes and implications of each
- Describet her elativei nfluences of exercise and injury on the childhood growth process
- List and describe several factors associated with influencing the childhood growth process
- List typical cognitive, affective, and motor development characteristics of the young child (ages 2 to 6) and discuss implications for the developmental movement program
- List typical cognitive, affective, and motor development characteristics of the older child (ages 6 to 10) and discuss implications for the developmentalm ovementp rogram

KEY CONCEPT

Development in childhood is marked by steady, incremental changes in the cognitive, affective, and motor domains.

CONCEPT 10.1

The rate of growth decelerates throughout early childhood resulting in yearly average incremental gains in height and weight of about 2 inches (5.1 cm) and 5 pounds (2.3 kg), respectively.

The period of childhood is marked by steady increases in height, weight, and muscle mass. Growth is not as rapid during this period as it is during infancy, and it slows gradually throughout childhood until the adolescent growth spurt. Childhood is divided here into the early childhood period of 2 to 6 years of age and the later childhood period from about 6 to 10 years of age. Figures 10.1 and 10.2 present height (stature) and weight growth charts for males and females from 2 to 20 years of age. Figures 10.3 and 10.4 provide body mass index-for-age percentiles for females and males age 2–20 (CDC, National Center for Health Statistics, 2011, online at: http://www.cdc.gov/growthcharts/clinical_charts.htm).

Growth in Early Childhood

During the early childhood years, growth in height and weight is not as rapid as it is during infancy. The growth rate decelerates slowly. By 4 years of age, the child has doubled his or her birth length, which represents only about one-half the gain experienced during the first 2 years. The total amount of weight gained from 2 through 5 years of age is less than the amount gained during the first year following birth. The growth process slows down after the first 2 years but maintains a constant rate until puberty. The annual height gain from the early childhood period to puberty is about 2 inches (5.1 cm) per year. Weight gains average 5 pounds (2.3 kg) per year. Early childhood, therefore, represents an ideal time for the child to develop and refine a wide variety of movement tasks ranging from the fundamental movements of early childhood to the sport or specialized skills of middle childhood.

Gender differences may be seen in height and weight, but they are minimal. The physiques of male and female preschoolers are remarkably similar when viewed from a posterior position, with boys being slightly taller and heavier. Boys have more muscle and bone mass than girls, and both show a gradual decrease in fatty tissue as they progress through the early childhood period. The proportion of muscle tissue remains fairly constant throughout early childhood at about 25 percent of total body weight.

Body proportions change markedly during early childhood because of the various growth rates of the body. The chest gradually becomes larger than the abdomen, and the stomach gradually protrudes less. By the time preschoolers reach first grade, their body proportions more closely resemble those of older children. Bone growth during early childhood is dynamic, and the skeletal system is particularly vulnerable to malnutrition, fatigue, and illness. The bones ossify at a rapid rate during early childhood and have been shown to be retarded by as much as three years in growth in deprivedc hildren.

The brain is about 75 percent of its adult weight by age 3 and almost 90 percent by age 6. The midbrain is almost fully developed at birth, but it is not until age 4 that the cerebral cortex is completely developed. The development of myelin around the neurons (**myelination**) permits the transmission of nerve impulses and is not complete at birth. At birth many nerves lack myelin, but greater amounts of myelin are laid down along nerve fibers as the child matures. Myelination is largely complete by the end of the early childhood period, allowing for the complete transference of nerve impulses throughout the nervous system.

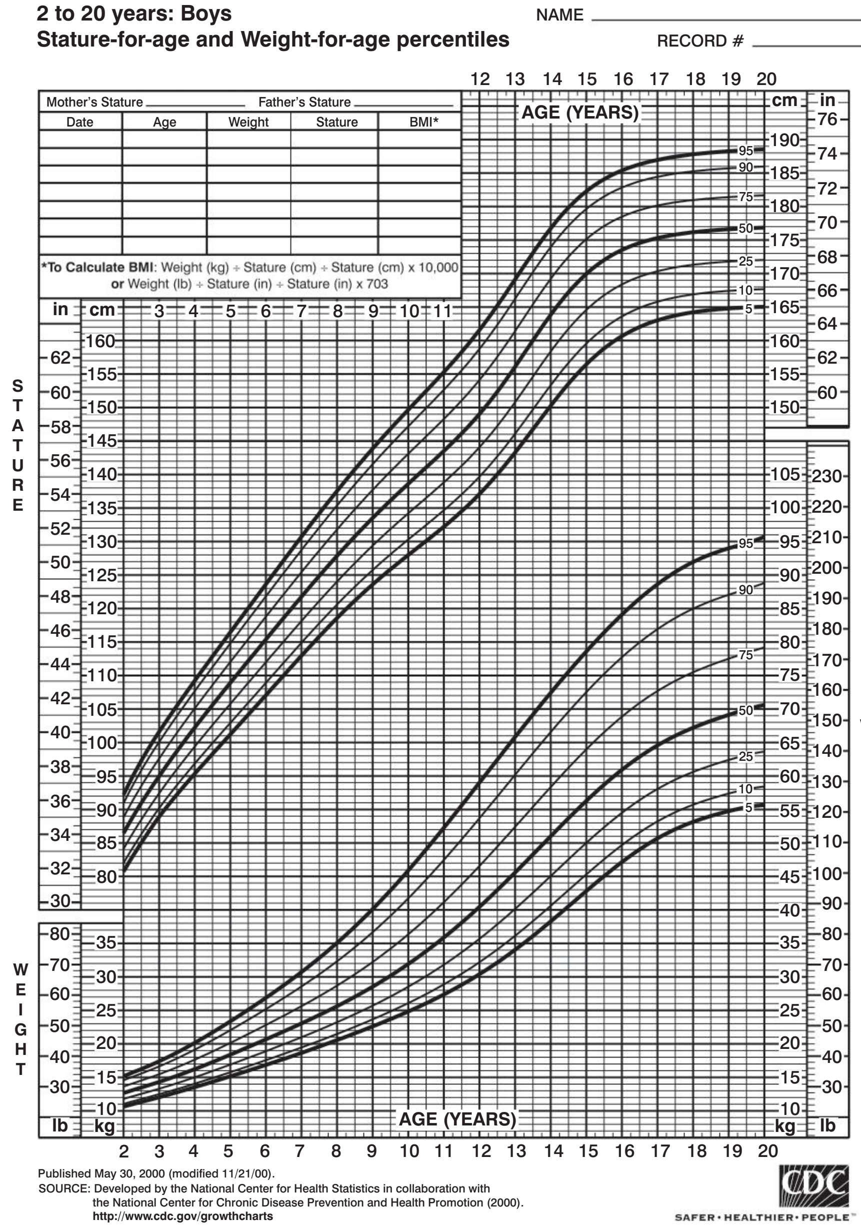


Figure1 0.1

Stature-for-age and Weight-for-age Percentiles for U.S. Boys 2 to 20 Years.

A child's movement patterns are increasingly complex following myelination of the cerebellum.

The sensory apparatus is still developing during the preschool years. The eyeball does not reach its full size until about 12 years of age. Certain sections of the retina are not completely developed until around the sixth year, and the young child is generally farsighted. Preschool

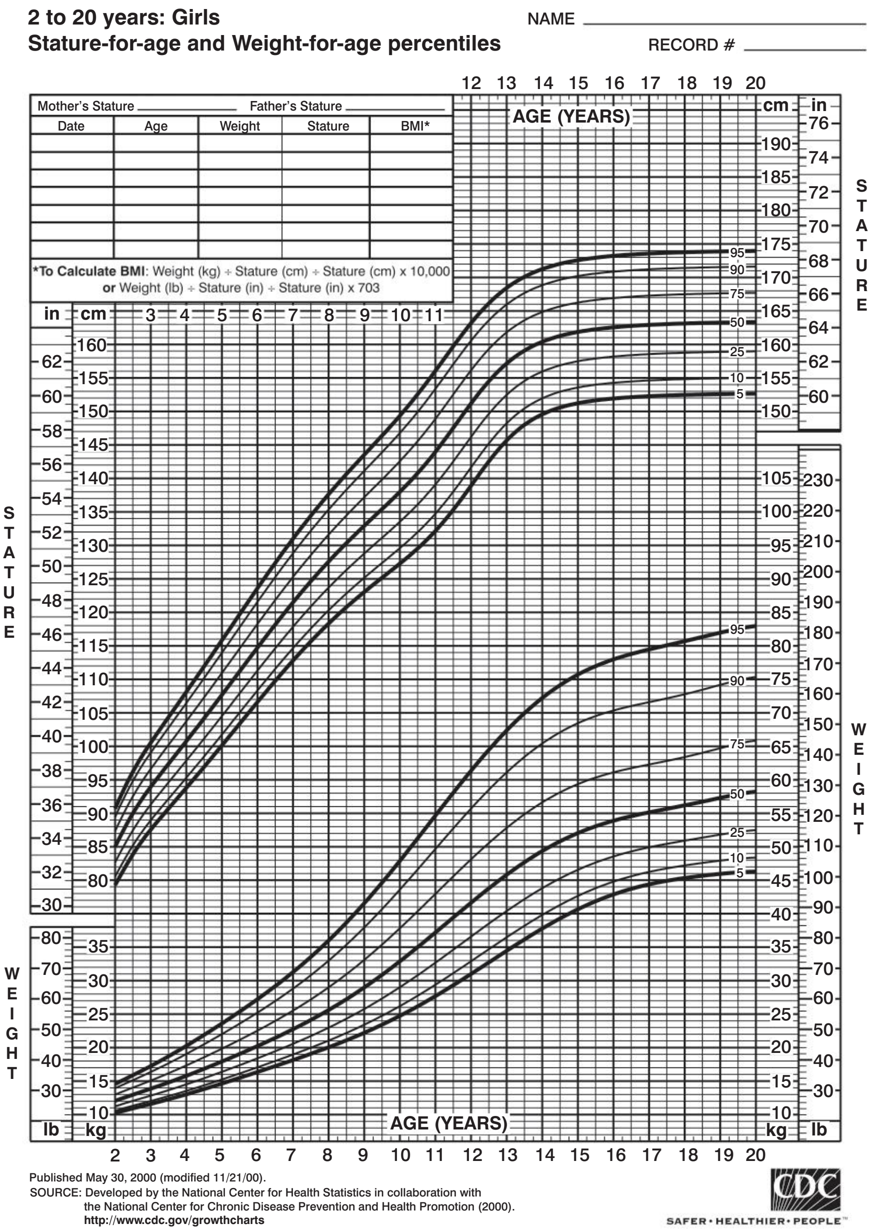


Figure1 0.2

Stature-for-age and Weight-for-age Percentiles for U.S. Girls 2 to 20 Years.

children have more taste buds than adults. They are generously distributed throughout the insides of the throat and cheeks as well as on the tongue, causing greater sensitivity to taste. The eustachian tube, which connects the middle ear with the throat, is shorter and flatter in the child, causing greater sensitivity to ear infections and fluid retention.

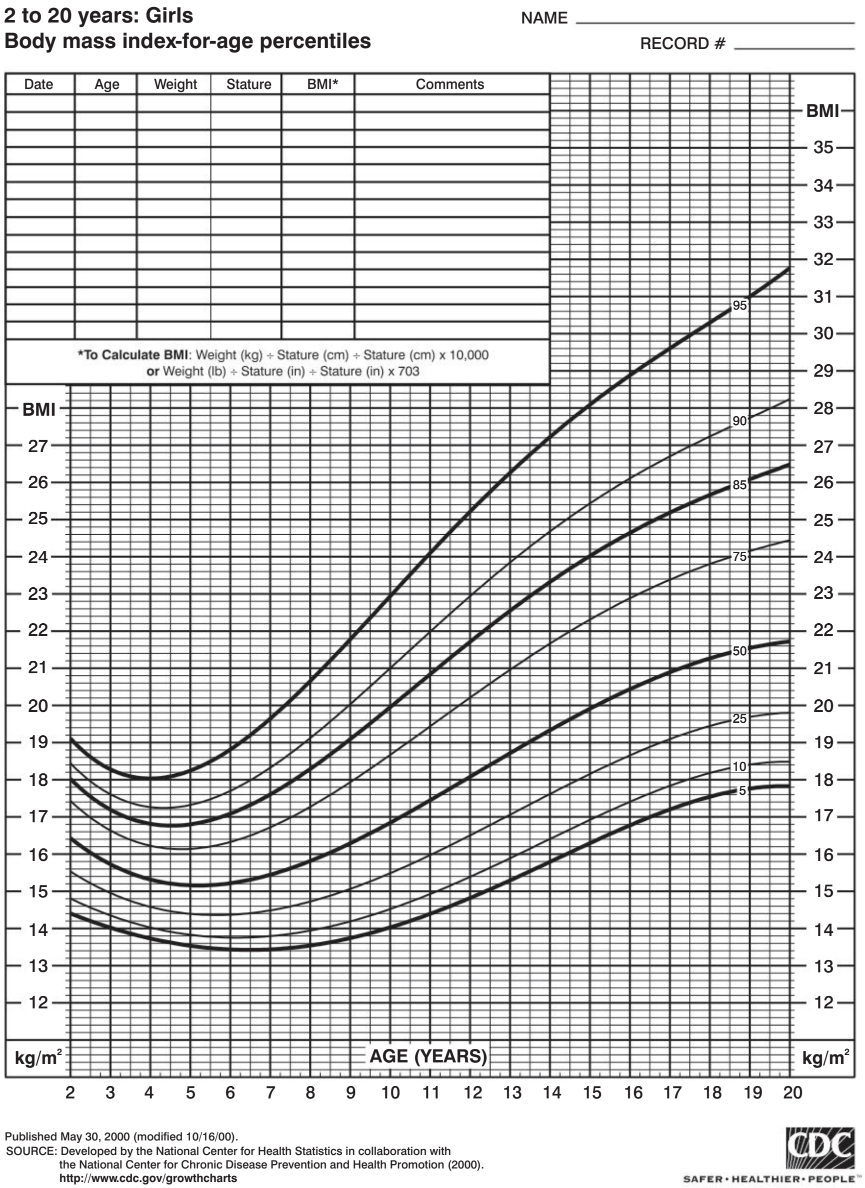


Figure1 0.3

Body Mass Index-for-age Percentiles for U.S. Girls 2 to 20 Years.

DEVELOPMENT IN EARLY CHILDHOOD

Play is what young children do when they are not eating, sleeping, or complying with the wishes of adults. Play occupies most of their waking hours, and it may literally be viewed as the child's equivalent of work. Children's play is the primary mode by which they learn about their bodies and movement capabilities. It also serves as an important facilitator of cognitive and affective growth in the

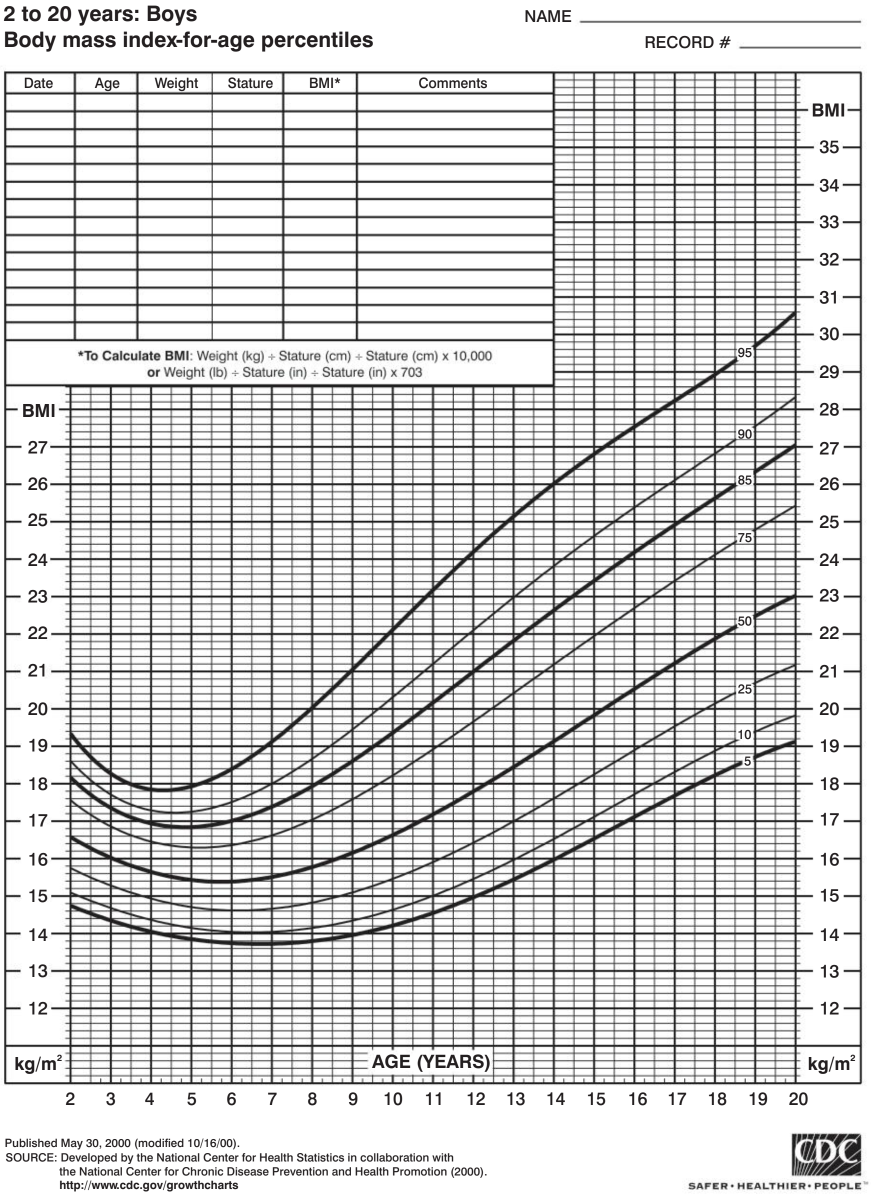


Figure1 0.4

Body Mass Index-for-age Percentiles for U.S. Boys 2 to 20 Years.

young child, as well as an important means of developing both fine and gross motor skills.

Young children are actively involved in enhancing their cognitive skills in a variety of ways. These early years are a period of important cognitive development and have been termed the "preoperational thought phase" by Piaget. During this time children develop cognitive functions that will eventually result in logical thinking and concept formulation. Young children are not capable of thinking from any point of view other than their own. They are extremely egocentric and view almost everything in terms of themselves. The perceptions of preschoolers dominate their thinking, and what is experienced at a given moment has great influence on them. During this preconceptual phase of cognitive development, seeing is, literally, believing. In the thinking and logic of preschool children, their conclusions need no justifications. Children at this age are unable to reconstruct their thoughts and show others how they arrived at their conclusions. Play serves as a vital means by which higher cognitive structures are gradually developed. It provides a multitude of settings and variables for promoting cognitive growth.

CONCEPT 10.2

During early childhood, gender differences are minimal.

Affective development is also dramatic during the early childhood years. During this period children are involved in the two crucial social-emotional tasks of developing a sense of autonomy and a sense of initiative. Autonomy is expressed through a growing sense of independence, which may be seen in a child's delight in answering no to almost any direct question. For instance, even if a child wants to play outside, he or she will often refuse an invitation to do so. This may be viewed as an expression of a new sense of independence and an ability to manipulate some factors in the environment rather than as an expression of sheer disobedience. A way in which to avoid this natural autonomous reaction is to rephrase the question "Do you want to go outside?" to form a positive statement such as "Let's go play outdoors." In this way, the child is not confronted with a direct yes-or-no choice. Care must be taken, however, to give children abundant situations in which expressions of their autonomy are reasonable and proper.

A young child's expanding sense of initiative is seen in curiosity, exploration, and very active behavior. Children engage in new experiences, such as climbing, jumping, running, and throwing objects, for their own sake and for the sheer joy of sensing and knowing what they are capable of doing. Failure to develop initiative and autonomy leads to feelings of shame, worthlessness, and guilt. The establishment of a stable self-concept is crucial to proper affective development in a young child because it has an effect on cognitive and psychomotor functions.

Through the medium of play, young children develop a wide variety of fundamental locomotor, manipulative, and stability abilities. With a stable and positive self-concept, the gain in control over musculature is a smooth one. The timid, cautious, and measured movements of the 2- to 3-year-old gradually give way to the confident, eager, and often reckless abandon of the 4- and 5-year-old. Vivid imaginations make it possible for young children to jump from "great heights," climb "high mountains," leap over "raging rivers," and run "faster" than an assorted variety of "wild beasts."

Children of preschool age are rapidly expanding their horizons. They are asserting their personalities, developing their abilities, and testing their limits as well as the limits of their family and others around them. In short, they are pushing out into the world in many complex and wondrous ways. Caretakers must understand preschoolers' developmental characteristics, their limitations, and their potentials. Only in this way can we effectively structure developmental experiences that truly reflect children's needs and interests and are within their levels of ability.

The following developmental characteristics represent a synthesis of findings from a wide variety of sources and are presented here to provide a more complete view of a child during the early childhood years.

Physical and Motor Development Characteristics

1. Boys and girls range from about 33 to 47 inches (83.8–119.4 cm) in height and from 25 to 53 pounds (11.3–24.0 kg) in weight.
2. Perceptual-motora bilitiesa rer apidly developing, but confusion often exists in

INTERNATIONAL PERSPECTIVES

Childhood Obesity and Chronic Malnutrition: An International Paradox

In North America and other developed countries there is an interesting paradox when compared to emerging or war-torn nations such as Haiti, Sudan, and Afghanistan. On one hand, we have an epidemic of abundance: obesity and all of the health-damaging baggage brought with it. On the other hand, we have the devastating effects of poverty and lack of a reliable food chain from producer to consumer, resulting in devastating consequences of chronic malnutrition.

We live paradoxically in a world of both feast and famine. As a result, the height, weight, and body mass index charts presented in this chapter, when applied globally, will look much different from country to country and from one socioeconomic cohort to another.

The bumper sticker that reads "Think Globally: Act Locally" gives us pause to remember that our "reality" is not necessarily that of another. Worldwide, effective parents, teachers, coaches, and therapists take time to recognize, understand, and do something about the reality in which they live while at the same time being aware of the reality of those beyond their reach.

body, directional, temporal, and spatial awareness.

3. Good bladder and bowel control are generally established by the end of this period, but accidents still occur.
4. Children during this period are rapidly developing fundamental movement abilities in a variety of motor skills. Bilateral movements such as skipping, however, often present more difficulty than unilateral movements.
5. Children are active and energetic and would often rather run than walk, but they still need frequent short rest periods.
6. Motor abilities are developed to the point that the children are beginning to learn how to dress themselves, although they may need help straightening and fastening articles of clothing.
7. The body functions and processes become well regulated. A state of physiological homeostasis (stability) becomes well established.
8. The body builds of both boys and girls are remarkably similar. A back view of boys and girls reveals no readily observable structural differences.
9. Fine motor control is not fully established, although gross motor control is developing rapidly.
10. The eyes are not generally ready for extended periods of close work due to farsightedness.

Cognitive Development Characteristics

1. Therei sc onstantlyi ncreasinga bilityt o express thoughts and ideas verbally.
2. A fantastic imagination enables imitation of both actions and symbols with little concern for accuracy or the proper sequencing of events.
3. There is continuousi nvestigationa nd discovery of new symbols that have a primarily personal reference.
4. The "how" and "why" of the child's actions are learned through almost constant play.
5. This is a preoperational thought phase of development, resulting in a period of transition from self-satisfying behavior to fundamentalsoc ializedbeh aviors.

Affective Development Characteristics

1. During this phase children are egocentric and assume that everyone thinks the way they do. As a result, they often seem to be quarrelsome and reluctant to share and get along with others.
2. They are often fearful of new situations, shy, self-conscious, and unwilling to leave the security of that which is familiar.

3. They are learning to distinguish right from wrong and are beginning to develop consciences.
4. Two- and 4-year-old children are often seen to be unusual and irregular in their behavior, whereas those who are 3 and 5 are often viewed as stable and conforming in their behavior.
5. Self-concepti sr apidlyd eveloping. Wise guidance, success-oriented experiences, and positive reinforcement are especially importantd uringt hesey ears.

Implications for the Developmental Movement Program

1. Plenty of opportunity for gross motor play must be offered in both undirected and directeds ettings.
2. Movemente xperiencess houlds tress movement exploration and problem-solving activities to maximize the child's creativity and desire to explore.
3. Them ovemente ducationp rograms hould include plenty of positive reinforcement to encourage the establishment of a healthy self-concept and to reduce the fear of failure.
4. Stress should be placed on developing a variety of fundamental locomotor, manipulative, and stability abilities, progressing from the simple to the complex as the child becomes "ready."
5. Interests and abilities of boys and girls are similar, with no need for separate activities during this period.
6. Plentyo fa ctivitiesd esigneds pecifically to enhance perceptual-motor functioning are necessary.
7. Advantage should be taken of the child's great imagination through the use of an assortment of activities, including drama and imagery.
8. Because of children's often awkward and inefficient movements, be sure to gear movement experiences to their maturity levels.
9. Provide a wide variety of activities that require object handling and eye-hand coordination.
10. Begin to incorporate bilateral and cross-lateral activities, such as galloping and skipping, after unilateral movements such as hopping have been fairly well established.
11. Encouragec hildren—to helpo vercome tendencies to be shy and self-conscious—to take an active part in the movement education program by "showing" and "telling" others what they can do.
12. Activities should stress arm, shoulder, and upper body involvement.
13. Withoutem phasizing mechanics, correct execution in a wide range of fundamental movements is the primary goal, without emphasis on standards of performance.
14. Do not stress coordination in conjunction with speed and agility.
15. Poor habits of posture are beginning. Reinforce good posture with positive statements.
16. Provide convenient access to toilet facilities and encourage the children to accept this responsibility on their own.
17. Provide for individual differences and allow for children to progress at their own rates.
18. Establishs tandardsf or acceptableb ehavior and abide by them. Provide wise guidance in the establishment of a sense of doing what is right and proper instead of what is wrong andu nacceptable.
19. Thed evelopmental movement program should be prescriptive and based on each individual's developmental level.
20. A multisensory approach should be used; that is, one in which a wide variety of experiences are incorporated, using several sensory modalities.

Growth in Later Childhood

The period from the sixth through the tenth years of childhood is typified by slow but steady increases in height and weight and progress toward greater organization of the sensory and motor systems. Changes in body build are slight during these years. Childhood is more a time of lengthening and filling out prior to the prepubertal growth spurt that occurs around 11 years of age for girls and 13 years for boys. Although these years are characterized by gradual physical growth, the child makes rapid gains in learning and functions at increasingly mature levels in the performance of games and sports. This period of slow growth gives the child time to get used to his or her body and is an important factor in the typically dramatic improvement seen in coordination and motor control during the childhood years. The gradual change in size and the close relationship maintained between bone and tissue development may be important factors in increased levels of functioning.

Differences between the growth patterns of boys and girls are minimal during the middle years. Both have greater limb growth than trunk growth, but boys tend to have longer legs, arms, and standing heights during childhood. Likewise, girls tend to have greater hip widths and thigh sizes during this period. There is relatively little difference in physique or weight exhibited until the onset of the preadolescent period. Therefore, in most cases, girls and boys should be able to participate together in activities. During childhood there is slow growth in brain size. The size of the skull remains nearly the same although there is a broadening and a lengthening of the head toward the end of childhood.

CONCEPT 10.3

Growth in height and weight during later childhood is slow and steady, representing a time of lengthening and filling out prior to puberty.

Perceptual abilities during childhood become increasingly refined. The sensorimotor apparatus is working in ever greater harmony so that by the end of this period the child can perform numerous sophisticated skills. Striking of a pitched ball, for example, improves with age and practice due to improved visual acuity, tracking abilities, reaction and movement time, and sensorimotor integration. A key to maximum development of more mature growth patterns in the child is use. Practice and experimentation with the maturing perceptual abilities will enhance the process of integration with the motor structures. Failure to have the opportunity for practice, instruction, and encouragement during this period will prevent many individuals from acquiring the perceptual and motor information needed to perform skillful movement activities.

DEVELOPMENT IN LATER CHILDHOOD

Children in the elementary school years are generally eager and able to assume responsibilities. They are able to cope with new situations and are anxious to learn more about themselves and their expanding world. Primary grade children take another big step when they enter kindergarten and first grade. Although these placements rarely represent a child's first separation from the home for a regularly scheduled, extended block of time, it is the first step out of the secure play environment of the home, nursery school, or day-care center into the world of older children and adults. Entering a school represents the first time that many children are placed in group situations in which they are not the center of attention. It is a time when sharing, concern for others, and respect for the rights and responsibilities of others are established. Kindergarten is a readiness time in which to make the gradual transition from an egocentric, child-centered play world to the group-oriented world of adult concepts and logic. In the first grade, the first formal demands for cognitive understanding are made. The major milestone of the first and second grader is learning how to read at a reasonable level. The 6-year-old is generally developmentally ready for the important task of "breaking the code" and learning to read. The child is also developing the first real understanding of time, money, and numerous other cognitive concepts. By the second grade, children should be well able to meet and surmount the broader array of cognitive, affective, and psychomotor tasks placed before them.

The following is a listing of the general developmental characteristics of the child from about age 6 to 10. It is presented to provide a more complete view of the total child and represents a synthesis of current findings.

CONCEPT 10.4

Boys and girls are similar in their growth patterns, with limb growth being greater than trunk growth throughout childhood.

Physical and Motor Development Characteristics

1. Boys and girls range from about 44 to 60 inches (111.8–152.4 cm) in height and 44 to 90 pounds (20.0–40.8 kg) in weight.
2. Growth is slow, especially from age 8 to the end of this period. There is a slow but steady pace of increments, unlike the more rapid gains in height and weight during the preschool years.
3. The body begins to lengthen, with an annual gain in height of only 2 to 3 inches (5.1–7.6 cm) and an annual gain in weight of only 3 to 6 pounds (1.4–2.7 kg).
4. The cephalocaudal (head to toe) and proximodistal (center to periphery) principles of development, in which the large muscles of the body are considerably more developed than the small muscles, are apparent.
5. Girls are generally about a year ahead of boys in physiological development, and separate interests begin to emerge toward the end of thisp eriod.
6. Handp referencei sfi rmly established with about 85 percent preferring the right hand and about 15 percent preferring the left.
7. Reaction time is slow, causing difficulty with eye-hand and eye-foot coordination at the beginning of this period. By the end they are generally well established.
8. Both boys and girls are full of energy but often possess low endurance levels and tire easily. Responsiveness to training, however, is great.
9. The visual perceptual mechanisms are fully established by the end of this period.
10. Children are often farsighted during this period and are not ready for extended periods of close work.
11. Mostf undamentalm ovementa bilities have the potential to be well defined by the beginning of this period.
12. Basic skills necessary for successful play become well developed.

DEVELOPMENTAL DILEMMA

Chronologically the Same BUT Developmentally Different

Often in later childhood differences in height, weight, and overall physical maturity are pronounced between boys and between girls of the same age. As early as age 10 or 11 early maturing boys experience a growth spurt and development of secondary sex characteristics brought about by a dramatic increase in testosterone levels. Similarly, early maturing girls experience a growth spurt and appearance of secondary sex characteristics as early as age 8 or 9. In fact, girls in the fourth and fifth grades (generally age 9 and 10) are frequently taller, heavier, and more advanced in a variety of motor performance scores including running for speed and jumping for distance. Moreover, early maturing boys and girls are often at a distinct advantage in sport activities that place a premium on speed, power, and strength.

The dilemma arises when we group children by chronological age rather than by developmental level. Chronological age is the most frequently used classification scheme, but during the period of later childhood it is often the least valid. What to do? How might a parent, teacher, coach, or therapist more adequately group children for participation in sport and game activities during later childhood? Resolving this dilemma is crucial for the meaningful and continued participation of slower, or even typically developing, children in sport activities.

13. Activities involving the eyes and limbs develop slowly. Such activities as volleying or striking a pitched ball and throwing require considerable practice for mastery.
14. This period marks a transition from refining fundamental movement abilities to the establishment of transitional movement skills in lead-up games and athletic skills.

Cognitive Development Characteristics

1. Attention span is generally short at the beginning of this period but gradually extends. However, boys and girls of this age will often spend hours on activities that are of great interest to them.
2. They are eager to learn and to please adults but need assistance and guidance in making decisions.
3. Childrenh aveg oodi maginationsa nd display extremely creative minds; however, self-consciousness seems to become a factor toward the end of this period.
4. They are often interested in television, computers, video games, and reading.
5. They are not capable of abstract thinking and deal best with concrete examples and situations during the beginning of this period. More abstract cognitive abilities are evident by the end of this period.
6. Childrena rei ntellectuallyc uriousa nd anxioust ok now "why."

Affective Development Characteristics

1. Interests of boys and girls are similar at the beginning of this period but soon begin to diverge.
2. The child is self-centered and plays poorly in large groups for extended periods of time during the primary years, although small-group situations are handled well.
3. The child is often aggressive, boastful, self-critical, overreactive, and accepts defeat and winningp oorly.
4. There is an inconsistent level of maturity; the child is often less mature at home than in school.
5. The child is responsive to authority, "fair" punishment, discipline, and reinforcement.
6. Children are adventurous and eager to be involved with a friend or group of friends in "dangerous" or "secret" activities.
7. Thec hild'ss elf-conceptb ecomesfi rmly established.

Implications for the Developmental Movement Program

1. There shouldb eo pportunitiesf orc hildren to refine fundamental movement abilities in the areas of locomotion, manipulation, and stability to a point where they are fluid and efficient.
2. Children need help in making the transition from the fundamental movement phase to the specialized movement phase.
3. Acceptance anda ffirmation tell children that they have stable and secure places in their schools and homes.
4. Abundant opportunitiesf ore ncouragement and positive reinforcement from adults are necessary to promote continued development of positive self-concepts.
5. Opportunities and encouragement toe xplore and experiment through movement with their bodies and objects in the environment enhance perceptual-motor efficiency.
6. There should be exposure to experiences in which progressively greater amounts of responsibility are introduced to promote self-reliance.
7. Opportunitiesf or graduali ntroductiont o group and team activities should be provided at the proper time.
8. Imaginary and mimetic activities may be effectively incorporated into the program during the primary years because the children's imaginations are still vivid.
9. Activities that incorporate the use of music and rhythmics are enjoyable at this level

and are valuable in enhancing fundamental movement abilities, creativity, and a basic understanding of the components of music andr hythm.

10. Children at this level learn best through active participation. Integration of academic concepts with movement activities provides an effective avenue for reinforcing critical thinkings kills.
11. Activities that involve climbing and hanging are beneficial to develop the upper torso and should be included in the program.
12. Discuss play situations involving such topics as taking turns, fair play, not cheating, and other universal values as a means of establishing a more complete sense of right orw rong.
13. Begin to stress accuracy, form, and skill in the performance of movement skills.
14. Encourage children to think before they engage in an activity. Help them recognize potential hazards as a means of reducing their often reckless behavior.
15. Encourages mall-groupa ctivitiesf ollowed by larger-group activities and team sport experience.
16. Posture is important. Activities need to stress proper body alignment.
17. Use of rhythmic activities to refine coordination is desirable.
18. Specializedm ovements killsa red eveloped and refined toward the end of this period. Plenty of opportunity for practice, encouragement, and selective instruction is important.
19. Participation in youth sport activities that are developmentally appropriate and geared to the needs and interests of children should be encouraged.

Factors Affecting Child Growth and Development

Growth is not an independent process. Although heredity sets the limits of growth, environmental factors play an important role in the extent to which these limits are reached. Factors such as nutrition, exercise, and physical activity are major considerations affecting growth.

Nutrition

The potentially harmful effects of poor nutrition during the prenatal period were highlighted earlier. Among the factors influencing physical development during the prenatal period, nutrition is the most important. Numerous investigations have provided clear evidence that dietary deficiencies can have harmful effects on growth during infancy and childhood. The extent of growth retardation obviously depends on the severity, duration, and time of onset of undernourishment. For example, if severe chronic malnutrition occurs during the child's first 4 years, there is little hope of catching up to one's age-mates in mental development, because the critical brain growth period has passed.

Concept 10.5

Prolonged dietary deficiencies and excesses can have a serious impact on the growth patterns of children.

The physical growth process can be disrupted by malnutrition at any time between infancy and adolescence. Malnutrition may serve also as a mediating condition for certain diseases that affect physical growth. For example, lack of vitamin D in a diet can result in *rickets,* a softening and deformity of the bones that occurs as a result of lime salts in newly formed bones. Vitamin B_{12} deficiencies may cause *pellagra,* characterized by skin lesions, gastrointestinal problems, and mitosal and neurological symptoms. Chronic lack of vitamin C may lead to *scurvy,* a disease characterized by loss of energy, joint pains, anemia, and a tendency toward epiphyseal fractures. All are relatively rare in most modern developed countries, but the effects of *kwashiorkor,* a debilitating disease, are seen in many parts of the world where there is a general lack of food and good nutrition. In the child with kwashiorkor, growth retardation can be expected as well as a large, puffed belly, sores on the body, and diarrhea.

Studies indicate that children suffering from **chronic malnutrition,** particularly during infancy and early childhood, never completely catch up to the growth norms for their age levels and suffer from **growth retardation.** This is apparent in developing nations where adult height and weight norms are considerably lower than those for industrialized nations. Nutritional status is linked to income level. Growth retardation can be found in all ethnic groups, but its prevalence varies with sex, ethnic origin, and income level. Stunted growth in children due to malnutrition is evident worldwide. In some developing countries almost 50 percent of children experience growth retardation due to inadequate nutrition (Pařízková, 1996). Even in industrial developed countries growth deficiencies occur in many cases caused by poverty and parental ignorance of basic nutritional information. The Centers for Disease Control reported that iron deficiency resulting in anemia represents the most common known form of nutritional deficiency in the United States (1998). They state that anemic infants were significantly delayed in attaining the motor milestones typical of that age period. Several child health organizations, including the American Academy of Pediatrics (Barness, 1993), have issued guidelines for the prevention of such childhood nutritional concerns.

Dietary excesses also affect the growth of children. In affluent countries, obesity is a major problem. Research has proposed an interesting hypothesis linking obesity and its intractability to dietary habits established during infancy and the period of childhood. There is considerable concern among professionals over the high consumption of refined starches and sugars by children. The constant barrage of television commercials loudly extolling one junk food or another, the "fast-food" addiction of millions, and the use of nonnutritive edibles as a reinforcer for good behavior all may have an effect on the nutritional status of children. The critical difference between adequate and inadequate nutrition has not been identified. The individual nature of the child, with his or her unique biochemical composition, makes it difficult to pinpoint where adequate nutrition ends and malnutrition begins. It is, however, a serious question that needs further exploration. The welfare of a vast number of children is at stake.

Exercise and Injury

One of the principles of physical activity is the concept of use and disuse. According to this principle, a muscle that is used will **hypertrophy** (i.e., increase in size) and a muscle that is not used will **atrophy** (i.e., decrease in size). Anyone who has had a limb placed in a cast for several weeks knows about atrophy. In children, activity definitely promotes muscle development. Although the number of muscle fibers does not increase, the size of the fibers does increase. Muscles respond and adapt to greater amounts of stress. Maturation alone will not account for increases in muscle mass. An environment that promotes vigorous physical activity on the part of the child will do much to promote muscle development. Active children have less body fat in proportion to lean body mass. They do not have more muscle fibers; they simply have more muscle mass per fiber and smaller fat cells.

CONCEPT 10.6

Physical activity generally has a positive effect on growth, except in cases of excessive levels of exercise.

Although it is doubtful that an individual's basic physique can be altered, it is certain that improvements within limits can be made. A popular method of classification of adult physique was developed by Sheldon et al. (1940) and later extended to children by Peterson (1967). This much-used system classifies individuals on the basis of fat, muscle, and bone length. An **endomorphic** physique is one that is soft and rounded in physical features (pear shape). The **mesomorphic** physique is well muscled, with broad shoulders, narrow waist, and thick chest (V shape). The **ectomorphic** physique is characterized by a tall, thin, lean look (angular shape).

Within each classification a person is rated on a scale of 1 to 7, with 1 representing the least amount of a characteristic and 7 the most of a characteristic. Therefore, the three-number sequence of 1-7-1 would represent a person very low on endomorphy, very high on mesomorphy, and very low on ectomorphy. A 2-3-6 would typify a person low on endomorphy, with some mesomorphic characteristics, and high on ectomorphy (perhaps a high jumper, or middle distance runner). Sheldon et al. (1954) found that males could typically be classified at the middle of the scale (i.e., 3-4-4 or 4-4-3) and females rated higher in endomorphy and lower in mesomorphy (i.e., 5-3-3).

Although physical activity generally has positive effects on the growth of children, it may have some negative effects if carried to the extreme. Malina, Bouchard, and Bar-Or (2004) indicated that several studies have reported reduced growth rates in the height and weight of young athletes involved in intensive training programs but that in many cases the research methodologies had limitations. They did point out the concern of **growth plate injuries** and their effect on bone growth. Certain sports lend themselves to the overuse of specific joints of a child's body. Overuse may result in epiphyseal injuries and growth plate damage. Much more research needs to be conducted on the beneficial limits of strenuous physical activity during childhood. The critical point separating harmful and beneficial activity is not clear. The rapid rise of youth sports and the intensity of training leave many unanswered questions. We can, however, assume that strenuous activity carried out over an extended period may result in injury to muscle and bone tissue of the child. "Swimmer's shoulder," "tennis elbow," "runner's knees," and stress fractures are but a few of the ailments plaguing children who have exceeded their developmental limits. Exercise and activity programs for children must be supervised carefully. The potential benefits to the growth process are great, but individual limitations must be accommodated.

CONCEPT 10.7

The critical line between beneficial and harmful amounts of physical exertion is not clear.

In summary, little evidence exists to support the notion that regular exercise has a direct effect on the length of bone growth (Malina, Bouchard, & Bar-Or, 2004). Bone growth is a hormonal process unaffected by activity levels. Exercise does, however, increase bone width and promote **bone mineralization,** which make for stronger, less brittle bones. Stress within the limits of the particular individual is beneficial to the bones. Chronic inactivity, on the other hand, has harmful effects on bone growth and may result in growth retardation.

Physical activity stimulates bone mineralization and muscle development and helps retard the depositing of fat. The vast majority of physical activity and athletic programs for children have beneficial effects. Injury, whether acute or chronic, may have negative effects on growth, depending on the severity and location. Refer to chapter 13, "Physical Development of Children," for a further discussion of health-related fitness training.

CONCEPT 10.8

Age of onset, duration, and severity determine how a variety of activity and nutrition factors influence later development.

Illness and Climate

A number of other factors influence the growth process, including illness and disease, climate, emotions, and disabling conditions.

The standard childhood illnesses (chicken pox, colds, measles, and mumps) do not have a marked effect on the growth of the child. The extent to which illnesses and diseases may retard growth depends on their duration, severity, and timing. Often, the interaction of malnutrition and illnesses in the child makes it difficult to accurately determine the specific cause of growth retardation. However, the combination of conditions puts the child at risk and greatly enhances the probability of measurable growth deficits.

A great deal of literature has reported the differences in height, weight, and onset of adolescence among individuals of varying climates. The interacting effects of nutrition and health as well as possible genetic differences (e.g., when comparing black Africans with white Americans) make it impossible to demonstrate a direct causal relationship between climate and physical growth. The available data suggest that American children born and raised in the tropics have more linear physiques but grow and mature at a slower rate than American children raised in more temperate climates. It is difficult, however, to relate climatic conditions to specific factors of growth and maturation. As noted by Malina, Bouchard, and Bar-Or (2004):

> The effects of climate extend beyond temperature and include other components such as relative humidity, precipitation, and topography. Other factors also must be considered, including quality of agricultural land, methods of food production, and availability of suitable conditions for infectious and parasitic disease vectors.(p. 574)

Secular Trends

A positive **secular trend** reflects the tendency for children to be taller, heavier, and more mature at an earlier age than children one or more generations ago. The trend for secular increases is not universal. Increases in growth, maturation, and physical performance levels have been demonstrated in most developed countries. Developing nations throughout the world, however, have not demonstrated secular increases and in some cases have even shown decreases in stature. There may be many reasons for this, but it is largely a reflection of the limited improvements in lifestyle and nutritional habits from one generation to another.

Malina, Bouchard, and Bar-Or (2004) reported that secular changes in length and weight are slight at birth but become progressively more pronounced until puberty, when there is again a lessening of differences. The largest differences in height and weight are found from age 11 to 15 (the pubertal years) and are apparent across all socioeconomic classes and races in developed countries.

CONCEPT 10.9

Although secular trends appear to have ceased in North America, this is not a universal phenomenon.

Children today mature more rapidly than they did a hundred years ago. The age at menarche, for example, decreased in European populations over the past century from an estimated range of 15.5 to 17.4 years to between 12.5 and 14 years (Eveleth and Tanner, 1976). Although secular trends in the maturation of boys are no doubt present, maturity data for them are lacking. There have been few indications of secular trends in height, weight, and maturation in the past twenty years. This is probably due largely to the elimination of growth-inhibiting factors and a peaking of improved nutritionala ndh ealth conditions.

SUMMARY

Growth during childhood decelerates from the rapid pace characteristic of the first 2 years. The slow but steady increases in height and weight during childhood provide the child with an opportunity to coordinate perceptual and motor information. The child has time to lengthen, fill out, and gain control over his or her world. Numerous factors, however, can interrupt the normal developmental process. Nutritional deficiencies and excesses may influence growth patterns and have lasting effects on the child, depending on the severity and duration of the poor nutrition. Severe and prolonged illness also interrupts the growth process.

The effects of acute and chronic exercise at low and high intensity levels are of great interest to researchers and youth sport coaches. Physical exercise has a positive influence on the growth process. Little evidence exists to support the claim that physical activity can be harmful to children, except in cases of extreme training requirements. The problem, however, is knowing when "extremes" have been reached for each child. Climatic factors have also been shown to accelerate or decelerate growth in children. North American children today are taller and heavier than their counterparts of a hundred years ago. Definite secular trends can be seen in many but not all cultures. Differences in lifestyle and dietary circumstances play an important role in the presence or absence of secular trends.

Questions for Reflection

1. What can growth charts tell us about the present state of the developing child?
2. How might interpretation of a growth chart differ among children of the same chronological age but from different social or cultural backgrounds?
3. What is the difference between the terms *undernourished* and *malnourished* and how is each manifested?
4. What role might prolonged illness or extreme climatic conditions play in childhood growth?
5. What is meant by the term *secular trend* and in what ways has it been demonstrated?

Critical Readings

Abernethy, B., Hanrahan, S. J., Kippers, V., Mackinnon, L. T., & Pandy, M. G. (2005). *The Biophysical Foundations of Human Movement,* 2nd ed. (Chapter 4). Champaign, IL: Human Kinetics.

Bar-Or, O., & Rowland, T. W. (2004). *Pediatric Exercise Medicine* (Chapter 9). Champaign, IL: HumanK inetics.

Heikens, G. T. (2005). *Rehabilitation of Sick and Malnourished Children: Evaluation, Requirements, Prognosis and Feasibility* (International Child Health Studies). Amsterdam, The Netherlands: Rozenberg.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, Maturation, and Physical Activity,* 2nd ed. (Chapters 3, 6, 29). Champaign, IL: HumanK inetics.

Web Resources

www.aap.org/visit/cmte25.htm

The American Academy of Pediatrics Committee on Nutrition webpage. Site provides information about the committee, the *Pediatric Nutrition Handbook* (5th ed.), resources such as handbooks and brochures, and links to related materials.

www.cdc.gov/growthcharts/

This site, linked from the Centers for Disease Control and Prevention, contains information regarding the 2000 CDC growth charts in the United States. The information provided includes the growth charts, data tables, educational materials, computer programs, and reports.

www.who.int/nutgrowthdb/

The World Health Organization's Global Database on Child Growth and Malnutrition, generated by the WHO Department of Nutrition for Health and Development. Site includes summary papers dealing with global trends in child malnutrition as wella so besity.

CHAPTER 11

DEVELOPMENT OF FUNDAMENTAL MOVEMENT: MANIPULATION SKILLS

KEY TERMS

Fundamentalm otorsk ills
Developmentals equences
Totalb odys equences
Components equences
Ipsilateralp attern
Contralateralp attern
Motorc ompetence
Intraskillsequen ces
Taskc onstraints
Environmentalc onstraints
Individualc onstraints

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Describe the developmental sequences for five manipulation skills
- Observe a child perform a manipulation skill and identify the developmental stage of that child
- Compare and contrast the total body versus component approach to developmental sequences
- Identify key individual, task, and environmental constraints acting on manipulation skills
- Identify major gender differences in the acquisition of manipulation skills
- Describe the characteristics of a proficient performer in manipulation skills
- Devise a manipulative skill observation assessment checklist as an individual or group activity

KEY CONCEPT

The childhood years should be focused on developing basic motor competence and efficient body mechanics in a wide variety of movement skills and situations.

Motor development is a complex process that occurs over the life span. Postural reflexes and the rudimentary movements of infants and toddlers provide children with practice in movement patterns and serve as the foundation for acquiring more voluntary motor skills during childhood. If you reflect back to the *phases and stages of motor development model* shown in chapter 3, you will see that the next step in the model is the fundamental movement phase. As the journey into childhood begins, children begin the development of these *fundamental movement patterns* or **fundamental motor skills** (FMS), as they are often known. Children are now able to explore the potential of their bodies as they move through space (*locomotion*), have increased control over their musculature in opposition to gravity (*stability*), and have an increasing ability to make controlled and precise contact with objects in their environment (*manipulation*).

Although childhood is focused on the acquisition of FMS, it is not important for the child at this age to focus on high degrees of skill in a limited number of movement situations. Rather, the focus of childhood should be on developing basic *motor competence* and efficient body mechanics in a wide variety of movement skills and situations.

From childhood and throughout adulthood the various movement patterns that are learned, used, refined, and changed are influenced by different factors that can affect skill performance. Newell (1986) identified these factors as *constraints* and grouped them into task, environment, and individual (both functional and structural) demands (see chapter 4 for more detail on Newell's constraints). For example, as children grow in height and gain weight, such individual structural constraints can affect changes in their movement patterns. Overweight children often have difficulties hopping and jumping and running as they have limited strength to move their increased mass through space. Environmental constraints also impact performance. For example, surfaces such as grass or wood can impact the ability of a child to run with ease, or the size of a ball can influence a child's ability to catch with his or her hands. Likewise, task demands such as throwing for force or throwing for accuracy might call for a different movement pattern to be used to achieve the throwing task successfully. All of these constraints interact to impact the skill performance of individuals and help explain both *intravariability* (variability of skill performance between/within different skills for one individual) and *intervariability* (variability between children of a similar age) seen during childhood and over the life span. Figure 11.1 provides a catching example of how environmental factors and the goal of the task act on the mover (along with his or her individual characteristics) and ultimately result in a movement outcome. While it is important to understand how constraints act on the child and result in a specific level of performance, what is more important to consider is the fact that task and environmental constraints can be manipulated by teachers, coaches, and clinicians to promote the motor development of children.

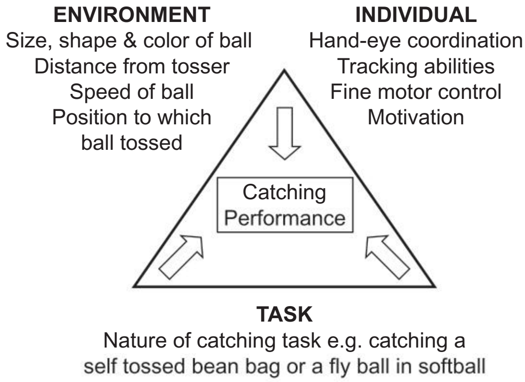


Figure 11.1
Constraints in Action: A Catching Example

CONCEPT 11.1

Individual, environmental, and task constraints influence a child's motor performance but can also be manipulated by teachers, coaches, and clinicians to promote the motor development of children.

In this chapter and the next one on locomotor skills we will examine the development of different FMS such as throwing, catching, and skipping. For each skill we will first ask the question: How do these skills emerge and develop? In this area we will focus on understanding the developmental sequences in the specific skill. After this we will summarize how a *proficient* mover might perform this skill as compared to an *initial* or inexperienced mover. Then we will examine what we know about how environmental, individual, and task constraints influence the performance of that skill.

Importance of Fundamental Motor Skills

The development of FMS is essential to achieving proficiency in various sports, games, and dances of a culture. They serve as the building blocks for efficient, effective movement and offer children ways to explore their environments and gain knowledge about the world around them. Developing FMS could be considered analogous to learning letters or characters of an alphabet. These characters provide the basis for learning words (combined motor skills), which then allow children to produce sentences and paragraphs (specific sports skills and dance sequences) by restructuring the letters in various combinations. If basic understanding of characters and letters is not learned, children are handicapped in their language development. Likewise in motor development, the ability to move easily in various combinations of FMS is compromised if children do not acquire basic motor competence during the early years.

In Chapter 3, Figure 3.1, Phases and Stages of Motor Development, illustrates how children should amass a broad base of FMS during early to middle childhood (approximately 3 to 7 years old). This base affords the children more possibilities (degrees of freedom) in their movement repertoires as it allows them more options in their movement responses. For example, a child who has had numerous opportunities to kick objects of various shapes, weights, and sizes, while the objects were stationary or moving, and while the child was also stationary or moving, will develop a repertoire of movement patterns that may be used to respond to a wide variety of task demands. That child will then have those options available to her when participating in games such as soccer or football that require different kinds of kicks and quick changes of position and direction in response to the movements of teammates or opponents. Children who develop motor competence in a wide variety of movement skills and situations will be more likely to be successful as they try their skills in the next step of the model, the specialized movement phase.

More recently a conceptual model developed by Stodden and colleagues (2008) highlights the importance of FMS to engagement in lifelong physical activity. At the heart of this model is a reciprocal and dynamic relationship between motor competence and physical activity (see Figure 11.2). Motor skill competence is defined in terms of common FMS, specifically manipulative and locomotor skill patterns. An underlying premise of this model is a common misconception that children "naturally" learn FMS. However, this is not true; many children do not reach proficient levels in these skills and demonstrate the requisite motor competence to be able to apply these skills to sports and games across childhood and adolescence (Goodway & Branta, 2003; Goodway, Crowe, & Ward, 2003; Goodway, Robinson & Crowe, 2010). One of the interesting parts of this model is that the relationship between motor competence and physical activity changes across developmental time.

In the early childhood years, it is suggested, young children's physical activity patterns may drive their development of motor skill competence.

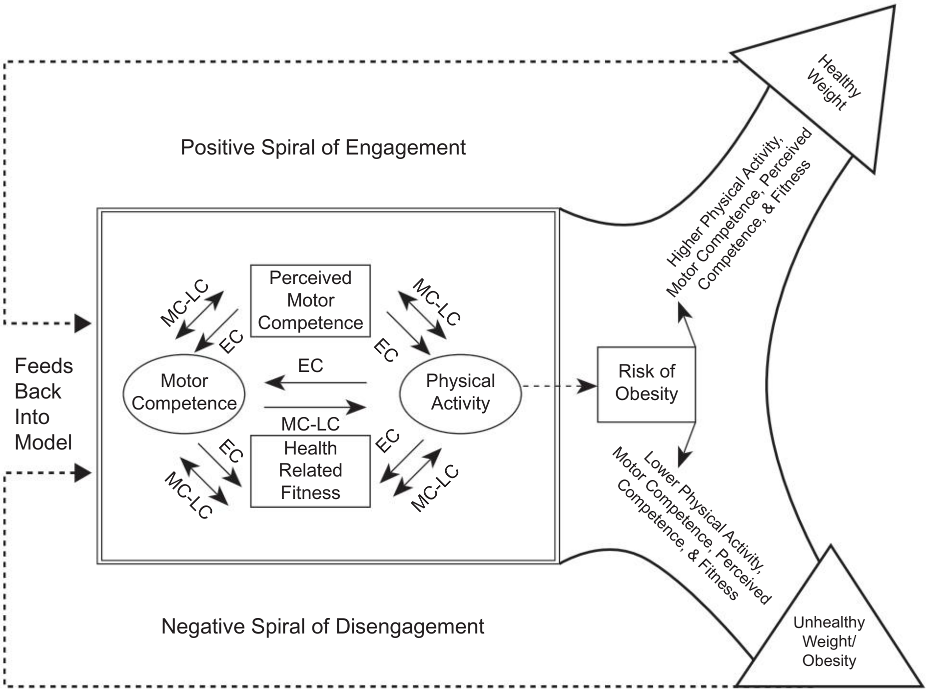


Figure1 1.2
Synergistic Model of Motor Competence and Physical Activity

A child with more access to physical activity will have more opportunities to develop her FMS, whereas a child with limited opportunities for physical activity will have correspondingly lower motor competence. These differences are most likely tied to factors such as access to an environment for physical activity, engagement in instructional motor programs/activities, socioeconomic status, parental/sibling influences, and climate, to name but a few. However, at this point in developmental time the relationship between physical activity and motor competence is weak and has most likely not yet had negative effects.

As children transition to middle childhood and adolescence, the relationship between physical activity and motor skill competence becomes more significant and will strengthen. Higher levels of motor skill competence offer a greater movement repertoire and more possibilities to engage in various physical activities, sports, and games. Children who are more highly skilled will most likely self-select higher levels of physical activity. Children who are more skilled are also more likely to perceive themselves as competent and gain intrinsic pleasure from participating in sports and games. Thus higher levels of perceived motor competence and actual motor competence will drive higher levels of physical activity, which in turn will give children greater opportunities to become more competent. We refer to these interactions as a *positive spiral of engagement* in sports and games as these children keep engaging in sports and games and keep getting more competent. But what happens to those less competent children? By middle childhood children who are less competent in motor skills will most likely self-select out of physical activity when given a choice or engage at lower levels if required to do physical activity such as in a physical education class. Thus low motor competence drives low physical activity levels, which minimizes a child's opportunities to improve motor competence. To compound this effect, by middle childhood children possess the cognitive capabilities to accurately assess their motor competence compared to same-age peers. They know if they are "good" or "bad" compared to their peers and this knowledge, along with multiple experiences of failure in physical activity settings, will drive low perceptions of motor competence. Thus, low actual and perceived motor competence, along with limited physical activity, result in what the authors refer to as a *negative spiral of disengagement* from sports and games. That is, the child has limited motor competence, believes she is "not very good at sports," and thus chooses sedentary activities over physical activity. As children move from middle childhood into adolescence there is an increasing divide between those motor competent and active children who enjoy physical activity and their less motor competent and inactive peers who avoid it. As can be seen from this model, the development of FMS competence in the early childhood years is central to promoting a physically active lifestyle across childhood and into adolescence.

CONCEPT 11.2

The development of motor competence in the early childhood years is important for engagement in physical activity and building positive perceptions of motor competence across childhood and adolescence.

UNDERSTANDING THE DEVELOPMENT OF FMS

The question emerges, then, of how interested adults can understand the development of specific skill patterns in young children. Two essential ways in which this understanding has been approached historically are through identification of sequences of development and the dynamic systems paradigm. Initial review of these two methods of research often concludes that the two are antithetical to each other. However, we contend that much can be gained by combining the two approaches.

Sequences of Fundamental Motor Skill Development

Developmental sequences have been a common way to examine the emergence of FMS. Motor development researchers (e.g., Branta, Halverson, Haubenstricker, Langendorfer, Roberton, Seefeldt, Williams) have used this method to describe the typical patterns of behavior in specific skills such as throwing or kicking. This approach to motor skills is focused on the *process* of the movement or how the movement qualitatively looks instead of the quantitative *product* or outcome of distance, velocity, or time. Developmental sequences use either (a) the **total body sequences** whereby movements for the entire body are described, or (b) the **component sequences** where developmental sequences are identified for a segment of the body such as arms, trunk, or legs. In both approaches to developmental sequences, descriptions of movement patterns are placed in order from crude and inefficient patterns of movement to more mechanically efficient and proficient forms of movement. Each step or stage in the sequence describes the common patterns of movement performed by children as they learn FMS. Using this approach children progressively move through the developmental sequences from less efficient patterns to more efficient patterns without any regression or skipping of stages.

Under a total body approach one stage represents the performance of the entire body by the child at that moment in time. It is believed that body segments are linked together in a whole. In contrast, the component method describes how specific body segments change over time and how one body segment may be linked to another one. Both of these sequential approaches provide rich detail on how children develop and acquire these motor skill patterns. Although seemingly different, these two approaches are more similar than different. For example, the most common profiles seen in the component approach to fundamental motor skills are often the specific stages identified by the total body approach. That is, the combinations of arm, trunk, and leg segmental sequence levels that appear most frequently together relate to the specific total body configuration stages. Both approaches are valid ways in which to assess change and track developmental progress. In some cases, such as in research and elite-level sport, the component approach may be the best way to examine all of the profiles exhibited when learning specific skills. However, in practical situations of teaching and coaching, the total body approach may be more easily and readily used to assess the motor skill development of children.

The total body and component stages were developed under core principles of stage theory (Roberton, 1978). These principles include the following:

- All children go through the same stages in the same order (*universal order*).
- Each stage shows a qualitatively different movement pattern from a previous stage.
- Therei sa n *intransitive order* where stages cannot be reordered or skipped.
- Later stages grow out of earlier stages (known as *hierarchical integration*).
- Within a stage behaviors mix and merge with previous behaviors and thus there can be no regression in stages (*consolidation process*).
- An imbalance between an individual's mental structure and the environment stimulates the emergence of a new stage (*equilibration process*).

Although these principles have held true for many children, some children did not seem to follow these principles.

It has become clear from motor development research (Garcia, 1994; Garcia & Garcia, 2002) that children are much more variable in their performance of FMS than stage theory might suggest. Three common weaknesses in stage theory were identified: (1) this linear approach did not account for regressions in performance that are often seen when the task changes, such as throwing for distance or accuracy; (2) stage theory did not account for children who reordered the sequence in which they learned skills or skipped over certain stages; and (3) this approach did not explain the process underlying why children shifted from one movement pattern to another. In more recent years we have been able to account for these weaknesses in stage theory and reconceptualize developmental sequences using a dynamic systems paradigm.

Dynamic Systems Theory and Stages of FMS

Using dynamic systems theory, the patterns of movement found in developmental sequences are viewed as possible movement choices for the child. In other words, children choose from an array of movement patterns (stages) to select the most appropriate pattern to achieve the task at hand. The total body stages and the most common profiles in the component sequences are most likely strong behavioral attractors that may be selected under specific movement conditions. Strong attractors are ones that are so embedded that it is difficult to move that person out of that state. Weak attractors are patterns of movement we may see occasionally, but they are not as stable as strong attractors and can more readily be changed by environmental and individual constraints. Using dynamic systems theory, there is no such thing as a "mature" movement pattern, as the most efficient pattern will vary depending on the task at hand. For example, if you stand a child five feet from a wall and tell him to throw and hit the wall, he may select from any of the five possible stages of throwing to perform the task. Most likely the child will choose something like a "chop" throw (stage 1) or an "ipsilateral" throw (stage 3) because the task does not demand a forceful throw. However, if a child is 25 feet from the wall, most likely the child will show the most efficient pattern of performance of which she is capable (stage 5).

Reconceptualizing the stages of developmental sequences into various attractors allows motor development specialists to build upon previous knowledge and to extend the information in useful ways. If we reconceptualize the idea that stages of FMS development are common, stable patterns of movement that can be altered, we can manipulate environmental and task constraints to help move children into new attractors that are more beneficial to the demands of a specific task. Thus, our job as teachers and coaches is to assist children in developing a large array of movement patterns from which they can select in different context-specific activities.

CONCEPT 11.3

Developmental sequences can be identified for many FMS. These common patterns of movement are behavioral attractors that represent movement options from which a child can chose in a given movement context.

In the next section we will examine the body of literature on manipulative skills using a dynamic systems approach. For each skill we will identify the total body and component (where developed) developmental sequences. We will then describe what we know about the performance of a proficient and immature performer. We will conclude each skill with an examination of the factors that might influence the performance of the skill in terms of individual constraints, environmental constraints, and the nature of the task, considering implications for practitioners. In the sixth edition of this text three stages of FMS development were described: *initial*, *elementary*, and *mature*. In this edition we have modified these terms slightly. *Initial* movers are considered beginning learners and represent the first stage in a developmental sequence. The next stage is referred to as *emerging* and depending on the developmental sequence can consist of stages 2–4. The last stage is referred to as *proficient* and refers to a child who has efficient movement mechanics. Table 11.1 identifies the developmental total body sequences of five manipulative skills. For each stage the words in italics provide a summary word or two in order to remember the stage, and below that is a description of the pattern of movement.

MANIPULATIVE SKILLS

Manipulative skills are a subset of skills that involve manipulating or controlling objects such as bats and balls. There are many manipulative skills including throwing, catching, kicking, punting, striking, rolling, and bouncing/dribbling. For the purposes of this chapter we will only review what we know about the first five skills and will not address rolling and bouncing.

Throwing

Throwing is one of the most functionally useful FMS as it is inherent in sports like baseball and softball and involved in sports such as basketball, soccer, and cricket. The throwing motion is also part of the patterns of sports skills such as the tennis serve, the overhead clear in badminton, and the spike in volleyball (Butterfield & Loovis, 1993; East & Hensley, 1985). In North America, being able to throw proficiently is important as many of the activities that are played in schools and communities involve this critical skill (McKenzie et al., 1998). There are different types of throwing such as the underhand throw, two-handed throw (as in a soccer throw-in), and overhand throw. However, it is the overhand throw that has received the most attention in the motor development literature and is by far the most researched fundamental motor skill.

Historically, researchers have examined throwing using a process and/or product approach. The product approach to throwing has looked at the outcome of the throw such as distance thrown or speed of the throw. The process approach aims to understand the pattern of movement. However, a common belief in the motor development literature is that the development of efficient patterns of movement will result in better product outcomes such as greater distance and speed (Barrett & Burton, 2002). When we look to the elite-level athlete, we see that proficient throwers not only have good form, but they can also throw long distances with speed; additionally, they can adjust their throwing patterns to the changing dynamics of the task and environment (Hamilton & Tate, 2002; Langendorfer & Roberton, 2002a). Table 11.2 outlines the characteristics of a proficient thrower.

Development of the Overarm Throw

Throwing is a complex gross motor skill that involves the interaction of different body parts

TABLE 11.1 Developmental Sequences of Five Manipulative Skills

Fundamental Motor Skill	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
	Initial Stage		***Emerging Stages***		***Proficient Stage***
Throw	*Chop* Vertical windup "Chop" throw Feet stationary No spinal rotation	*Sling Shot* Horizontal wind-up "Sling shot throw" Block rotation Follow-through across body	*Ipsilateral Step* High windup Ipsilateral step Little spinal rotation Follow-through across body	*Contralateral Step* High windup Contralateral step Little spinal rotation Follow-through across body	Windup Downward arc windup Contralateral step Segmented body rotation Arm-leg follow-through
Catch	*Delayed Reaction* Delayed arm action Arms straight in front until ball contact, then scooping action to chest Feet stationary	*Hugging* Arms encircle ball as it approaches Ball is "hugged" to chest Feet are stationary or may take one step	*Scooping* "To chest" catch Arms "scoop" under ball to trap it to chest Single step may be used to approach the ball	*Hand Catch* Catch with hands only Feet stationary or limited to one step	*Move to Ball* Catch with hands only Whole body moves through space
	Initial Stage	***Emerging Stages***		***Proficient Stage***	
Kick	*Stationary Push* Little/no leg windup Stationary position Foot "pushes" ball Step backward after kick (usually)	*Stationary Leg Swing* Leg windup to the rear Stationary position Opposition of arms and legs	*Moving Approach* Moving approach Foot travels in a low arc Arm/leg opposition Forward or sideward step on follow-through	*Leap-Kick-Hop* Rapid approach Backward trunk lean during windup Leap before kick Hop after kick	
Punt	*Yoking-Push* No leg windup Ball toss erratic Body stationary Push ball/step back	*Stationary Leg Swing* Leg windup to the rear Ball toss still erratic Body stationary Forceful kick attempt	*Moving Approach* Preparatory step(s) Some arm/leg yoking Ball toss or drop	*Leap-Punt-Hop* Rapid approach Controlled drop Leap before ball contact Hop after ball contact	
Strike	*Chop Strike* "Chop" strike-bat Feet stationary	*Pushing* Horizontal push/swing Block rotation Feet stationary/stepping	*Ipsilateral Step* Ipsilateral step (back foot steps across) Diagonal downward swing	*Contralateral Step* Contralateral step Segmented body rotation Wrist rollover on follow-through	

TABLE 11.2 Characteristics of a Proficient Thrower

Proficient throwers demonstrate the following:

- Longc ontralaterals tep
- Segmental rotation of the trunk where the hip rotates first, followed by the spine, shoulder, humerus, and forearm
- Humerusla gs behind trunk
- Forearmla gsbeh ind humerus
- Throwing armf ollows through across body

coordinating with each other to apply sophisticated biomechanical principles in action resulting in the transfer of significant force to the ball. Major League Baseball pitchers are considered expert throwers, and some can throw a ball at more than 160 kilometers per hour. Yet it is clear that young children do not throw like this. So, how do throwing skills emerge and develop?

Monica Wild (1938) was one of the earliest researchers in throwing, analyzing the throwing patterns of 32 children aged 2 to 12 years. Her most novice thrower (stage 1) was 2–3 years old with a front facing throw, stationary feet, and no trunk rotation (Wild, 1938). By 6.5 years of age children demonstrated more proficient patterns (stage 4), could step with a contralateral (opposite arm to foot) pattern, and had trunk rotation. Since these early days, other researchers have added immensely to our understanding of the complex world of throwing. Researchers at Michigan State University developed a total body approach to throwing (Seefeldt, Reuschlein, & Vogel, 1972) in contrast to their counterparts at Wisconsin (and then Bowling Green State University) who used a component approach to the developmental sequences (Roberton & Halverson, 1984).

Total Body Developmental Sequences of Overarm Throwing

Table 11.1 and Figure 11.3 show the five-stage developmental sequence of throwing (Seefeldt, Reuschlein, & Vogel, 1972), similar to Wild's work. The initial stage of throwing (stage 1) is inefficient with a stationary base of support, front facing, and hip flexion and chopping arm action to generate force. By stage 3 children step and throw but on the ipsilateral foot (same foot and arm). It is not until stage 4 that a child takes a contralateral step (opposite arm to leg) and begins the journey to more proficient throwing. By stage 5 the child has acquired the preparatory movements and force dynamics of a proficient thrower. These throwing stages have demonstrated preliminary validation via a mixed-longitudinal sample of children (Haubenstricker, Branta, & Seefeldt, 1983).

Garcia and Garcia (2002) longitudinally tracked six children aged 2 to 5 years across two years and analyzed 3,469 throws. Their findings concurred with a dynamic systems approach showing that children moved back and forward between adjacent and nonadjacent stages across time depending upon individual and environmental constraints (e.g., motivation, body awareness). The study concluded that throwing development was individual, highly variable, nonlinear, and context sensitive in line with the dynamic systems view of development. Another developmental sequence in throwing has taken a different approach and suggests that sequences of development exist at the body component level and not the total body level (Roberton,1 977).

Component Developmental Sequences of Overarm Throwing

The component approach to throwing suggests throwing development should be examined at the component level; namely, the step, backswing, trunk, humerus, and forearm components (Roberton, 1977). In Table 11.3 a brief summary of the developmental sequences for each of the

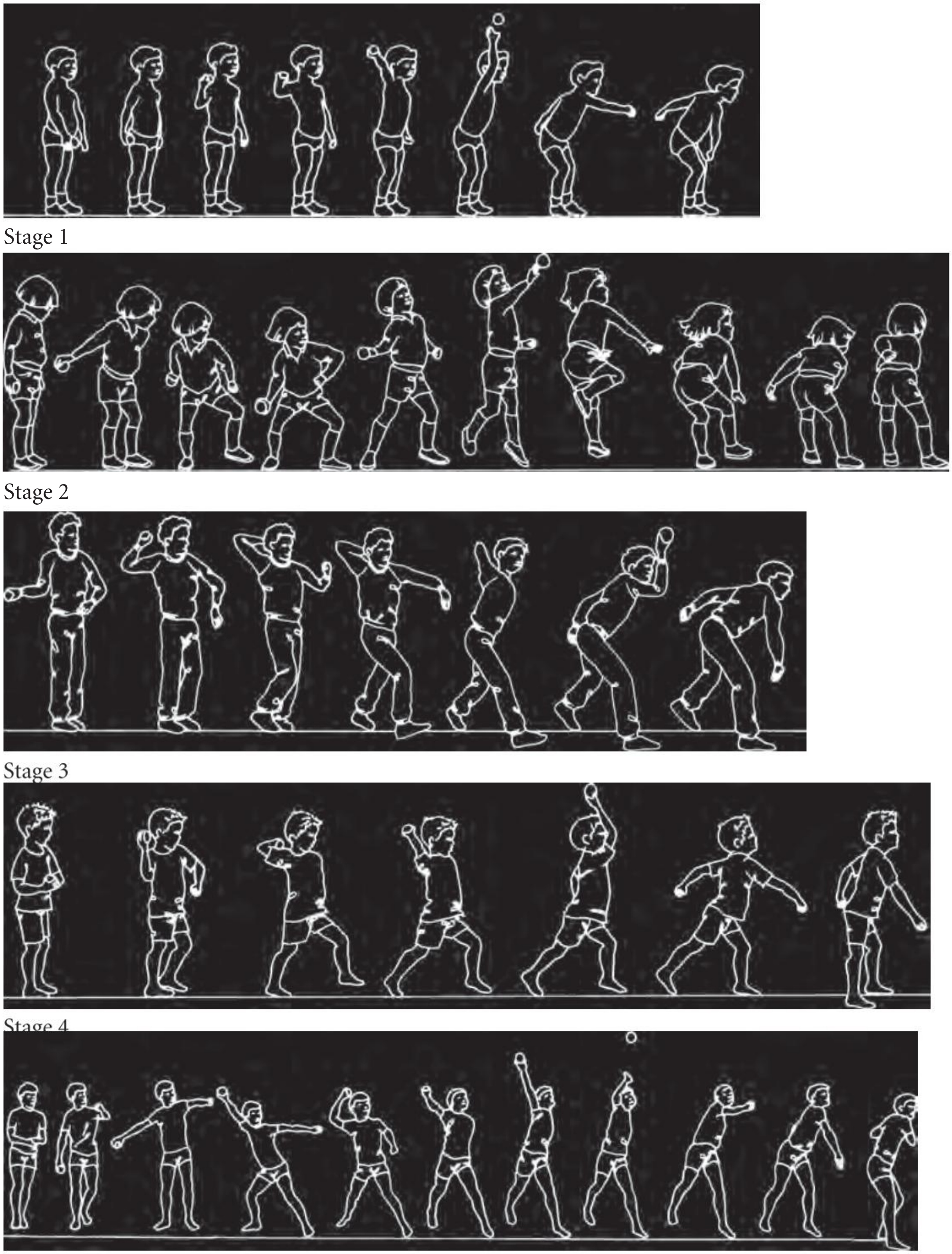


Figure 11.3

Developmental Sequences of Throwing

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TABLE 11.3 Component Developmental Sequences of the Overarm Throw

Step	Backswing
S1 *No Step*—The child throws from the initial stationary foot position.	B1 *No Backswing*—The ball in the hand moves directly forward to release from the arm's original position.
S2 *Homolateral Step*—The child steps with the foot on the same side as the throwing hand.	B2 *Elbow and Humeral Flexion*—The ball moves away from the intended line of flight to a position behind or alongside the head.
S3 *Contralateral, Short Step*—The child steps with the foot on the opposite side from the throwing hand.	B3 *Circular Upward Backswing*—The ball moves away from the intended line of flight to a position behind the head via a circular overhead movement.
S4 *Contralateral, Long Step*—The child steps with the opposite foot a distance of over half the child's standingh eight.	B4 *Circular, Downward Backswing*—The ball moves away from the intended line of flight to a position behind the head via a circular, down-and-back motion, which carries the hand below the waist.

Trunk
T1 *No Trunk Action* or *Forward-Backward Movements*—Only the arm is active in force production. If trunk action occurs, it accompanies the forward thrust of the arm by flexing forward at the hips. Sometimes there is trunk extension prior to hip flexion.
T2 *Upper Trunk Rotation or Total "Block" Rotation*—The spine and pelvis both rotate away from the intended line of flight and then simultaneously begin forward rotation, acting as a unit or "block."
T3 *Differentiated Rotation*—The pelvis precedes the upper spine in initiating forward rotation. The thrower twists away from the intended line of ball flight and then begins forward rotation with the pelvis while the upper spine is twisting away.

Humerus	Forearm
H1 *Humerus Oblique*—The humerus moves forward to ballr elease.	F1 *No Forearm Lag*—The forearm and ball move steadily forward to ball release.
H2 *Humerus Aligned But Independent*—The humerus moves forward to ball release in a plane horizontally aligned with the shoulder, forming a right angle between humerus and trunk.	F2 *Forearm Lag*—The forearm and ball appear to "lag" behind the shoulder.
H3 *Humerus Lags*—The humerus moves forward to ball release horizontally aligned, but at the moment the shoulders (upper spine) reach front facing, the humerus remains within the outline of the body (as seenf romt hes ide).	F3 *Delayed Forearm Lag*—The lagging forearm delays reaching its final point of lag until the moment of front facing.

5 components is outlined (see Roberton, 1977 for more detailed descriptions). Under each component there are between 3 and 4 steps. A child would be rated on each of the components. For example, an initial performer would demonstrate a Step-1, Backswing-1, Trunk-1, Humerus-1, Forearm-1 (1-1-1-1-1) with no step, no backswing or trunk rotation, and a humerus that is oblique with a forearm that has no lag. This action is much akin to the "chopping" action of stage 1 in the total body approach where almost all of the throwing action comes from the arm. However, the component approach provides a more sophisticated analysis of the biomechanical factors occurring in forceful throws than the total body approach. For example, the component approach distinguishes

between a short (S3) and long (S4) contralateral step, recognizing that proficient throwers take a long contralateral step when they throw for force (Langendorfer & Roberton, 2002a). Additionally, the component approach examines the mechanics of the trunk action and differentiates between "block" (hips, trunk, and shoulders rotate as a block) and "differentiated" (hips rotates before trunk before shoulder) rotation. The same is true for the humerus (upper arm) and forearm action where in the component approach the importance of humeral lag (humerus lags behind the shoulder) and forearm lag (forearm lags behind the humerus) are recognized in the production of force (Langendorfer & Roberton 2002a). Thus, an efficient thrower, such as a baseball pitcher, would demonstrate S4, B4, T3, H3, F3 (see Table 11.3). All of these actions result in significant force being imparted to the ball.

In the component approach it is important to note that all components are not perfectly correlated as suggested in the total body approach, but they are also not totally independent (Langendorfer & Roberton, 2002a, 2002b). For example, just because a child moves from a Step-1 to Step-2 (no step to ipsilateral step), it does not mean that the other components such as trunk will change accordingly (Langendorfer & Roberton, 2002a). Within the component approach, change in component levels can occur at different rates and at different times for different components. Although the component approach was developed under a stage theory perspective, the probabilistic view of dynamic systems theory works well with this approach. The component sequences outline the wide variety of possible configurations (behavioral attractors) of throwing performance and show that children can demonstrate different configurations of body components based upon individual, task, and environmental constraints (Hamilton & Tate, 2002). Langendorfer and Roberton (2002b) found that of the possible 27 configurations of component levels, only 14 were demonstrated, indicating that there are certain profiles or behavioral attractors in throwing that represent common patterns of throwing movement.

Both total body and component sequences of development provide valuable information for teachers. Using developmental sequences allows teachers to assess and track the development of throwing in their children. Teachers can use a five-step process to do this:

1. Observe ande valuatet hed evelopmentall evel of the child.
2. Identifyt hed esiredp erformance (desired attractor) for the child to perform.
3. Considerw hati ndividualf actors might be influencing the child.
4. Considerh ow tom anipulatea spects oft he environment to promote the skill.
5. Watch the child perform the task and modify it to make it more difficult or easier based upony ouro bservations.

Product Measures of Throwing

Distance thrown, accuracy of the ball thrown, and velocity or speed of the ball are common product measures used to evaluate overarm throwing proficiency. Two major outcomes are known about these product measures of throwing:

1. There are distinct gender differences in outcome measures of throwing.
2. Therea rea ge-related increasesi n outcome measureso ft hrowing.

Constraints in Throwing

Newell (1984) suggests that motor performance is a product of the interaction between and among individual, task, and environmental constraints. Table 11.4 identifies key individual, environmental, and task constraints in the throwing literature. The development of throwing is not linear or prescriptive; rather it is dynamic and variable in nature. It is important that teachers understand this critical point. As teachers select tasks for their students, these teachers can often elicit a more advanced pattern of throwing by considering individual constraints and changing the task and environmental constraints to demand such a performance. Thus, the selection of appropriate tasks becomes an important role in order for teachers to promote throwing development.

TABLE 11.4 Individual, Task,an dE nvironmental Constraints in Throwing

Constraints in Throwing		
Individual	**Task**	**Environmental**
• Gender • Age • Biological	• Accuracy • Force	• Size of target • Distance from target • Instruction

Individual Constraints in Throwing

Individual constraints are factors that are internal to the individual. In throwing the two major areas of individual constraints that have been examined are gender and age. However, a few studies have examined other biological factors in throwing. Southard (2002) manipulated the mass of 5–12-year-old children's arm segments (humerus and forearm) to approximate the relative mass of an adult arm. Results showed that the adult mass condition improved the throwing performance of more immature throwers. Southard suggested that changes in relative mass of upper limb segments as a result of normal growth and development may, in part, be a contributing factor to the development of more advanced throwing patterns over time. Stodden, Langendorfer, Fleisig, and Andrews (2006a,b) conducted a biomechanical analysis of throwing, categorizing participants by throwing proficiency on the component sequences. They found boys were more likely to have more advanced movement mechanics (higher attractor profiles) than girls. Interestingly, step length significantly predicted ball velocity, demonstrating the link between process (pattern of movement) and product (velocity) in throwing.

Relative to gender and age, boys outperform girls at every age and in every category of throwing (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002a, 2002b; Roberton & Konczak, 2001; Sakurai & Miyashita, 1983; Thomas & Marzke, 1992). The gender differences found in throwing are the largest for any fundamental motor skill (Nelson et al., 1991; Thomas & French, 1985; Williams, 1996). Gender differences are categorized as an individual constraint because of the biological factors associated with them. Figure 11.4 shows age-related gender differences in throwing (Seefeldt & Haubenstricker, 1982). By stage 5, the typical boy is 63 months whereas the typical girl is 102 months (a difference of more than 3 years).

Thomas and colleagues (1994) found that gender differences for throwing distance were three times the size of gender differences for other tasks. Morris, Williams, Atwater, and Wilmore (1982) found that 5–6-year-old girls were similar to 3–4-year-old boys in throwing for distance, highlighting the large gender differences. A meta-analysis of 21 throwing studies (5 accuracy, 11 distance, and 5 velocity) reported that boys' performance was 1.5 standard deviations greater than girls starting as early as ages 4 to 7 years when throwing for force and distance (Thomas & French, 1985). By age 12 years, the boys were 3.5 standard deviations ahead of the girls for throwing speed. Halverson and colleagues (1982) and Roberton and colleagues (1979) also reported gender differences for velocity that continued to increase with age. Halverson et al. (1982) calculated a yearly rate of change of velocity for both boys and girls. Boys increased 5 to 8 ft/sec/year, in contrast to the girls, who only changed 2 to 3 ft/sec/year in kindergarten to second grade, and 2 to 4.5 ft/sec/year from third to seventh grade (Halverson et al., 1982; Roberton et al., 1979). Runion, Roberton, & Langendorfer (2003) undertook an interesting study. They evaluated the throwing velocities of 50 13-year-old boys and girls and compared them to a 1979 sample of 13-year-olds. The

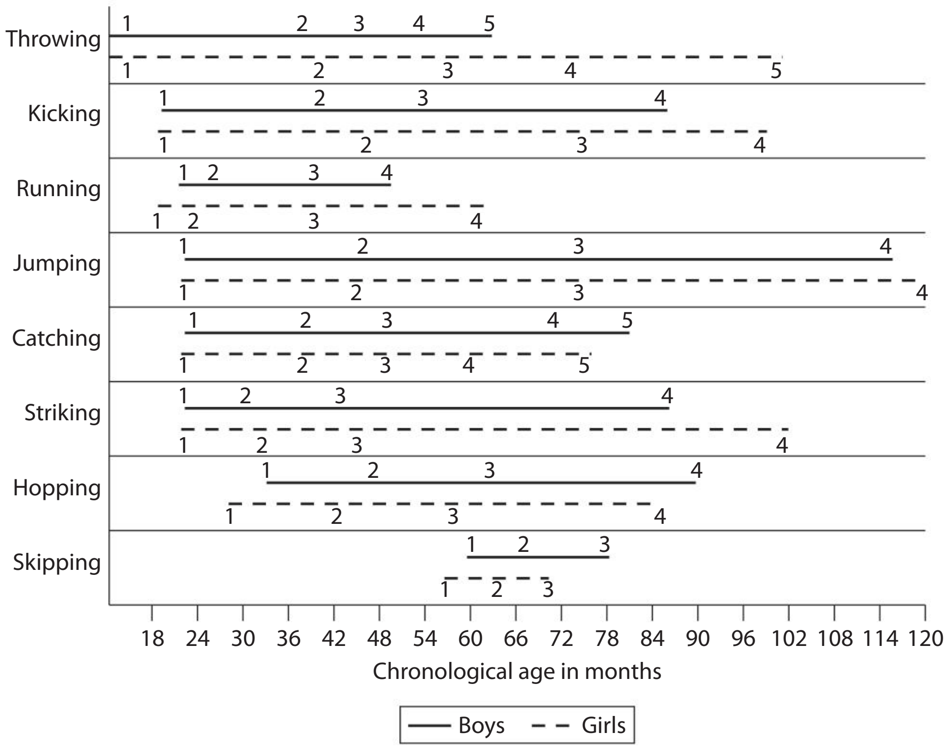


Figure1 1.4
Age-Related Changes in the FMS of Children

theory was that with the increase in youth sports, particularly for girls, the more recent participants would outperform the data collected 30 years ago. Overall they found that boys' and girls' throwing velocities had not improved from 1979 to 2003 and that gender differences still persisted in favor of boys in both cohorts.

Gender differences in throwing have also been reported for countries other than the United States. Sakurai and Miyashita (1983) found significant gender differences in Japanese children aged five to nine years. Pan and Lu (2001) indicated that Chinese boys' performance on overhand throw for accuracy and distance was better than girls' from age 7–12 years. Other work has found that German males outperformed their female counterparts in throwing form and velocity (Ehl et al., 2005). A study of 6-, 8-, and 10-year-old Aboriginal Australian children also demonstrated gender differences with boys throwing faster than girls and 10-year-olds faster than 6-year-olds (Thomas, Alderson, Thomas, Campbell, & Elliot, 2010).

Nelson et al. (1986) found that biological factors of joint diameters, shoulder/hip ratio, and sum of skinfolds only accounted for a small (10%) percentage of the variance in gender differences in throwing. Specific biological measures have been correlated with gender differences including a moderate correlation between boys' arm muscle circumference and distance thrown (Nelson et al., 1991); boys' greater external to internal rotation rate versus girls having less of a maximum angle of twist (Thomas & Marzke, 1992); neuromuscular coordination (Yan et al., 2000); and body awareness (Garcia & Garcia, 2002).

Gender differences are not only limited to forceful throws because boys are also more accurate than girls when throwing at targets (Moore & Reeve, 1987; Moore, Reeve, & Pissanos, 1981; Thomas & French, 1985). Moore and colleagues (1981) found kindergarten boys threw farther and more accurately than girls. Langendorfer (1990) suggested that gender differences found for accuracy can be attributed to environmental factors as accuracy tasks require the ability to adapt and change movement patterns to meet the accuracy goal. It may be that as boys have more advanced throwing patterns, they have a greater repertoire of movement patterns to select from to meet the task demands; or that boys have more experience at throwing and can apply this experience in a variety of conditions (Langendorfer, 1990).

Overall, gender differences in both product and process measures of throwing have implications for the physical educator or coach. If girls are significantly worse than boys in throwing at all ages, it is important that the physical educator and coach ensure that sports and games involving throwing do not naturally advantage boys. Modification of rules and playing areas may be necessary.

Other individual factors of interest include age. Langendorfer and Roberton (2002a, 2002b) identified how throwing performance changed across age by describing common attractor profiles and attractor pathways for the development of throwing at different ages. Attractor profiles describe the overall throwing pattern for specific components, and attractor pathways describe the shifting patterns from one throwing pattern to another across time. The strongest attractors for children for the trunk, humerus, and forearm component were (refer back to Table 11.3):

- 5–6 years: 1-1-1- or 2-1-1 or 2-2-1 or 2-2-2
- 7 years: 2-3-2 or 2-1-1 or 2-2-2

Attractor profiles have been found to be linked. In other words, as one body component changes, so does another. Langendorfer and Roberton (2002a) suggested that it was necessary for the trunk to rotate (T2 or T3) in order to achieve a more advanced arm action (H2 or H3). The work of Garcia and Garcia (2002) and Oslin et al. (1997) supports this view, and in addition, suggests it is valuable to use a sideways orientation to set up a contralateral step in order to get the trunk rotating. All researchers were in agreement that if a child did not have a rotating trunk (at least block rotation), this acted as a constraint limiting the development of more advanced movements of the humerus and forearm. However, differentiation of the trunk (T3) may appear after humeral lag is reached (Langendorfer & Roberton, 2002a). Other possible factors influencing the development of advanced levels of the trunk and humerus component could include the relationship between the backswing component and arm component levels (Langendorfer & Roberton, 2002a).

Task Constraints

Task constraints are factors related to the goal of the activity. In throwing, the commonly investigated areas have dealt with throwing for accuracy versus force. From a constraints perspective, the task or goal of the activity has a powerful influence on the throwing pattern we demonstrate. For example, if a child is placed 35 feet from a wall and told to hit the wall with a tennis ball, most likely he or she would select a throwing pattern with wind-up, contralateral step, trunk rotation, humeral and forearm lag, and follow-through. That is, the child would choose the most mechanically efficient pattern he was capable of demonstrating for the task at hand. However, if the same child were placed 10 feet from a wall and told to throw the ball at the wall, most likely he would demonstrate a chopping motion with the arm and no step or trunk action. That is, the task demands do not require significant force and thus a different pattern of throwing was selected. In this manner, children may demonstrate different patterns of throwing depending on the task demands. When tasks vary in their goal (such as accuracy versus force), throwing performance changes in relation to the intended goal.

Manoel and Oliveira (2002) examined throwing in a group of 7-year-old boys and girls. They reported more advanced throwers threw farther than less advanced throwers, but there was no difference in accuracy. Roberton (1987) determined that the task constraints of force and accuracy influenced product scores. She reported velocity was reduced by one developmental year when comparing a "throwing hard" condition versus an accuracy condition. However, there was little change in throwing performance between force and accuracy among more primitive throwers. Langendorfer (1990) determined that males improved close to one developmental level when changing from an accuracy goal to a force goal. Lorson and Goodway (2007) determined the task of "throwing hard" changed the step component of throwers as compared to a group that did not receive the "throwing hard" prompt.

It is interesting to note that throwing for distance/force versus throwing for accuracy only seems to influence the throwing patterns of more advanced performers. It may be that more advanced throwers have a variety of throwing patterns available to them and are able to select those that best suit the task demands (Langendorfer, 1990; Roberton, 1987). Advanced throwers often seem to select more primitive patterns of throwing if the task allows them to do so (Hamilton & Tate, 2002; Langendorfer, 1990). Yet more primitive throwers have limited throwing options to select from and are unable to adjust their throwing patterns to the demands of the throwing task.

Environmental Constraints

Environmental constraints deal with those factors external to the individual. Environmental constraints include the manipulation of the throwing environment such as the distance to be thrown and the size of the target. They also include the size of the ball and sociocultural influences such as opportunities to practice throwing and differential effects of instruction.

There is little empirical evidence with respect to sociocultural influences on throwing; however, there has been some discussion of these factors in the literature. For females, factors such as the limited number of advanced female throwers to imitate and less support from parents to throw may have an impact on their throwing performance and account for the gender differences found in throwing (East & Hensley, 1985; Nelson et al., 1986; Thomas & French, 1985). Organized activities, such as youth sport, could be another contributing environmental factor. Research suggests that boys tend to participate in more organized throwing experiences such as baseball (Butterfield & Loovis, 1993; Halverson et al., 1982; Thomas & Marzke, 1992) and that differences exist in the quality of throwing opportunities (Butterfield & Loovis, 1993). Garcia and Garcia (2002) suggest that young girls respond differently than boys in instructional throwing environments. In their study of preschoolers, girls were motivated to throw to please the teacher and to receive positive feedback, stickers, smiles, and encouragement. In contrast, boys were more intrinsically motivated by improving their own skill and competing against other boys; this was particularly true for the more skilled throwers.

The size, shape, and mass of the ball are factors that may influence the throwing pattern (Southard, 1998). Teachers and coaches can manipulate environmental factors to improve throwing performance. For example, baseball coaches have increased the mass of the baseball in training as a tool to increase ball velocity in pitchers (DeRenne, Tracy, & Dunn-Rankin, 1985). Although there is little empirical literature in this area, those of us who frequently teach throwing to children know that ball size and shape influences the pattern of throwing. A few researchers have found that the size of the ball influences the mechanics of the throw (Burton, Greer, & Wiese, 1992; Burton, Greer, & Wiese-Bjornstal, 1993). This is particularly true for young children; we need to be aware of the relatively smaller size of their hands to the ball size. For example, throwing a softball might seem like a good task to an adult, but it is clear that the hand size of younger aged elementary children is too small to grip the ball appropriately.

Other factors such as how far a child must throw, or the size of the target that it is thrown to, can influence the pattern of the throw. Hamilton and Tate (2002) examined the influence of three different throwing distances (scaled to height: 2, 4, and 6 times body height) and three different target sizes (3, 5, and 7 feet square) on the throwing performance of 26 third-grade children. They found more advanced step, trunk, and humerus body components were demonstrated when the children had to throw longer distances. No significant effects were found for target size, although the investigators acknowledged their targets may have been too big and did not require high levels of accuracy. The manner in which skilled throwers adapt their throwing patterns to the distance thrown was evident in a study of the throwing patterns of collegiate baseball throwers (Barrett & Burton, 2002) and elementary-aged children (Lorson & Goodway, 2008). Barrett and Burton found that players altered their throwing patterns depending on how far they needed to throw. When throwing into base from the infield an ipsilateral step was often seen, whereas throws from the outfield required more advanced throwing components. Lorson & Goodway (2008) examined gender differences in the throwing form of children playing a throwing game before and after instruction. They found differences between the pretest and after instruction for boys' on the trunk and forearm components and for girls' on the step and trunk components. The improvement after instruction and gender differences were similar to those found in a controlled, practice context.

A significant environmental constraint is the influence of instruction on throwing performance. There is a growing body of work in this area and some innovative and effective methods to teach children to throw that have significant implications for teachers and coaches. It seems particularly important to develop effective instructional practices for girls as research has found persistent gender differences in throwing performance with many studies showing that these gender differences persevere after instructional intervention (Browning & Schack, 1990; Dusenberry, 1952; Garcia & Garcia, 2002; McKenzie et al., 1998; Thomas et al., 1994).

Early work by Dusenberry (1952) found a three-week instructional program resulted in both genders improving distance thrown but boys threw further than girls with the same amount of training. In contrast, Halverson and colleagues (Halverson & Roberton, 1979; Halverson, Roberton, Safrit, & Roberts, 1977, 1979) found no improvements in throwing velocity between groups (throwing instruction, a movement program without throwing instruction, and a comparison group) for an eight-week throwing program. However, a subsequent review of the developmental level in throwing components reported more advanced patterns of forearm lag, trunk action, stepping action, and spinal rotation in the throwing instruction group (Halverson, Roberton, Safrit, & Roberts, 1979. McKenzie and colleagues (1998) showed that throwers in a school program designed to enhance physical activity performed significantly better on distance and accuracy tasks in throwing compared to students in a regular physical education program. Again, this may speak to throwing practice opportunities versus the actual nature of the throwing instruction.

A number of studies have considered the role and knowledge of the teacher in throwing instruction. Graham and colleagues (1991) compared the influence of a trained physical educator to a classroom teacher on the qualitative and quantitative outcomes in throwing of 60 first- and third-graders' performance over three years. Interestingly, this study found that students taught by the classroom teacher were more skilled in throwing than throwers who were instructed by a trained physical educator. Although these findings may seem surprising, it may be that the classroom teacher's more "recess-like" physical education had more throwing activities overall, including more forceful throwing opportunities such as dodgeball. In contrast, the physical education specialist may have concentrated more on the development of all motor skills, not just throwing (Graham et al., 1991). A study by Walkwitz and Lee (1992) found that improving the throwing content knowledge of teachers through a motor development orientation improved teacher behaviors, which resulted in a significant impact on the stepping patterns of children. Cohen, Goodway, and Lidor (in press) found that when a teacher was trained to deliver aligned development feedback based upon throwing component sequences, improvements in ball velocity and throwing body components were found compared to what the teacher did naturally.

Other studies have looked at the nature of throwing cues and feedback provided within the instructional environment. Fronske and colleagues

(1997) were the first to use critical cues to help third- and fifth-graders with immature throwing patterns improve on throwing distance and the step and backswing component. The findings revealed that the use of cues improved throwing distance and form (step and arm) more than for a group that did not receive specific instruction. Oslin and colleagues (1997) used a specific presentation of cues called component specific instruction to improve throwing performance of 22 children aged 3–6 years. Overall, component specific instruction increased throwing efficiency, but there was no difference between a force production sequence or forward chaining sequence. Lorson and Goodway (2007) used critical cues and task constraints of a forceful throw to bring about changes in developmental levels and ball velocity of second- and third-grade students.

A more recent innovative approach to throwing instruction with 34 kindergartners compared a biomechanical-developmental approach to a traditional approach to teaching throwing (Stodden & Rudisill, 2006). The biomechanical approach focused on the exploitation of hypothesized control parameters that promote optimal energy transfer through the kinetic link system (Stodden et al., 2006a,b). Specifically, instruction focused on generating linear and angular momentum of the trunk and center of mass in addition to optimal preparatory positioning of the humerus, forearm, and wrist to promote energy transfer during the throwing motion. The results of this study showed that the instructional strategy integrating biomechanical concepts was more effective in promoting certain aspects of the throwing skill. This study was also the first to show a reduction in gender differences in throwing arm components. Gender differences in ball velocity were not reduced, which may indicate that additional intervention time was needed to more effectively reorganize coordination and interactions among segments to change ball speed.

Lorson (Lorson, 2005; Lorson & Goodway, 2008) followed up the Stodden study by investigating the influence of three instructional strategies taught by physical education teachers on the throwing performance of 105 first- and second-grade children. The three instructional approaches were: (1) the biomechanical approach developed above by Stodden (Stodden & Rudisill, 2006); (2) a critical cue group emphasizing three critical cues ("laser beams" for sideways orientation, "long step," and "twist and throw hard"); and (3) a traditional group utilizing the cues ("side to target," "arm way back," and "throw hard") suggested by a major elementary physical education textbook (Graham, Holt/Hale, & Parker, 2007). The results from this study found the biomechanical approach was more successful than the other two approaches in promoting change in the humerus and forearm. No differences were found between the groups for the step and trunk component, as well as ball velocity. Significant gender differences were present at the pretest and remained at the posttest with boys' throwing performance and velocity greater than those of girls. Lorson added the unique aspect of looking at the application of throwing performance to a game situation (Lorson & Goodway, 2008). The step, trunk, and forearm components in a throwing game were correlated with body component levels during practice. Overall, these findings suggest that any of the three strategies improved throwing performance, with the biomechanical approach the most useful tool to help develop the humerus and forearm components.

In summary, a review of the throwing literature suggests that:

- Valid developmental sequences exist for throwing.
- Gender differences are present in throwing, with boys better than girls.
- Children exhibit variable, nonlinear, and context-sensitive emergence of throwing behaviors in line with a dynamic systems approach.
- Individual, task, and environmental constraints influence throwing performance.
- Throwing instruction positively impacts the performance of the overarm throw.
- Process measures of throwing are more sensitive to instruction than product measures such as velocity.
- A variety of instructional approaches including models, critical cues, and the biomechanical

approach yield significant effects on throwing performance.
- A long contralateral step is important in order to begin rotating the trunk on the legs.
- The biomechanical approach seems to have the best results in impacting the humerus and forearm components of the throw.
- Gender differences present prior to the interventions persist across the intervention; even though girls get better from instruction, they do not catch up to boys at the end.
- During initial instruction of the overarm throw, the focus should be on throwing for force to evoke the most mature pattern.

INTERNATIONAL PERSPECTIVES

Motor Skills in Children: Are We a Product of our Sports Culture?

The data in Figure 11.4 provide a guideline about the age at which 60% of the children tested could perform a particular skill at a specific stage. These data were collected on children in the Midwestern part of the United States. However, we know from a constraints perspective that environmental factors influence the emergence of motor skills in children. That is, the type of sports to which children are exposed will influence the development of those motor skills that are in the sport culture. Get in a group and select a country whose popular sports are familiar to you (e.g., U.K., Japan, Australia). Now think about similarities and differences of the sports culture in this country compared to the U.S. sports culture. Take a look at the chart in Figure 11.4 and discuss how these data might look different for boys and for girls in these two countries. Do you think that you will see different data for the two countries? In what skills? And in what genders? What role do you think sports cultures play in the development of children's motor skills?

Catching

Like throwing, catching is also a commonly used skill in sports, games, and lifetime activities. It is a manipulative skill whose goal is to retain possession of the object. The kind of catch performed is dependent on the task and environmental demands such as the position and velocity of the ball in the air, the shape and size of the ball, and the trajectory of the ball. As a result, catching can be done with one hand or two. In catching's more primitive form, young children learn to catch balloons, large balls, and beanbags with their arms and hands. As children progress through elementary school they become better able to catch balls of different sizes, shapes, and velocity with one and two hands. At the elite sports level we see amazing feats of catching where individuals intercept the ball in seemingly impossible situations. Many sports such as basketball, baseball, softball, rugby, and American football rely on proficient catching skills in order to play the game. There is a fairly large body of literature on catching to inform the physical education teacher and coach. For the purposes of this chapter we will only examine the literature on two-handed catching.

Children need to possess several skills in order to be able to catch a ball including eye-hand coordination, the ability to track an object with the eyes and consistently anticipate and intercept this object, perceptual awareness, and fine manipulation of the fingers to the flight dynamics of the object. The proximodistal law of developmental direction is relevant to the emergence of catching behaviors. This law states that children learn to gain control of their body from the midline out to their hands. The law is seen in action in the development of catching behaviors as children first learn to catch by trapping the ball to their chest then become able to catch a ball tossed to their chest with their hands, and finally can catch a moving ball in the air. It is not until children can catch a ball on the move with their hands that they are ready to apply catching skills to the arena of sports.

Proficient Catchers

There are many kinds of catching but the two that have received most attention in the developmental literature are two-handed catching and one-handed catching. Many of the major motor development scholars agree on the characteristics of a proficient catcher (Gabbard, 2004; Gallahue & Ozmun, 2006; Haywood & Getchell, 2006; Payne & Isaacs, 2008) and these characteristics can be found in Table 11.8. Skilled catchers are seen in many sports across the world from the fast reactions of the first baseman in baseball and the wicket keeper in cricket to the precision of the wide receiver catching an American football while flying through the air. Skilled catchers are central to the successo fm anys ports.

In contrast, we have all observed an initial catcher. Often she turns the head to the side, closes the eyes, and leans away from the incoming ball for fear of being hit in the face. She does not track the ball's flight, and the arms and hands make little or no adjustments to the spatial characteristics of the ball, just responding at the last moment as the ball comes toward the body. The fingers tend to stay rigid and the arms and hands do not "give" into the ball. If the ball is tossed with force, it will frequently bounce out of the outstretched hands, assuming the ball connects with them. The timing of the catching motion is out of synch with the ball flight, and many children demonstrate balance difficulties once they have received a forcefully thrown ball. If the ball is small, it is rarely caught; if the ball is large, such as a playground ball, the children will trap it against their chest using their arms. Inexperienced catchers such as these do not possess the necessary skills to be able to successfully apply catching to the sports arena. Sadly, many parents and coaches do not consider these factors as they make decisions about their child's ability to engage in organized sport. In many community organized sports leagues, children with poor catching skills are placed in positions such as first base where they cannot possibly meet the demands of the task asked of them. From a developmental perspective, these children would be much better off practicing their catching skills with parents, siblings, and peers, rather than engaging in miserable experiences in organized sport where the child's developmental level does not match the task demands.

Development of Two-Handed Catching

Developmental sequences of catching are available for both the total body (Haubenstricker, Branta, & Seefeldt, 1983) approach and the component (Roberton & Halverson, 1984) approach to catching.

Total Body Developmental Sequence of Two-Handed Catching

Table 11.1 and Figure 11.5 illustrate the five-stage sequence of catching a ball. The first stage of this

TABLE 11.5 Characteristics of a Proficient Catcher

Proficient catchers demonstrate the following:

Preparation for Catching
- Trackt heb allw itht hee yes
- Alignb odyw ithi ncomingfl ight characteristics of object
- Feetsli ghtlya part
- Prior to catch, arms relaxed at side or slightly in front

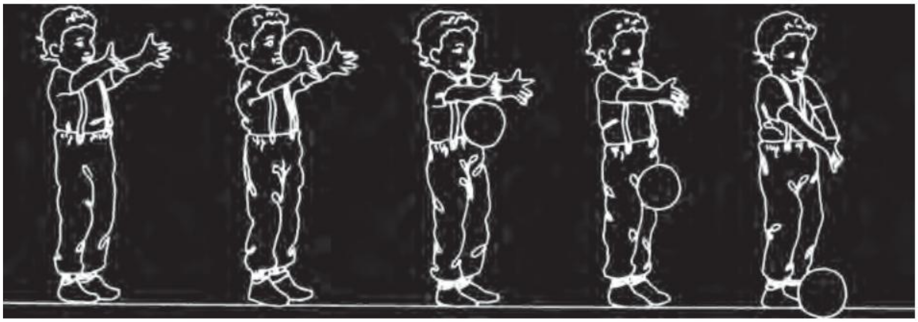
Reception of the Object
- Handsm ovet o intercept the object—fingers adjust to precise spatial characteristics of the object (fingers up for high ball, down for low ball)
- Arms "give"o nc ontactt o absorb the force
- Fingersg raspo bjecti n well-timed simultaneous action
- Body weightt ransferredf romf ront to back

sequence mirrors the description of the inefficient catcher above. The child progresses to hugging (stage 2), then scooping (stage 3) a larger ball. It is not until stage 4 that the child can hand catch a ball tossed to the trunk (he would miss a ball tossed outside of the parameters of the body). By stage 5, the child can now move his body to catch the ball. The stages for catching have undergone preliminary validation in a mixed longitudinal sample (Haubenstricker, Branta, & Seefeldt, 1983). Given these stages, parents, teachers, and coaches need to recognize that a child is not ready to engage in team sports involving catching until she reaches stage 5.

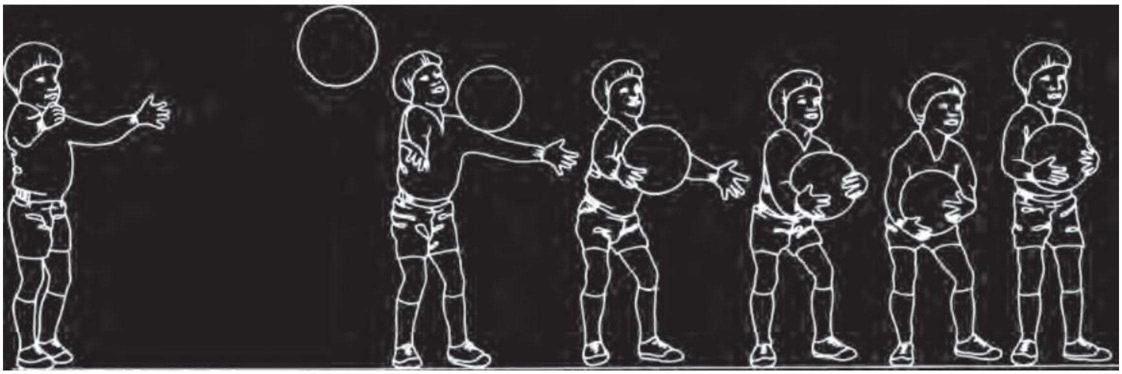
The catching data in Figure 11.4 reveal that catching is one of the few skills where girls are ahead of their male counterparts. Girls show stage 4 behaviors around 60 months, whereas boys reach this stage 12 months later at 72 months. The proficient (stage 5) stage of catching is reached at 76 months for girls and 82 months for boys.

Component Developmental Sequence of Two-Handed Catching

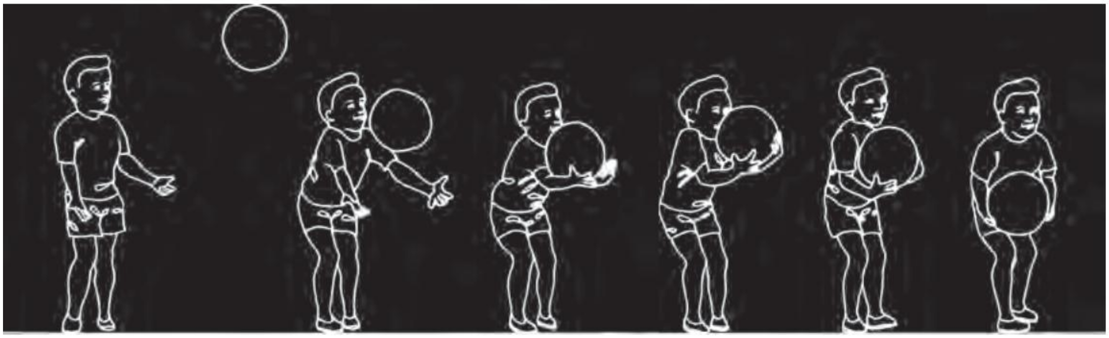
A component developmental sequence for catching exists that is the product of an integration of several pieces of empirical work. This sequence consists of a 4-step arm component, 3-step hand-action component, and 3-step body-action component (Haywood & Getchell, 2009). The original catching sequence was proposed by Harper (1973) and cited by Roberton and Halverson (1984). Later, Strohmeyer, Williams, and Schaub-George (1991) used a mixed longitudinal sample to attempt to validate these sequences. The hand and body components were validated, but the arms were not. Thus, a modified arm component was adapted from Haubenstricker, Branta, and Seefeldt (1983) and added to the Strohmeyer et al. (1991) hand and body components, resulting in the three-component sequence in Table 11.6.



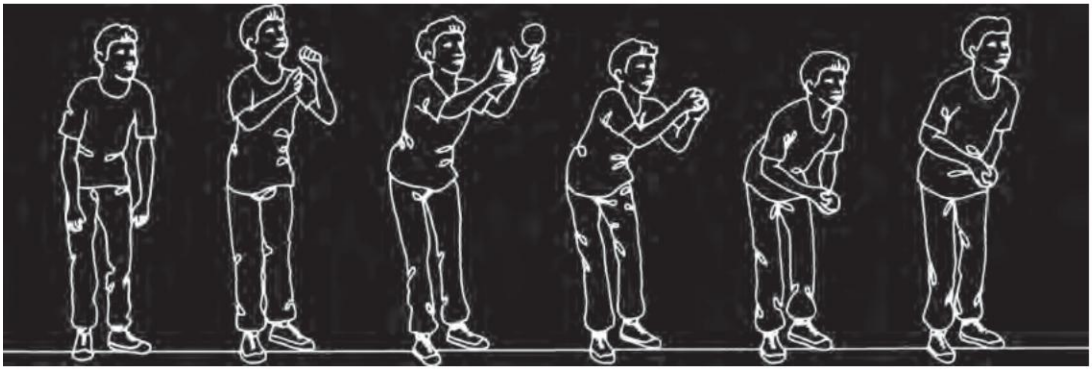
Stage 1



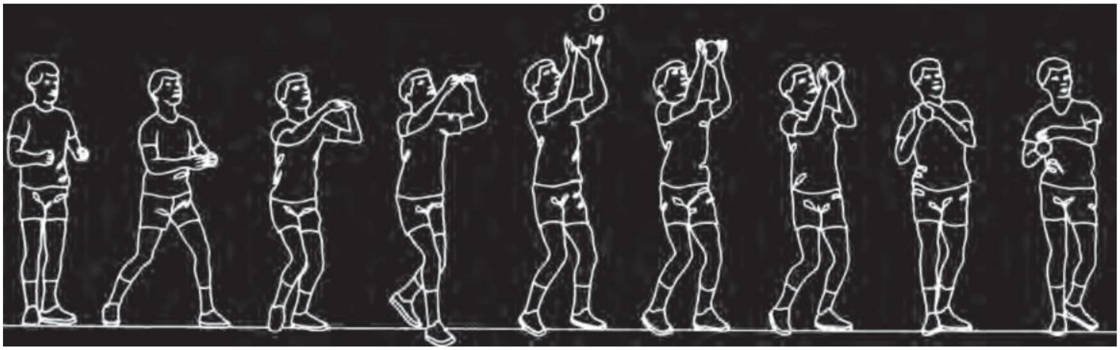
Stage 2



Stage 3



Stage 4



Stage 5

Figure 11.5

Developmental Sequences of Catching

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Constraints in Catching

There are many individual, task, and environmental constraints that influence the performance of catching, as shown in Table 11.7.

As we examine the catching literature we will find a lot of contradictory findings in the empirical literature. We must be cautious in drawing conclusions from the catching findings as catching is

TABLE 11.6 Component Developmental Sequences of Catching

Arm

A1 *Little Response*—Arms extend forward, little adaption of arms to ball flight; ball is often trapped against chest.

A2 *Hugging*—Arms move sideways to encircle (hug) the ball; ball is trapped against chest.

A3 *Scooping*—Arms are extended forward under ball (scoop), ball is trapped against chest.

A4 *Arms "Give"*—Arms extend to meet object with the hands; arms and body "give," ball is caught withh ands.

Hands

H1 *Palms Up*—The palms of the hand face up.

H2 *Palms In*—The palms of the hands face each other.

H3 *Palms Adjusted*—The palms of the hands adjust to ball flight and size. Thumbs or little fingers are placed close together, depending on the height of the flight path.

Body

B1 *No Adjustment*—No adjustment of body in response to ball's flight path.

B2 *Awkward Adjustment*—Arms and trunk begin to move in relation to ball's flight path but the head remains erect, creating an awkward movement to the ball.

B3 *Proper Adjustment*—Feet, trunk, and arms move to adjust to path of oncoming ball.

TABLE 11.7 Individual, Task, and Environmental Constraints in Catching

Individual	Task	Environmental
• Gender	• Balll ocation and flight trajectory	• Size of ball
• Age	• Distance and height	• Ball color and background
• Experience	• Balls peed	• Viewing time
• Bodyp arameters		• Instruction

a tough task to research, and it is hard to control the many factors that influence catching patterns. One might wonder why there is so much confusion. However, there is little standardization in the way catching is evaluated and the conditions under which catching is performed. Some researchers use a process-oriented approach to catching such as identifying the patterns of movement, while others use a product approach based on success (or not) of the catch. Additionally, in many of the older catching studies, there was little description of the nature of the catching conditions, so replication of these findings has been impossible. There remains a lot to learn about catching, but let us examine what we do know.

Individual Constraints

Individual constraints are those factors that are internal to the individual. In catching, the major areas of individual constraints that have been examined are gender, age, and experience. The findings relative to gender differences in catching are mixed. Some studies have suggested that across age boys outperform girls in catching (Butterfield & Loovis, 1998; DuRandt, 1985; Isaacs, 1980; Loovis & Butterfield, 1993; McKenzie et al., 2002; Thomas & French, 1985), while others indicate there are no gender differences in catching (Morris et al., 1982; Payne & Koslow, 1981). Although the results for gender appear to be mixed, the answer to these conflicting findings may be found in the nature of the catching task set for the children and the way the authors identified a successful or proficient catching pattern. Morris and colleagues (1982) suggested that age was a more important factor than gender in children aged 3 to 6 years. Other work agreed with this finding, indicating that as a child got older (4–8 years), catching performance increased (DuRandt, 1985), and that chronological age was more influential on catching scores than other factors (DuRandt, 1985). Loovis, Butterfield, and Bagaka (2008) examined catching behaviors across time in a multicohort longitudinal design of children in grades K–8, 2–8, and 4–8. In contrast to other literature on catching, boys performed better than girls in the initial K–8 cohort, although they showed similar slow, steady growth trajectories over the nine years of the study. Also, children who participated in organized sports were more likely to demonstrate proficient catching. Loovis and Butterfield (2003) found that age, sex, and hand length contributed significantly to catching accuracy and catching form in young children (grades K–2).

We might logically expect that an individual's experience influences catching performance. A number of studies (Butterfield & Loovis, 1998; Kourtessis, 1994; Lefebvre, 1996; Starkes, 1986) support this view, suggesting that prior catching experience in ball sports like baseball positively impacts catching performance. Interestingly, while supporting this view, Butterfield and Loovis (1998) reported that engagement in organized sport activities was not significantly related to the development of catching. Rather, informal play, parental encouragement, and instruction in physical education were considered more influential. The role of experience in catching is far from clear, but one might assume that children need practice opportunities to improve catching performance.

Task Constraints

Task constraints are factors related to the goal of the activity. In this section we will examine studies that deal with task factors such as ball location, flight trajectory, distance of projection, and effects of height of interception. McConnell and Wade (1990) examined the influence of a ball projected to different locations on the catching skills of 108 children aged 5–10 years. Tossing a ball too close to the body or too far away was associated with unsuccessful catches. A number of studies have examined the relationship between a ball's flight trajectory and catching performance (Bruce, 1966; DuRandt, 1985). Early work by Bruce (1966) suggested there was no relationship between two ball trajectories and catching performance. However, this finding is in contrast to other work. Williams (1968) found unskilled catchers performed better with a flatter angle of projection (34°) in contrast to the overall group that did better with a higher projection angle (44°). DuRandt (1985) also suggested younger children (4 years) seemed to catch low trajectory balls best, and slightly older (6 years) children caught medium trajectory balls best. By age 8 years, there were no significant differences among the three different trajectories used in the study. It may be suggested that by age 8 years, students are proficient enough to adjust to varying flight trajectories presented.

In a study of 36 6–7-year-old children, Payne (1982) found that the distance of projection was not significantly related to catching performance, but ball size was. In contrast, other scholars (Belka, 1985; McConnell & Wade, 1990) found that catching success was greater for near distances as opposed to intermediate and far distances. Again, the contradictory findings in this area probably lie in the ways in which catching behaviors were evaluated. Belka (1985) suggested that for younger children a chest height catch resulted in superior scores to waist and knee height catches. However, by age 10 years, children were proficient in varying heights of interception such as chest, waist, and knee height. The speed a ball is tossed also affects the nature of the coincidence-anticipation part of the catching task. Bruce (1966) found catching performance declined as ball speed increased from 25 feet/second to 33 feet/second. However, slowing the toss down to slower ball speeds may not be the answer as young children are often inaccurate with these slower speeds. They tend to move too early to anticipate the ball (Haywood, Greewalh, & Lewis, 1981; Isaacs, 1983).

Environmental Constraints

Environmental constraints deal with those factors external to the individual. Environmental constraints include ball size, ball color and background color, viewing times, and the influence of instruction on catching. Many teachers will select a larger ball to catch when working with young children. Early work by Smith (1970) supported this view, indicating larger balls were easier to catch. Smith tied this rationale to the young child's lack of ability to track the ball and less skill in the fine motor control aspect of the task. Other studies using the outcome of the catch as the means of assessment (e.g., whether the hands made contact with the ball or whether they maintained control of the ball) supported this notion, showing that children catch larger balls more successfully than smaller balls (Payne, 1985; Payne & Koslow, 1981). In contrast, some studies have shown that smaller balls result in better catching performance (Isaccs, 1980; Wickstrom, 1983). The rationale behind this work is that children were forced to use their hands to catch a small ball, but with bigger balls they could resort to hugging the ball into their chest. Clearly, when a teacher changes the size of the ball to be caught, she influences the catching pattern used. We believe that if children are incapable of catching a smaller ball, then a larger ball should be used to build success and motivation. Once children can catch a ball with their hands, the teacher should systematically decrease the size of the ball.

Another factor that influences catching is ball color and background. Morris (1976) found overall blue and yellow balls were caught more readily than white balls, and specifically that 7-year-olds catch blue balls against a white background best. As children get older the impact of color diminishes. Isaacs (1980) reported an interesting finding relative to ball color: a child caught his preferred color ball more successfully than other color balls.

Children need to visually track a ball to catch it, thus the amount of time they have to view the ball influences catching performance. Research has found that as viewing time decreases so does the success of catching the object (Whiting, Gill, & Stephenson, 1970). Other work has suggested that older children better predict the position of the ball in the air for interception when viewing time is short (Lefebvre & Reid, 1998).

One of the major environmental constraints that influence catching performance is instruction. Given the critical nature of catching in a wide variety of sports and games, we know relatively little about the impact of instruction on catching performance. However, those studies that have been conducted report that instruction positively impacts both the product and process aspects of catching performance (Goodway, Rudisill, & Valentini, 2002; Graham, 1991; McKenzie et al., 1998; Toole & Arink, 1982).

Toole and Arink (1982) compared the influence of movement education as opposed to traditional instruction on the motor skill performance of catching, throwing, striking, and kicking in first-grade children. The catching skill improved more from the traditional instructional approach as compared to the movement education approach. The authors suggested that the command style of instruction with demonstration and specific instructions probably accounted for this improvement. A couple of studies have compared the influence of physical education specialists to trained classroom teachers on FMS performance of children, including the skill of catching (Graham, 1991; McKenzie et al., 1998). Both studies found that instruction improved catching skills but there was no difference between physical education specialists and trained classroom teachers. In the McKenzie et al. study (1998) catching gain scores for boys were significantly greater than those of girls, although the curriculum had a small to moderate effect on the skill improvement. In Graham's (1991) study, children improved the process and product aspects of catching across the three years as one might expect; again, there were no differences by program.

A study by Goodway, Rudisill, and Valentini (2002) is one of the few studies to take a developmental approach, using **developmental**

sequences to examine the influence of instruction on catching development in preschoolers and kindergartners. Intervention 1 with disadvantaged preschoolers used a direct-instruction approach. Intervention 2 with developmentally delayed kindergartners used a mastery motivational climate approach to teach the intervention. Prior to the intervention, "hugging" and some "scooping" behaviors were most common for the participants in Intervention 1. The older children in Intervention 2 demonstrated more variability in their catching performance as might be expected with an older age group. Both Intervention 1 and 2 resulted in significant pre- to postintervention changes in the arm component for the children in the intervention groups. In Intervention 1, 75% of the intervention group improved at least one level, and in Intervention 2, 68% of the intervention group improved one level. Different patterns of change were found between the interventions for the body and hand components. It was suggested that the differing task constraints in the two interventions, in the form of cue words and instructional tasks, shaped or constrained the emergence of catching behaviors. That is, the children responded to what was taught and emphasized in the specific intervention. The authors concluded that instruction improves catching performance for preschool and kindergarten-aged children. The instructional time allocated for catching was 120 minutes in Intervention 1 and 60 minutes in Intervention 2, showing that catching performance can be impacted in a relatively little amount of instructional time.

In summary, a review of the catching literature suggests the following:

- Valid developmental sequences exist for catching.
- Gender differences are present in stages of catching with girls better than boys.
- Individual, task, and environmental constraints influence catching performance.
- Instruction positively impacts the performance of catching with the emergence of catching development shaped by the nature of the intervention.

Kicking

Kicking is a ballistic skill that is a form of striking with the foot. Many sports use variations of kicking, but the most popular sport that relies on kicking skills is soccer or football as it is called in much of the world. Soccer has become a worldwide sport played by millions of people in over 204 countries. Around the world kicking is used in other organized sports such as American football and rugby, and also in cultural activities such as sepak tekraw, hackey-sack, or shuttlecock.

In order to be able to kick children need to possess eye-foot coordination, balance, and perceptual motor abilities. Overlock (2004) found a significant relationship between static and dynamic balance ability and kicking. Despite the large number of people around the world using kicking skills, there is relatively little known about the development of the skill and the individual, task, and environmental constraints associated with kicking. The one skill that has limited research on it is place kicking, a form of kicking where the child kicks a ball placed on the ground. It is believed that place kicking is a foundational skill that, once mastered, enables children to apply their kicking skills to other skills such as foot dribbling and passing.

Proficient Kickers

As for all of the other fundamental motor skills, proficient kickers apply biomechanical principles to maximize the performance dynamics of the kick. Proficient kickers are able to adjust the force, distance, trajectory, and type of kick to changing task dynamics in order to accomplish the goal of the task. If you watch a professional football game, you will see a football player perform hundreds of variations of kicks from soft touches where the ball is lightly kicked a few feet to forceful kicks where the ball is driven halfway down the field. The type of kick performed depends on the force and position of the ball when it is received and also the intended outcome of the kick. In kicking, there is a stabilizing leg that bears body weight and a manipulative leg that contacts the ball (Gabbard, 2004).

TABLE 11.8 Characteristics of a ProficientK icker

Preparatory Action
- Continuousm otion intot heb all
- Longl asts tep(or leap) before the ball
- Stabilizing foot beside or slightly behind ball
- Trunk slightlyl eaned back

Force Production
- Manipulativel eg startsb ack with knee flexed
- Forceful forward swing of leg with sequential inertia—thigh rotates first followed by lowerl eg
- Legs traightens as it makesc ontact with ball
- Trunkl eansb acka t contact

Follow-Through
- Manipulative leg travels vigorously forward and upward, often causing the stability leg to come off the ground and perform a hopping pattern (this dissipates force)
- Trunkl eansb ackward
- Arms in opposition to legs to counter the rotatory forces of leg

There are three parts to a proficient place kick: preparatory action, force production, and follow-through. The characteristics of a proficient kicker are reported in Table 11.8.

Unlike skilled kickers who have preparatory, force production, and follow-through actions, initial kickers tend to show a single motion that lacks the power-producing aspects of the proficient kick. Less skilled kickers tend to stand behind the ball in a stationary position, push the ball forward with a flexed leg, and have no observable rear leg swing, and there is little, if any, motion of the upper body and the arms. Obviously, with a motion as primitive as this, the child is unable to adapt the kick to sports and games or other more complex environments.

Development of Kicking

Only one group of researchers has identified a four-stage developmental sequence for kicking performance (Haubenstricker, Seefeldt, Fountain, & Sapp, 1981). Table 11.1 and Figure 11.6 portray the developmental sequence of kicking a ball.

In stages 1 and 2 the child is stationary behind the ball and the kick has little functional utility. It is not until stage 3 that the child can perform a continuous movement into the ball with a step-kick pattern or short run and kick. In this stage the child begins to develop more force by getting the manipulative leg behind the trunk for force production. By stage 4 the child has added a long last step or leap into the ball, a powerful leg drive to contact the ball, and follow-through actions to dissipate the force generated from the powerful kick.

Figure 11.4 shows the age at which 60% of girls and boys perform a particular stage of kicking. Early (stage 1) kicking behavior emerges around 20 months for boys and girls. At this point boys begin to be in advance of girls, a trend that increases with age. In these early stages children will often alternate their kicking foot and footedness has yet to be determined by the child (Gabbard, 2004). Gabbard (2004) suggests that humans are innately drawn to stabilize on their left side, leaving the right side as the manipulative limb, and that this shift to right-footedness occurs toward middle childhood. Interestingly, the incidence of left-footedness is consistent across the life span (Gabbard & Iteya, 1996). By stage 3 there is a marked difference between boys who acquire this stage of kicking at 54 months and girls who do not reach it until 74 months. The final stage of kicking takes a long time to emerge at 87 months for boys and 99 months for girls. Gender differences

Stage 1

Stage 2

Stage 3

Stage 4

Figure1 1.6

Developmental Sequences of Kicking

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favoring boys are not only found in process measures such as developmental stages, they are also found in product measures such as distance kicked, and these differences increase with age (DeOreo & Keogh, 1980).

There is limited empirical evidence on kicking; much of it is biomechanical in nature and from Europe. Gámez and colleagues (2004) compared the three-dimensional kicking kinematics of 8–10-year-old experienced football players to adult data in the literature. Overall, children had less peak hip, knee, and ankle velocity than adults (speed of limb segments). The timing of the velocity of limb segments also differed between children and adults. Another kinematic study by Bransdorfer (1999) examined the relationship between kicking kinematics and skill level in 20 3–8-year-old children. The results reported knee flexion at contact for all four stages of skill level of players. Also, there was a segmental relationship between deceleration of the thigh and acceleration of the shin in skilled (stage 4) kickers as predicted. Some evidence of this relationship was also found in stage 3 kickers.

Some limited work has looked at environmental constraints such as instructional issues in kicking. Not surprisingly, Bargren (2000) found that children in a motor development program improved their kicking skills as a result of instruction, as compared to a control group that did not. Poole and colleagues (1996) found a disconnect between third-graders' perceived ability in kicking (which was high) and actual performance. It was suggested that children had not spent enough time kicking to develop an accurate representation of skillfulness.

A number of studies have looked at individual factors influencing kicking. Butterfield and Loovis (1994) investigated the influence of individual constraints of age, sex, balance (static and dynamic), and sports participation on kicking in 716 children aged 5–14 years. Sex (grade 6 boys outperformed girls) and static and dynamic balance were significantly predictive of kicking behaviors. There is a definite need to know more about kicking and the individual, task, and environmental factors that constrain the skill. Additionally, there needs to be a systematic examination of ways in which we teach kicking to children in order to evaluate appropriate approaches for children of different ages, skill levels, and gender.

Campos, Gallagher, and Ladewig (1995) investigated the effects of age (8–10 and 12–14) and skill level (skilled, unskilled) on knowledge and decision-making components of soccer. The results show that skilled players exhibited superior performance on soccer knowledge and soccer decision making independent of age level. This finding suggests that younger skilled children can perform similar to older skilled children if they are truly equated on the amount of soccer skill. Further, skill level influenced the child's ability to make appropriate decisions during the game, indicating that the opportunity to develop skills in soccer is more important than a child's age.

Punting

Punting is also a ballistic skill that is a form of kicking where the foot strikes an airborne ball, typically dropped by the kicker. Many sports use variations of punting such as the goal kick in soccer and the punt in rugby and American football. Punting is a more complex skill than kicking in that the player must drop the ball to his or her foot in order to punt it. Punting requires eye-hand-foot coordination, balance, and perceptual motor abilities. As with kicking, there is little or no empirical evidence to guide the teacher and coach in the learning process.

Proficient Punters

Punting follows many of the biomechanical principles of kicking in order to maximize the power-producing dynamics of the punt. Proficient punters can punt the ball with precision to a specific location on a field and also punt for distance. There are three parts to a proficient punt that mirror the aspects of kicking: preparatory action, force production, and follow-through. Table 11.9 identifies the characteristics of a proficient punter.

The performance of an initial or inexperienced punter is very similar to that of a poorly skilled kicker. Inefficient punters (Seefeldt & Haubenstricker, 1978) often start from a stationary position, toss the ball up into the air rather than drop it onto their foot, and demonstrate a pattern where they raise their manipulative leg in tandem with their arms (a pattern known as yoking). The manipulative leg does not have a rear leg swing and the trunk and arms have little action.

Development of Punting

Roberton (1984) hypothesized a component sequence for punting consisting of a four-step "ball release phase: arm component," three-step "ball-contact phase: arm component," and three-step

Table 11.9 Characteristics of a Proficient Punter

Preparatory Action
- Armse xtendedi nf ronto f trunk
- Continuousm otion into theb all
- Longl ast step (orl eap)b efore the kick
- Trunk slightlyl eaned back

Force Production
- Manipulative legi sb ack withk nee flexed
- Forceful forward swing of leg with sequential inertia—thigh rotates first followed by lowerl eg
- Legs traightens as it makesc ontact with ball
- Anklee xtended atb all contact
- Trunk leansb ack

Follow-Through
- Arms move to side and then move in opposition to kicking leg
- Manipulative leg travels vigorously forward and upward, often causing the stability leg to come off the ground and perform a hopping pattern (this dissipates force)

"ball-contact phase: leg action component." This approach was not validated. The same group of researchers that developed a sequence for kicking also developed a total body four-stage sequence for punting (Seefeldt & Haubenstricker, 1978). Table 11.1 and Figure 11.7 illustrate the four stages of punting a ball for force. Except for dropping the ball, they mirror the stages of kicking. Stages 1 and 2 are stationary, and it is not until stage 3 that the child can step and drop the ball. By stage 4 the child has added the necessary power dynamics to produce a forceful punt that can be used productively in sports and games. There are no age and stage data available for punting, although experience with children suggests that kindergarten-aged children are still at the rudimentary stages, and typically it is not until later elementary school that you might see a more proficient punt from the average child. Although we do not empirically know if gender differences exist with punting, one might suspect that they do, given these data on kicking.

The only study found on punting examined the influence of two instructional approaches (teacher versus learner rotated format) on the punting skills of fifth-grade children. Both approaches were valuable to teach punting to low-ability children; however, the learner rotated format was most profitable (Goldberger and Gerney, 1990).

In conclusion, the developmental sequences on kicking and punting are very similar and teachers can apply their knowledge from one to the other. Kicking and punting skills are important to teach, especially ensuring that girls get plenty of opportunity to practice and develop their skills due to the gender differences found in kicking favoring boys. There is a strong professional body of literature, mostly in the soccer coaching journals, that has much to share about what coaches "know" (from experience) about teaching kicking. However, we know almost nothing about this skill empirically. The area of kicking and punting is wide open to empirical investigation.

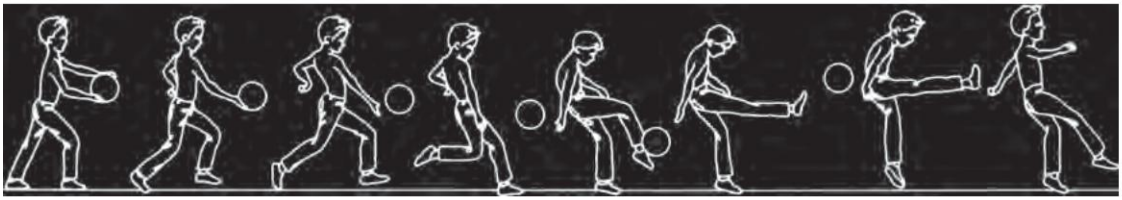
Striking

Striking is a ballistic, propulsion skill that takes on many forms in many sports and is taught across the school-aged physical education curriculum. There are several forms of striking such as sidearm,

Stage 1

Stage 2

Stage 3



Stage 4

Figure 11.7

Developmental Sequences of Punting

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underarm and overarm, one-handed, and two-handed. The kind of striking selected is, in part, influenced by the task demands such as the position of the object in the air and other environmental and task-oriented constraints. In its primitive form young children strike balloons and balls with their hands, body parts, and short paddles. They can strike with one hand or two. As they progress through elementary school they learn one-handed striking in table tennis, two-handed striking with a bat (batting), and other sport-specific forms of striking such as a forearm in badminton

Developmental Dilemma

To Play or Not to Play: That Is the Question!

Jose and Yolanda are 4-year-old fraternal twins born prematurely. Both children are small for their age but love being involved in motor skills and are begging their mother to let them join the local T-ball league that many of their friends are in. Jose runs at stage 3 and throws, catches, and strikes at stage 2. Yolanda runs at stage 4, throws and catches at stage 5, and strikes at stage 4. Their mother is worried about whether T-ball is "right" (developmentally appropriate) for her two children. There are two T-ball leagues in her community. One is very competitive. The coaches of these teams train the children very intensely three times per week and have games one time per week in preparation for travel baseball/softball. The other league is recreational and coached by parents, many of whom are not knowledgeable about the sport or children. In this league the children meet 30 minutes before the game to warm up and practice skills and then have one game per week. As you are the physical educator of her older children, Jose and Yolanda's mother approaches you to ask the following questions:

- Are Jose and Yolanda on target with their motorski lls?
- Should children of this age be playing organized sports like T-ball?
- Do Jose and Yolanda have the necessary skills to be in T-ball?
- If I decide to sign them up for a league, which one should I choose?
- What can I do with them at home to work ont heirski lls?

How would you respond to Jose and Yolanda's mother?

(sidearm strike) and a volleyball serve (overarm strike). Striking is an essential skill in many lifetime activities such as badminton, tennis, squash, racquetball, volleyball, baseball, and softball. As such, one would think that we might know a lot about the development of this important skill, but the reality is we know relatively little.

There are several factors that are important to being able to strike an object. Eye-hand coordination is critical, as is the ability to track the object with the eyes and consistently intercept an object. One motor development principle that is pertinent here is the proximodistal (from the midline to the furthest part of the body or implement) law of developmental direction. That is, children learn to control their body from the midline out. In striking a balloon with the hand, the hand is most distal to the body and hard to control in young children. However, when we put a bat in a child's hand, the end of the bat is now most distal and places a significant burden on the child to know where in three-dimensional space the bat is positioned. We have often seen a preschool or kindergarten-aged child swing a bat at a stationary ball on a tee, and watch her miss the ball. The adults watching often wonder how a child can miss an object that is stationary. But for the young child, this is a complex and challenging task for which the child has to comprehend the distal end of the bat, and then struggles in the precise task of making the end of the bat contact the ball. In this situation, the child needs to use a shorter bat, "choke up" on the bat, or use his hand in order to reduce the demands of the task. As individuals progress to become skilled strikers, they can make amazingly accurate judgments and perform precise movements in short periods of time as evidenced by Major League Baseball players.

Proficient Strikers

Proficient strikers are able to adjust the position of the body, arm, and implement (racket or bat) to meet the incoming object, connect with it, and impart a specific amount of force to the object to precisely place it on the playing field or court. For example, the skilled badminton player can powerfully place the birdie right to the edge of the service line, or complete a soft touch and "drop shot" the birdie carefully over the net. In the same manner, skilled batters can connect with a curved ball pitched at more than 160 kilometers per hour and place the ball on the field in order to advance the runner to the next base. Sidearm striking and batting share many similar characteristics, especially in the force production part of the movement. Where there are differences, they are in the preparatory and follow-through actions. Table 11.10 identifies the characteristics of a proficient striker. Similar to other ballistic skills, there are three parts to proficient striking incorporating the preparatory action, force production action, and follow-through action.

The performance of the unskilled or initial batter is very similar to the "chopping" motion of poorly skilled throwers. Initial strikers often face the object they are trying to strike, have an overarm pattern of chopping, and swing the implement from high to low with flexion and extension of the arm and no step. The arms and wrist are often rigid, making it challenging to adjust the angle of the bat/racket to the oncoming object. Sometimes in initial strikers, the timing of the child's swing can be out of synch with the flight of the object.

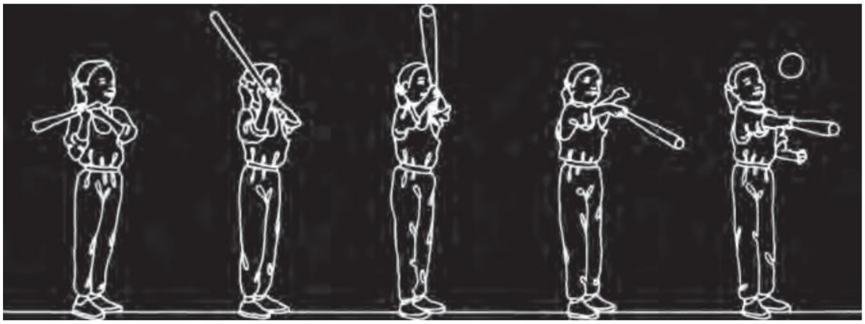
Development of Two-Handed Striking (Batting)

Only one group of researchers has identified developmental sequences for striking with a bat (Seefeldt & Haubenstricker, 1982). Table 11.1 and Figure 11.8 show the four-stage sequence of striking with a bat. Figure 11.4 shows the age at which 60% of girls and boys perform a particular stage of striking. Initial (stage 1) striking behavior emerges around 20 months with little differences among gender. By stage 3 (emerging strikers) boys are in advance (43 months) of girls (49 months). There is then a long period of time before the emergence of proficient stage 4 behaviors: 87 months for boys and 102 months for girls.

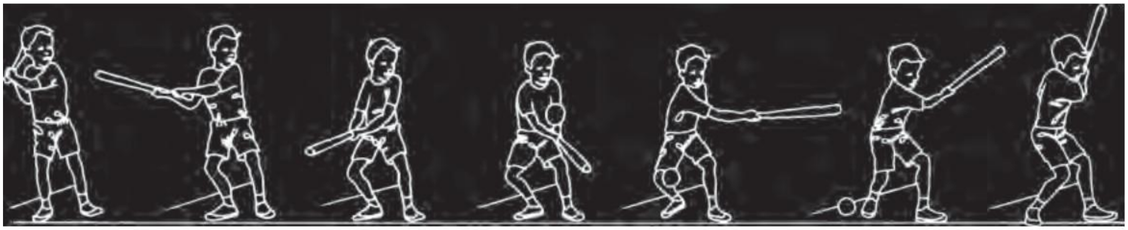
These data in Figure 11.4 are supported by other data in the literature on striking. Espenschade and Eckert (1980) suggest that sidearm striking becomes apparent by approximately 36 months. Harper and Struna (1973) studied longitudinal changes in one-handed striking of two children across a year. This work showed that as children developed in their striking skills, they developed more of a sidearm swing, contralateral

TABLE 11.10 Characteristics of a Proficient Striker

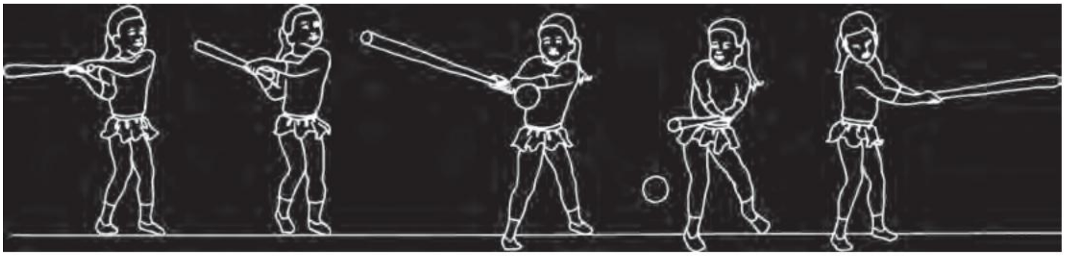
SidearmS triking	Batting
Preparatory Action	Preparatory Action
• Swingingb atb acki n a horizontal plane	• Body oriented sideways with weight on back leg
• Body orienteds ideways	• Step and weight shifts forward as hands go back
ForceP roduction Action	Force Production Action
• Long contralaterals tep intoh it	• Contralateral step into hit
• Swingingt hrougha f ullr ange of motion	• Swinging through a full range of motion
• Differentiatedt runk and hipr otation to contribute rotary forces	• Differentiated rotation to contribute rotary forces
• Extendinga rmsj ustb efore contact	• Combining backswing, step, pelvic rotation, trunk rotation, arm swing, ball contact, and follow-through to maximize forces
• Combiningba ckswing, step, pelvic rotation, trunk rotation, arm swing, ball contact, and follow-through to maximize forces	• Extending arms just before contact
Follow-Through Action	Follow-Through Action
• Armc omesa crossb ody	• Wrists roll
• Bodym ovesa cross base leg	• Bat swings across body
	• Weight shifts to front foot



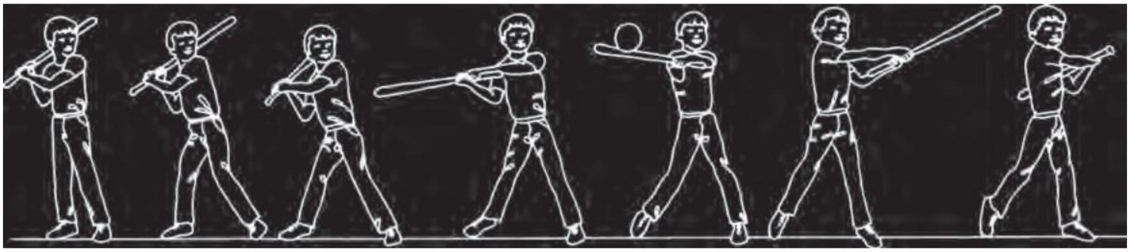
Stage 1



Stage 2



Stage 3



Stage 4

Figure 11.8

Developmental Sequences of Striking

step, and spinal and pelvic rotation. Wickstrom's (1968) study of 33 preschool children aged 21 to 60 months showed that the younger children (younger than 30 months) used an overarm swing to contact a suspended ball. With some feedback, they shifted to a sidearm pattern, and by four years, their pattern resembled that of an adult. Loovis and Butterfield (1995) investigated the relationship of age, sex, balance, and sport participation on the development of sidearm striking by 717 children aged 4–14 years. Development of mature striking was associated with sex; boys performed better at all grades except in grade 5 where the percentage of girls showing a mature sidearm-striking pattern approximated that of boys.

Other work on striking has hypothesized a component approach to striking patterns. Langendorfer (1987) and Messick (1991) used cross-sectional analysis to propose component developmental sequences for overarm striking. Langendorfer proposed eight component sequences based on observation of 1- to 10-year-olds that included the trunk, humerus, forearm, leg, pelvic range of motion, spinal range of motion, elbow angle, and racket action. In contrast, Messick proposed elbow angle, trunk, and racket sequences based on observations of 9- to 19-year-olds performing overhand tennis serves. Neither of these sequences has been validated longitudinally.

More recently Miller, Vine, and Larkin (2007) developed a striking assessment called the Miller Amalgamated Striking Instrument (MASI) using the total body sequences and the principles underlying component developmental sequences. The MASI had 10 components with 3 levels of efficiency in each component. In assessing 161 children aged 6–7 or 9–10 years on 6 trials of striking the ball for distance, the MASI found a significant correlation between process measures (MASI) and product measures (distance of ball). As with throwing, it appears that as the mechanics of the striking movement improve, so does the ability to translate that into product outcomes like the distance a ball is struck.

There is little empirical work on striking development with many of the studies that have investigated striking actually having a different focus. Wegman (1999) investigated the influence of three practice models (repetitions, random, and combined) on the acquisition of striking in 54 girls in grade 4. Performance significantly improved for all three groups, but the repetitions group performed better than the other two groups at the end of practice. A contextual interference effect in retention was shown for racket striking, in which the random group was significantly better than the repetitions and combined groups. This finding was attributed to the open nature of the striking skill and prior experience of participants. Johnson and Ward (2001) showed that classwide peer tutoring (students helping students) with third-grade children in a striking unit resulted in fewer total practice trials, more correct trials, and a higher percentage of correct trials than in a baseline condition. Additionally, the intervention was effective for high- and low-skilled girls, and children could accurately (90%) determine one another's performance in striking. Bram and Feltz (1995) examined the effects of batting feedback on motivational factors and batting of young baseball players. The study concluded that contact average may be more appropriate feedback for young players (compared to batting average) as it is less ambiguous and is based on a more realistic definition of success. French, Spurgeon, and Nevett (1995) proposed a study to examine differences in cognitive and skill execution components of game performance in 159 young baseball players with varying levels of expertise. The results indicated that baseball skill execution during game play maximally discriminated expertise levels.

A couple of studies have been conducted on affordances in striking. Davids, Bennett, and Beak (2002) looked at children's sensitivity to haptic (a sense of touch) information in perceiving affordances of a tennis racket for striking a ball. The findings concluded that children could demonstrate reliable preference for a tennis racket to optimally afford striking to a maximum distance in advance of performing a strike. The nonvisual condition was most reliable, suggesting that haptic information was more important in the absence of vision. Additionally, as time progressed, so did the children's affordances. Gagen (2002) found that racket size and child strength measures significantly predicted 59% of the variance in speed and control of striking a tennis ball. She concluded that reaching a critical ratio of racket size to striker size is needed to force a striker to reorganize the movement pattern.

The world of striking is varied with little empirical evidence to guide the teaching-learning process. Teachers need to consider the developmental level of the child in order to determine appropriate striking tasks. Roberton and Halverson (1984) suggest the need to scale the size and weight of the implement to the child. Much of the literature agrees that children need a sideways orientation, a long contralateral step into the object transferring weight to the front foot, good power dynamics in the swing, and follow-through. The area is ripe for research for investigators interested in striking and the individual, task, and environmental factors that influencet hep atterno ft he strike.

Summary

Children demonstrate developmental sequences in the acquisition of FMS during childhood. It was originally believed that children moved through these developmental sequences starting with the initial phase of movement being inefficient. As a child progressed through the developmental sequences he increasingly became more mechanically proficient and better able to apply these skills in sports and games. More recently we have taken this knowledge of developmental sequences and reconceptualized it using a dynamic systems and constraints perspective. The qualitatively different patterns of movement seen in the developmental sequences are believed to represent behavioral attractors or common ways of moving for the skill as children progress through learning the skill. Children may choose from these behavioral attractors in a movement situation, and the movement selected will depend on the interaction of constraints imposed by the individual, environment, and task. Total body and component sequences have been proposed for five manipulation skills. Knowledge of the developmental sequences and the constraints acting on the skill better prepare the teacher, coach, or clinician to design developmentally appropriate movement experiences for children.

Questions for Reflection

1. What role does FMS development play in the physical activity of children?
2. How would you break the negative spiral of disengagement in a low-skilled child?
3. Explain how the relationship between motor competence and physical activity changes from early childhood to middle childhood and adolescence.
4. Compare and contrast the total body approach and component approach to developmental sequences. How are they similar and how are they different?
5. Select catching or throwing and compare and contrast the total body or component sequences. How are these sequences similar and different? Which one is best?
6. Explain how stages of FMS are viewed within dynamic systems theory.
7. Select one of the five manipulative skills and summarize the individual, task, and environmental constraints influencing the skill.
8. In the skill above, identify how you could manipulate environmental or task constraints to make the task easier or harder for a child.
9. If you were a teacher or a researcher of throwing, what assessment would you use to track the development of throwing skills and why?

Critical Readings

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WEB RESOURCES

National Association of Sport and Physical Education

http://www.aahperd.org/naspe/

Website provides links to national standards in physical education and a host of resources for practitioners in promoting motor skills.

Physicale ducationw ebsite—PEC entral

http://www.pecentral.org/)

Website provides lesson plans, assessment instruments, and other professional resources for physical education and health teachers.

HeadS tart BodyS tart

http://www.aahperd.org/headstartbodystart/

Website provides ideas to promote physical activity and motor skills in preschool-aged children.

University of Michigan Your Child Development and Behavior Resources

http://www.med.umich.edu/yourchild/topics/devmile.htm

Website provides resources on developmental milestoneso fi nfantsa nd children.

CHAPTER

12 Development of Fundamental Movement: Locomotor Skills

KEY TERMS

Locomotorsk ills
Phylogenetic
Ontogenetic
Highgua rd
Middleg uard
Age-related
Age-dependent
Norm-referenced
Criterion-referenced
Validity
Reliability

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Describe the developmental sequences for Þve locomotor skills
- Observe a child perform a locomotor skill and identify the developmental stage of that child
- Compare and contrast the total body versus component approach to developmental sequences
- Identify potential learner constraints inßuencing locomotor skills
- Identify interskill sequences in locomotor skills
- Describe the characteristics of a proÞcient performer in Þve locomotor skills
- Devise a locomotor skill observation assessment checklist as an individual or group activity
- Describe three common assessment instruments to measure FMS and identify considerations for selection of an instrument

KEY CONCEPT

Locomotor skills allow individuals to navigate through space or move their body from one point to another and constitute foundational skills for engagement in sports, games, and lifetime activities.

A group of kindergartners spill out into the playground on a sunny day, running and squealing with the joy of being outside. Two little girls hold hands and start skipping around the playground together while a couple of boys race across the playground to the slide. Another two girls are playing hopscotch. It seems like a typical day on the playground. Watching these children play we might assume that young children naturally learn these motor skills of childhood and that all children look alike in the patterns of movement they demonstrate, but this is not so. If we were to look carefully at this picture we might see one girl skipping in an easy, rhythmical pattern with her arms swinging in opposition to her legs. Meanwhile her friend keeps up by showing a one-sided step-hop pattern with the right knee and right arm coming up together and the left side just stepping (she cannot skip). The boy who reaches the slide Þrst sprints quickly with his heels kicking his buttocks and his arms pumping, while the other, heavier boy runs more slowly with arms straight. Across on the hopscotch area one girl hops with ease and the other lands on two feet; it seems she cannot hop on one foot. It is clear from this closer analysis that these children vary considerably in their motor development and movement competence. So how do young children learn these seemingly ÒnaturalÓ locomotor skills of childhood? And what factors inßuence their motor development?

In the previous chapter we examined the body of literature on manipulative skills using a dynamic systems approach. We will use a similar approach in this chapter for locomotor skills. For each skill we will identify the *intraskill* (within one skill) sequences using total body and component (where developed) developmental sequences. We will continue to use the idea of how performers shift from *initial*, to *emerging*, and then *proficient* patterns of performance. We will then describe what we know about the performance or technique of a *proficient* and *initial* performer. We will conclude each skill with an examination of the research on potential constraints (individual, environmental, and task) that might inßuence the skill and implications for practitioners and clinicians. We will also consider the *interskill* (between skill) sequences, in other words, in what order locomotor skills emerge. Overall, the research on locomotor skills is less prevalent than that on manipulative skills, and constraints that have been studied are typically individual in nature.

Locomotor skills consist of a group of fundamental motor skills (FMS) that allow individuals to navigate through space or move their body from one point to another. Similar to manipulation skills, developing basic competence in these skills is essential for engagement in meaningful physical activity for health and to move effectively in various sports, games, and dances. Running, galloping, hopping, skipping, jumping, leaping, and sliding are the most common forms of locomotor skills. Motor development theorists often refer to locomotor skills as **phylogenetic**. That is, these skills are not culturally determined but are common to the ÒphylumÓor species of human beings. Along with this perspective is the notion that they develop more ÒnaturallyÓand with less need for formal instruction and feedback. In contrast, the manipulative skills discussed in the previous chapter are more **ontogenetic**; that is, they are more culturally determined and require formal practice and feedback in order to develop competence in them.

DEVELOPMENT OF LOCOMOTOR SKILLS

In this section we will describe the development of six locomotor skills; run, gallop/slide, skip, jump, and hop. Table 12.1 identiÞes the developmental total body sequences of Þve of these locomotor skills. For each stage the words in italics provide

Table 12.1 Developmental Sequences of Five Locomotor Skills

Fundamental Motor Skill	Stage 1	Stage 2	Stage 3	Stage 4
Gallahue & Ozmun	***Initial Stage***	***Emerging Stages***		***Proficient Stage***
Run	*Run High Guard* ArmsÑ high guard Flat-footed contact Short stride Wide stride, shoulder width	*Run Middle Guard* ArmsÑ middle guard Vertical component still great Legs near full extension	*Heel-Toe Arms Extended* ArmsÑ low guard Arm oppositionÑ elbows nearly extended Heel-toe contact	*Pumping Arms* Heel-toe contact (toe-heel when sprinting) Arm-leg opposition High heel recovery Elbow ßexion
Gallop	*Choppy Run* Resembles rhythmically uneven run Trail leg crosses in front of lead leg during airborne phase, remains in front at contact	*Stiff Back Leg* Slow-moderate tempo, choppy rhythm Trail leg stiff Hips often oriented sideways Vertical component exaggerated	*Smooth Rhythmical* Smooth, rhythmical pattern, moderate tempo Feet remain close to ground Hips oriented forward	
Skip	*Broken Skip* Broken skip pattern or irregular rhythm Slow, deliberate movement Ineffective arm action	*High Arms & Legs* Rhythmical skip pattern Arms provide body lift Excessive vertical component	*Rhythmical Skip* Arm action reduced/hands below shoulders Easy, rhythmical movement Support foot near surface on hop	
Hop	*Foot in Front* Nonsupport foot in front with thigh parallel to ßoor Body erect Hands shoulder height	*Foot by Support Leg* Nonsupport knee ßexed with knee in front and foot behind support leg Slight body lean forward Bilateral arm action	*Foot Behind Support Leg* Nonsupport thigh vertical with foot behind support leg, knee ßexed More body lean forward Bilateral arm action	*Pendular Free Leg* Nonsupport leg is bent, knee pumps forward and back in a pendular action. Forward body lean Arm opposition with swing leg
Long Jump	*Braking Arms* Arms act as ÒbrakesÓ Large vertical component Legs not extended	*Winging Arms* Arms act as ÒwingsÓ Vertical component still great Legs near full extension	*Arms Swing to Head* Arms move forward, elbows in front of trunk at take-off Hands to head height Take-off angle still above 45 degrees Legs often fully extended	*Full Body Extension* Complete arm and leg extension at take-off Take-off near 45 degree angle Thighs parallel to surface when feet contact for landing

a summary word or two in order to remember the stage, and below that is a description of the pattern ofm ovement.

RUNNING

Running is a form of locomotion that involves projecting the body forward on alternating feet as the bases of support. An extension of walking, running incorporates an airborne phase, during which both feet are off the ground, and can be viewed on a continuum from a slow jog to a fast sprint. Factors such as a contralateral pattern, a childÕs strength-to-weight ratio, and dynamic balance are all important in the development of running skills. Running is probably one of the most important FMS as it is used in almost all sports and games played by children and in lifetime activities. It is also one of the earliest skills in which children develop competency.

Proficient Runners

The development of a proÞcient running pattern requires that children have sufÞcient strength in each leg to propel the body up and forward, and for heavier children this can be a limiting factor. Dynamic balance is also important. Children must have enough multilimb coordination to coordinate both legs and maintain a steady stride. As children progress in their running development, they become more efÞcient by producing forces in the line of the direction of the movement and eliminate extraneous movements that work against forward momentum in the initial stages of the skill. For example, their arms pump forward and backward and they lean forward as they run. Developmental changes such as these result in greater biomechanical efÞciency and typically better product outcomes such as running faster. Children who are competent runners (sprinters) are proÞcient in several aspects of the run as outlined in Table 12.2.

However, many young children do not demonstrate the biomechanical efÞciencies described above. Initial runners tend to keep their bodies more upright or in a vertical plane when running. Arms do not contribute to the power dynamics of the skill and may be used for balance. Physical growth factors in young children such as small feet and a high center of gravity make the running task more challenging for a young child from a balance perspective. Thus, initial runners will tend to have a wide stance and short, ßat-footed strides as adaptations to poor balance, and to lower the center of gravity and widen the base of support. For the very beginning runner arms are placed in **high guard** (arms lifted to shoulders or higher) or **middle guard** (arms lifted to waist) position. These arm

TABLE 12.2 Characteristics of a Proficient Sprinter

ProÞcient runners demonstrate the following:

Force Production
¥ Body leans forward
¥ Base leg extends 180 degrees at push-off
¥ Opposite (or swing) leg drives forward with knee bent
¥ Arms ßexed (90 degree angle) and pump in opposition to the legs

Swing Phase
¥ Demonstrate a ßight phase when both feet are off the ground
¥ After push-off the swing leg bends and heels come close to buttocks in order to shorten the lever of the leg and allow faster movement toward foot contact again

Support Phase
¥ Heel to toe or ball of foot landing

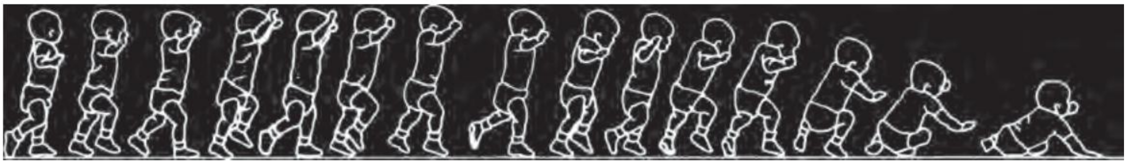
positions help to stabilize the trunk during the run and offer some degree of protection if the young runner falls forward. Neither the leg nor arm actions are efficient from a biomechanical perspective as they work against the line of direction of intended movement. However, these actions help children accomplish the run as they allow the runners to experience the feeling of moving their center of gravity forward outside of the base of support when using alternating bases of support.

Development of Running

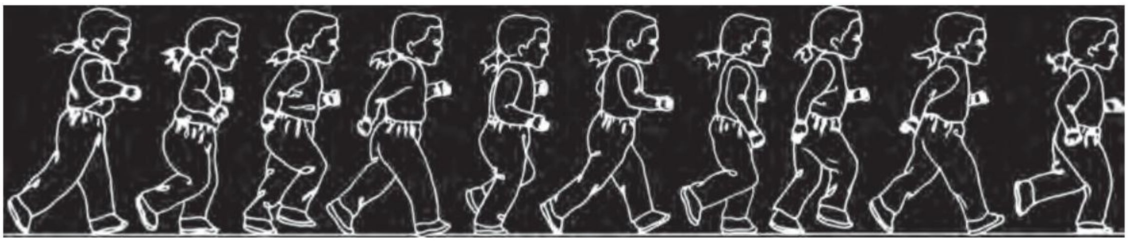
Running has been examined from a process and product perspective. The *process* of running examines the pattern of running movement; in this area developmental sequences for running have been proposed from both a total body approach and a component approach. In contrast *product* measures of running have looked at the outcome of the run. Outcome measures include distance runs such as the mile run, timed sprints in a variety of different distances, and shuttle runs or agility runs where the runner moves back and forth between two lines. More recently a commonly used product measure of running in physical education is the Pacer test, which is part of the Fitnessgram.

Total Body Developmental Sequence in Running

Table 12.1 and Figure 12.1 show the four-stage developmental sequence of running (Fountain, Ulrich, Haubenstricker, & Seefeldt, 1981; Seefeldt, Reuschlein, & Vogel, 1972). In developing these sequences children were given the task constraint of running as fast as they could to elicit a sprinting action if they were capable. Initial runners demonstrate a short, wide stride with high knee lift (stage 1). Over time the stride width becomes narrower until it is shoulder width apart in stages 3 and 4. Initial arm actions are protective in nature starting in high guard (stage 1) and then dropping to middle guard (stage 2). By stage 3 the arm action is in opposition to the legs but the arms are straight, and it is not until stage 4 that we see the mechanical efficiency of arms at a 90 degree angle pumping in opposition to the legs. The position of the trunk in relation to an imaginary vertical line also changes across developmental time. Initial runners (stages 1 and 2) are more upright. By stage 4 the trunk begins to lean forward and there is an approximately 10 degree forward lean in the line that runs from the hips to the shoulders (Michigan's Exemplary Physical Education Curriculum Project, 2006). This forward lean contributes to the power dynamics of sprinting,



Stage 1



Stage 2

Stage 3

Stage 4

Figure1 2.1 Developmental Sequences of Running

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allowing forces to propel the sprinter forward at greater speed.

Running is one of the earliest emerging FMS beginning around 18Ð22 months with girls being slightly ahead of boys (see Figure 11.4 in chapter 11). Boys move through these stages fairly quickly and reach a proÞcient performance of running by age 4 years. For girls it is not until a little after their Þfth birthday that a stage 4 is obtained. It is important to remember that these data shown in Figure 11.4 represent **age-related** changes in FMS and not **age-dependent** changes. That is, 60% of the children tested showed a speciÞc stage at a speciÞc age. Thus, one cannot say that *all* 4-year-old boys will show a stage 4 of running, but many will. For those children that do not follow the age-related changes, some will reach proÞcient levels of running at earlier ages and others not until much later. In addition to the total body developmental sequences, component sequences have been developed for running.

Body Component Developmental Sequence in Running

A two-component developmental sequence has been proposed for running (Roberton, 1983; Roberton & Halverson, 1984). Table 12.3 outlines the three-step leg action component and the four-step arm action component. Overall, the characteristics of the component approach to running match the patterns described by the total body framework.

Both the total body and component developmental sequences demonstrate how children become more mechanically efÞcient as they progress through the stages of development. Despite this, even the highest levels of these sequences portray basic competence in running. Elite sprinters or long-distance runners take this basic running competence and reÞne the mechanical efÞciency to the highest levels, limiting the degrees of freedom of limbs so that each gait cycle is the most efÞcient it can be. The biomechanical literature has excellent

TABLE 12.3 Component Developmental Sequences of Running

Leg Action	Arm Action
L1 *Minimal flight, flat-footed*Ñ The foot toes out and the swing leg curves outward. Knee of the swing leg is bent more than 90 degrees.	A1 *High guard to middle guard arms*Ñ Arms do not contribute to the running action. They are motionless or shift side to side in response to the running motion.
L2 *More flight time, may be flat-footed*Ñ Longer stride and recovery knee ßexed to at least 90 degrees. Thigh has lateral swing causing recovery foot to cross midline of the body in the rear.	A2 *Arms swing bilaterally*Ñ Arms swing to counter hip and leg motions. Arms appear to ßail across the midline.
L3 *Heel or ball foot contact, extension of leg on take-off*Ñ Longer stride with heel-toe or ball of toe contact. Support leg fully extends at take-off. Higher heel recovery in swing phase and knee lift in forward swing.	A3 *Arms extend and flex in opposition*Ñ Arms pump in opposition to legs. As they pump forward they ßex, and as they swing back they extend. Arms swing across midline of body and out away from trunk.
	A4 *Arms pump in opposition to legs at 90 degree angle*Ñ Humerus moves forward and back against leg action.

examples of kinematic and kinetic (describes the motions of bodies and the force production) data onr unning.

Product Measures of Running

In the 1970s and 1980s a signiÞcant amount of research, including some national data collected by the American Alliance for Health, Physical Education, and Recreation (AAHPERD), was conducted on the product measures of running such as run velocity and run times (AAHPERD, 1976; Branta, Haubenstricker & Seefeldt, 1984; Fountain et al., 1981; Milne, Seefeldt, & Reuschlein, 1976). From a constraints perspective age and gender were found to be important individual constraints. Overall, running speed (average velocities) varied greatly by age, sex, and distance run, with improvements for both boys and girls as a function of age until the teenage years. Branta, Haubenstricker, and Seefeldt (1984) found that running speed increased by about 30% from ages 5 to 10 years. In their longitudinal Motor Performance Study the mean times for a 30-yd dash for boys and girls, respectively, were 6.77 sec and 6.88 sec at age 5, to 4.75 sec and 4.85 sec at age 10, to 4.24 sec and 4.46 sec at age 14. Similarly, performances in the 120-foot agility run and the 400-foot shuttle run decreased linearly from ages 5 through 14 years. Process-product research has shown that the developmental stage of running (process) can account for up to 19% of the variance in run times (product) for boys and about 29% for girls (Fountain, Ulrich, Haubenstricker, & Seefeldt, 1981). Given these data on the developmental sequences of running described above, it is easy to see how the greater biomechanical efÞciency in the more proÞcient stages of running could lead to faster running speeds. However, it seems that there is a time lag between the acquisition of proÞcient running patterns and the ability to translate that into faster running speeds.

There are practical implications to these data for physical educators and coaches. Running emerges in a relatively short time frame in early childhood years. As such, parents, teachers, and coaches should provide plenty of opportunities for young children to practice running and receive feedback on their technique. Focusing children on pumping arms and powerful legs is important. Once running is more developed, young children should also have experiences in the many forms of running such as sprinting, jogging, and changing direction quickly as required in numerous sports and games. These opportunities will provide children with the Òbase campÓ of locomotor skills from which they can move up the mountain of motor development (see Clark & Metcalfe, 2002) and apply the skill of running to engagement in lifetime sports and physical activity.

CONCEPT 12.1

Process measures of a fundamental motor skill describe the pattern of movement whereas product measures examine the outcome of the movement; although related, each tells something different about the movement of the child.

GALLOPING AND SLIDING

Galloping and sliding are very similar rhythmical skills. They both require a rhythmic step forward along with a leap step to the other foot. The gait pattern of the movement is asymmetrical and uneven. Galloping emerges Þrst and is the Þrst asymmetric locomotor skill learned by children. Galloping has a forward orientation in contrast to sliding, which has a sideways orientation. In order to gallop or slide children need dynamic balance and coordination, and a childÕs strength-to-weight ratio can also inßuence the ßight (leap) aspects of the movement. Galloping and sliding do not appear to be very functional skills, but if one looks to dance, galloping and sliding can be seen in many folk and cultural dances around the world. Elementary physical education teachers often use galloping or sliding as an ÒinstantactivityÓin order to develop leg strength, coordination, and cardiovascular endurance as children enter the gym. Additionally, sliding can be seen in sports like basketball, Þelding in baseball or softball, and in preparing to block at the net in volleyball. There is almost no developmental research on sliding, so the focus of this section will be on galloping.

Proficient Gallopers

Galloping is a combination skill made up of a step and a leap-step with an uneven temporal component. That is, galloping requires an uneven pattern where the step takes longer than the leap-step (Clark & Whitall, 1989). Proficient gallopers can maintain a fluid, rhythmical pattern, keep their hips front facing, and move to music or a tempo. They also have sufficient strength in both legs to project their body weight forward and lead with either leg in front (see Table 12.4).

Initial gallopers struggle with many aspects of the skill and in the very early stages they look as if they are doing a lopsided run. The rhythm of an initial galloper is ÒchoppyÓand often the trail (rear) leg crosses in front of the lead leg in the air. Initial gallopers often have a ÒfavoriteÓleg and cannot gallop with both legs leading. It is often a very Òcognitive experienceÓfor them with looks of great concentration on their faces as they try to maintain the pattern of the movement.

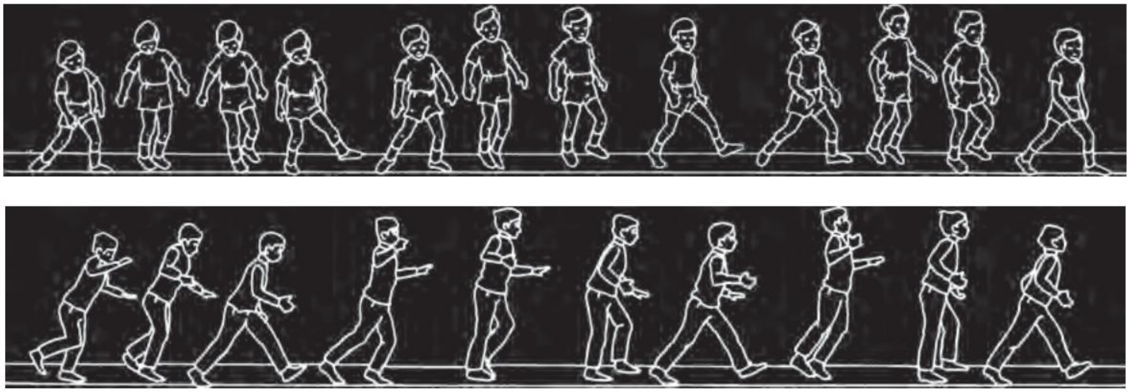
Development of Galloping

Table 12.1 and Figure 12.2 illustrate the three-stage developmental sequence of galloping (Sapp, 1980).

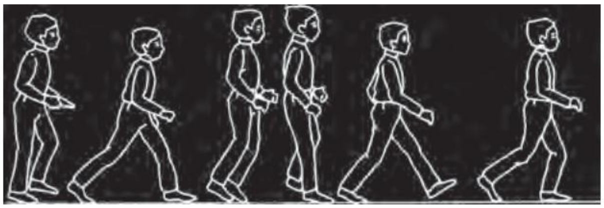
TABLE 12.4 Characteristics of a Proficient Galloper

ProÞcient gallopers demonstrate the following:
¥ Smooth, ßuid, rhythmical action
¥ Lead leg that stays in front
¥ Hips front facing
¥ Trail leg that lands beside or slightly behind lead leg
¥ Feet remain close to surface
¥ Knees that are ßexed slightly while in ßight
¥ Ability to lead with both right and left legs in front

Stage 1



Stage 2



Stage 3

Figure1 2.2 Developmental Sequences of Galloping

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Initial gallopers (stage 1) show an action that looks like a blend of a gallop and a run; they struggle to keep their lead leg in front, and their knees are bent. Emerging gallopers (stage 2) show one of two approaches to the galloping; in both cases a lead and trail leg emerge, and they freeze their degrees of freedom in their back leg by making the back leg stiff. One approach is to lock out the back leg, turn the hip sideways, and drag it along the ßoor, a movement coined the Òwounded soldierÓ approach. The other approach is coined Òrocking horse.ÓChildren bounce off a locked-out back leg before weight bearing on their front leg again. In stages 1 and 2 there tends to be a high vertical component to the skill. The proÞcient (stage 3) galloper shows the characteristics identiÞed in Table 12.4. Children in this stage can vary the galloping skill, changing directions and using their hands and arms free for other movements such as those in a dance. There are no 60% data for galloping, but experience tells us that many children as young as 2 years of age show the initial stages of galloping. When we look at the *interskill* (between skills) FMS sequences, an initial or emerging stage of running seems to be a precursor to the initial stage of galloping.

CONCEPT 12.2

Intraskill (within) skill sequences are just as orderly as interskill (between) skill sequences. Both are valuable sources of information to inform instruction of children and physical education curricula.

TABLE 12.5 Characteristicsof a Proficient Skipper

¥ Rhythmical weight transfer and ability to maintain the pattern easily
¥ Stays close to the surface
¥ Limited vertical component
¥ Limited use of arms as force producers
¥ Landing and taking off from the toe

SKIPPING

Like galloping and sliding, skipping is a rhythmical, bipedal combination skill. Skipping consists of a combination movement that requires the child to execute a step-hop on one foot followed by a step-hop on the alternate foot. It is more complex than other locomotor skills as it requires two skills to be performed on the same leg before weight transfer occurs to the other lead leg, and it is rhythmical in nature. In order to skip children need a contralateral pattern, dynamic balance, coordination, and leg strength. Like many other locomotor skills, it can be inßuenced by a child© strength-to-weight ratio, and this is speciÞcally true for skipping where the body is projected off the ground on one foot. Also like galloping and sliding, skipping is used in many folk and cultural dances around the world. Skipping can also be used functionally by teachers to promote cardiovascular endurance in warm-up games and dances. Anecdotally, Allen Burton, a well-known motor development researcher, once referred to skipping as the Òhappy skill.ÓThere is a certain truth to this. If we look around our playgrounds and backyards, we see young children spontaneously break into a skip with a smile while playing.

Proficient Skippers

ProÞcient skippers demonstrate an easy, ßuid pattern of movement that stays close to the ground. They have sufÞcient dynamic balance and leg strength in each leg to be able to show a smooth hopping pattern on each leg. Thus, stage 3 of hopping is considered a precursor for skipping to develop. ProÞcient skippers can also vary the speed and direction of the skip. Table 12.5 illustrates the characteristics of a proÞcient skipper.

Initial skippers struggle to maintain a rhythmical pattern and have a much higher vertical component to the skip. The skip is less ßuid and appears to be broken down into its constituent parts: a step, separated by a hop. The knees and arms drive upward, bringing about this vertical action. Initial skippers also struggle to keep up a continuous step-hop pattern, and the Òcognitive loadÓ(amount of concentration necessary) is high. Some of these early skippers also show us the Òone-sided skipÓwhere the child will only hop on one side of the body and have an ipsilateral pattern (same arm and same leg come up together).

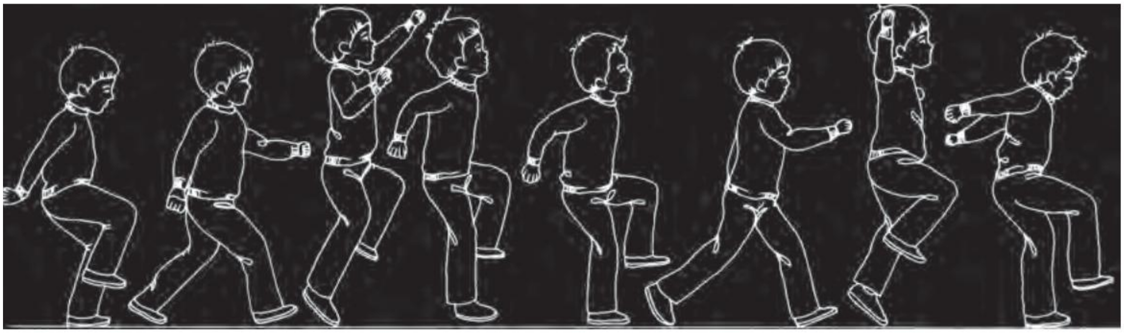
Development of Skipping

Both the total body approach and the component approach have been used to describe the changes in patterns that children demonstrate as they learn to skip.

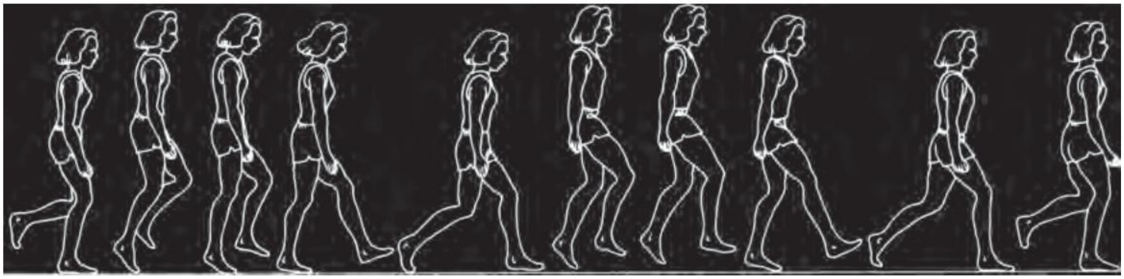
Total Body Developmental Sequence in Skipping

Table 12.1 and Figure 12.3 illustrate the three-stage sequence of skipping (Seefeldt & Haubenstricker, 1974, 1982). Overall, the children move from slower and more deliberate, choppy attempts, to a skip with an exaggerated arm lift, to ßuid, rhythmical movement. Initial (stage 1) skippers cannot maintain a consistent step-hop skip beat and show one of three kinds of adaptations to the skill: (1) a broken skip pattern that results in a slow and deliberate step-pause-hop, (2) a double-hop on each side as they

Stage 1



Stage 2



Stage 3

Figure1 2.3 Developmental Sequences of Skipping

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are attempting the skill, or (3) the one-sided ipsilateral skip pattern described above. Emerging skippers (stage 2) can maintain a rhythmical step-hop pattern, but the vertical component is high and there are exaggerated and ßailing arm actions with high knee actions. The proÞcient (stage 3) skipper demonstrates the characteristics shown in Table 12.5.

In terms of the interskill sequence, skipping is one of the last locomotor skills to develop. From its initial patterns to proÞciency the intraskill sequence develops in the shortest amount of time, from approximately 4½ years to 6½ years (Seefeldt & Haubenstricker, 1982; see Figure 11.4). Although girls and boys demonstrate the initial skill around the same time, there is a slight advantage to girls

TABLE 12.6 Component Developmental Sequences of Skipping

L1 *One-sided skip*Ñ Ani psilateral pattern where one side skips and the other side just steps.	A1 *Bilateral assist*Ñ Arms move in unison pumping up and down, resulting in a high vertical component on the hop.
L2 *Alternating flat-footed step-hop pattern*Ñ A skipping pattern that has a ßat-footed landing.	A2 *Semi-opposition*Ñ Arms move forward together at Þrst, then break into semi-opposition.
L3 *Alternating ball of foot step-hop pattern*Ñ Ap roÞcient skipping pattern with alternating step hop and landing on the ball of the foot.	A3 *Opposition*Ñ Arms swing loosely in opposition to the nonsupport leg.

in reaching the proÞcient form about 6 months beforeb oys.

Component Developmental Sequence of Skipping

A two-component sequence has also been identiÞed for the leg and arm components (Roberton & Halverson, 1984). Table 12.6 shows the arm and leg components, and these components in many ways reßect the total body stages.

Skipping is a complex and often frustrating skill for young children. Although there is not much empirical data to guide the teaching-learning process, the developmental sequences and age-related data are valuable. As the skill develops so rapidly between the preschool/kindergarten years, parents, teachers, and physical educators should provide children with plenty of opportunities to practice the skill and the prerequisite skill of hopping.

JUMPING

Jumping is a body projection skill that involves a take-off and landing on both feet. It is an explosive skill that requires signiÞcant muscular strength, multilimb coordination, and dynamic balance in order to be performed proÞciently. There are three phases to a jump: a preparatory phase where the body positions itself for the impending jump, a force-producing phase where the body generates the forces necessary to get off the ground, and a follow-through phase where the body lands and attenuates the forces generated. The vertical jump and the horizontal jump are the two jumps on which we have the most information. Jumping in general is a well-utilized skill in many sports. Sports like gymnastics, basketball, and volleyball demonstrate remarkable feats of proÞcient jumping skills, particularly the vertical jump. Other Þeld events such as high jump and long jump show how elite athletes can maximize their body mechanics and jump great heights and distances.

Proficient Jumpers

ProÞcient jumpers have learned how to control their body dynamics during the preparatory, force producing, and follow-through phases of the jump. Jumping has a signiÞcant timing element to it, and proÞcient jumpers can coordinate multiple body parts to place the body in an effective position to produce the most force in the line of the intended direction of the jump. During the airborne phase jumpers can reposition their body to attenuate the landing forces from the jump. Table 12.7 illustrates the characteristics of a proÞcient jumper, in this example performing a horizontal jump.

Initial long jumping often starts with prejumping behaviors. This typically consists of the child repeatedly bouncing up and down with knee ßexion and extension and arms moving bilaterally. In these prejumping behaviors the child is not actually able to coordinate his body

TABLE 12.7 Characteristics of a Proficient Horizontal Jumper

Preparatory Phase
¥ Knees bent and body leans forward at the hip
¥ Armss wingf orwarda nd backt o generate momentum

Force-ProducingP hase
¥ Arms and legs extend quickly and forcefully upward and forward
¥ Full extension of the body occurs from the toes through the trunk, with the shoulder angle at 180 degrees, arms extended
¥ At take-off body lean is close to a 45 degree angle

FlightPh ase
¥ As body is in the air, arms move down and back
¥ Legsm ovef orward andu pw ithk nees bent

Landinga ndF ollow-Through Phase
¥ Heels reach forward to touch surface
¥ Thighsp arallelt ot hes urface
¥ Armse xtendf orward top ull the body forward
¥ Hips travel in an arc almost touching the heels at landing and then move upward

or exert enough force to propel his body off the ground. Initial long jumpers (stage 1) are able to get their body off the ground but cannot jump long distances; the movement is more vertical, and there is little body lean. These children may take off with two feet but often land on one foot. Arm actions are extraneous and ßailing in an attempt to maintain balance under the challenging conditions of jumping, and these children frequently fall on landing.

Development of Horizontal Jumping

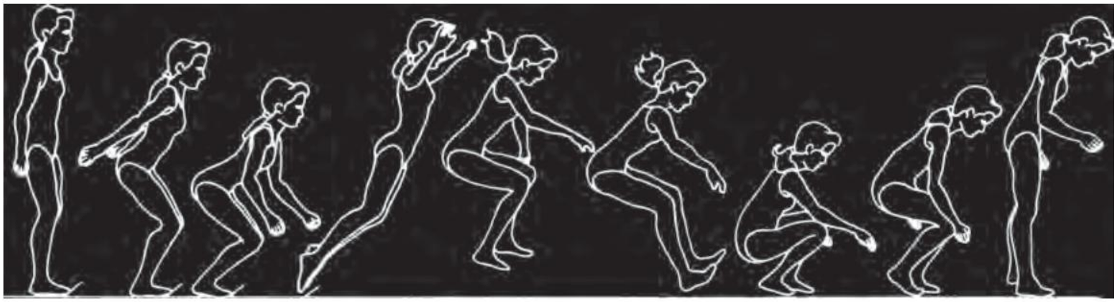
Jumping has been studied from both a product and process perspective. From a product perspective common product scores are distance or height jumped. Both total body and component sequences have been identiÞed in describing the process of jumping. Both the total body and component sequences share many commonalities with a few differences in arm and leg actions.

Total Body Developmental Sequence of Jumping

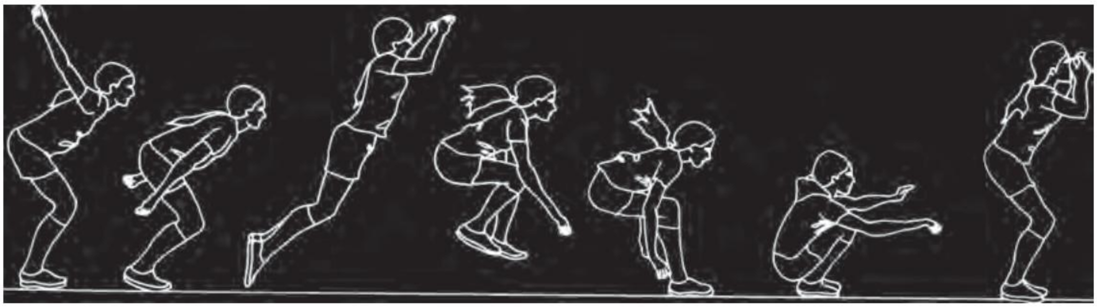
The total body approach has identiÞed a four-stage sequence in horizontal jumping (Branta, 1992; Haubenstricker, Seefeldt, & Branta, 1983; Seefeldt, Reuschlein, & Vogel, 1972). Table 12.1 and Figure 12.4 depict information on the four stages of jumping. These data were generated from a task constraint where children were told to Òjump as far as you canÓ from a standing position using a two-footed take-off. In the initial stage (stage 1) the jump is more vertical than horizontal and arms swing back toward the body (braking arms) to counteract the forward lean that seems so fearful for this initial stage of jumper. During the emerging stages (stages 2 and 3) the arms move from an upward and sideways Òwing-ingÓ position to swinging forcefully forward but not with the arms fully extended. It is not until stage 3 that a forward lean at take-off is demonstrated. By the proÞcient stage (stage 4), jumpers are leaning at a 45 degree angle at take-off, swinging their arms forcefully above their head with full shoulder extension, and have a momentary position in the air where the body is in full extension. Truly proÞcient jumpers seem to ÒhangÓ in the air for a split second with this full extension before drawing their legs underneath them in preparation for landing.

Figure 11.4 shows the age at which 60% of children performed a speciÞc stage of jumping. Initial jumping behaviors emerge between 1.5 and 2 years of age. By their fourth birthday both genders

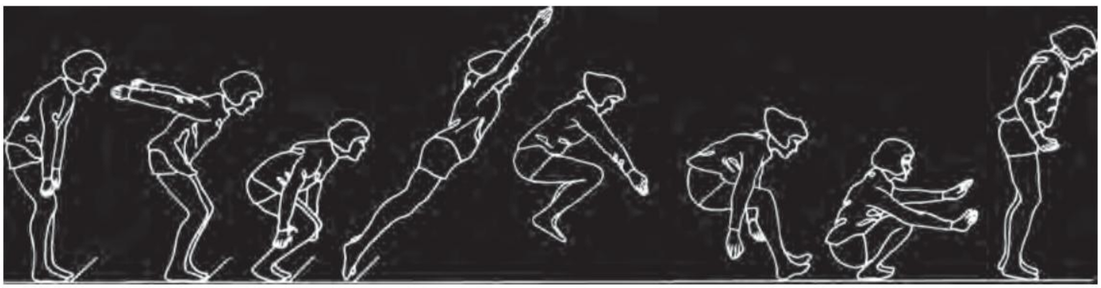
Stage 1



Stage 2



Stage 3



Stage 4

Figure1 2.4 Developmental Sequences of Horizontal Jumping

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have moved to a stage 2 jump with Òswinging arms.Ó It takes another two years before children move to stage 3, with boys and girls demonstrating these jumping behaviors a little after their sixth birthday. Boys reach jumping proÞciency by approximately 114 months with girls getting there at 120 months (10 years of age). As such the intraskill jumping sequence is one that takes the longest timeframe from the emergence of initial jumping to the onset of proÞcient jumping.

Component Developmental Sequence of Jumping

Jumping also has been examined from a component perspective with leg and arm components (Clark & Phillips, 1985; Roberton & Halverson, 1984) and a trunk component (Roberton & Halverson, 1984). Changes in the trunk component are a by-product of the force producing aspects of the jump, namely the arm component and leg component. Thus Table 12.8 shows the arm and leg components (Clark & Phillips, 1985).

Often in the component approach the levels of the different components are related but not directly linked. This is also true in jumping. Clark and Phillips (1985) reported that children ages 3 to 7 years usually had more advanced leg actions than arm actions. Also, fewer than 30% of the children had the same level of arm and leg action.

Product Measures of Jumping

A number of researchers have looked at jumping from a product perspective (Branta, Haubenstricker, & Seefeldt, 1984; Haubenstricker & Branta, 1997; Isaacs & Pohlman, 2000; Isaacs, Pohlman, & Hall, 2003; Wickstrom, 1983). Overall this work shows that as children get older, they demonstrate improvements in product measures such as height or distance jumped. As with many of the other skills, caution needs to be exerted in seeing these changes as *age-dependent* (they naturally occur as a function of age); rather they are more *age-related* (these trends are true for some children but not others). It is not age alone that manifests these improvements in jumping; rather as children get older they often have greater dynamic strength and balance, and better multilimb coordination resulting from physical growth and neuromuscular development. For many of the nationÕs obese children, skills like jumping are extremely challenging as the child does not possess the necessary strength to propel her body off the ground.

Branta and colleagues (1984) tracked vertical and horizontal jumps for children longitudinally starting at age 5 and going through age 14 years. Across time, the mean jumping performance for girls and boys improved on both of these body projection skills. In the vertical jump, from age 5 to 10 years the average yearly incremental change was

TABLE 12.8 Component Developmental Sequences of Jumping

LegC omponent	Arm Component
L1 *One-footed take-off*Ñ The jumper tries to jump but steps out with one foot. There is little preparatory knee ßexion.	A1 *No action*Ñ The arms are stationary or after take-off they may ÒswingÓ to the side.
L2 *Knees straight*Ñ The jump begins with knee extension prior to heel lift from the surface.	A2 *Arm swing forward*Ñ Arms start at the sides and swing forward (or sideways) at the shoulder.
L3 *Simultaneous extension*Ñ The jumper extends the knees as the heels lift off the ßoor.	A3 *Arms extend, then partially flex*—Arms swing backwards together during knee ßexion and then forward at take-off but never reach above the head.
L4 *Heels first, knees next*Ñ The jump begins with the heels coming off the ground Þrst, quickly followed by knee extension. This action occurs as the jumper falls or tips forward.	A4 *Arms extend, then fully flex*—Arms swing backwards during knee ßexion and then forward at take-off with full arm extension above the head.

approximately 1 inch for both boys and girls. Both boys and girls nearly doubled their jumping heights during these ages. However, by age 12 years, the yearly change for girls was relatively constant while the boys began to improve their jumping scores more dramatically. From ages 8 to 14 boys gained 7.56 inches compared to girls at 6.34 inches. Findings for the horizontal jump were similar. From ages 5 to 10 years children improved their jumps as much as 7 inches annually, but showed less than 2-inch yearly gains by age 14. Horizontal distance gains represented a 75% improvement for girls and a 71% increase for boys from ages 5 to 10 years. In considering these Þndings we need to look at the changes in physical growth in children as potential individual constraints inßuencing the trends in jumping performance.

In summary, jumping is a complex skill requiring coordination, strength, and balance. It takes a very long time to develop to proÞciency from the initial emergence of jumping behaviors. There are different kinds of jumping, and Wickstrom (1983) utilized a variety of sources to provide a developmental progression of jumping tasks. He suggested the following approach for two-footed jumping: (a) jumping down from a height, (b) jumping up, (c) jumping forward, and (d) jumping over an object. For the practitioner it is important to recognize that children need lots of opportunity to practice the skill of jumping. However, jumping involves signiÞcant physical exertion and large blocks of time for jumping should not be planned into a lesson. Rather, jumping should be placed in several different lesson plans alongside other activities that are less strenuous in nature.

CONCEPT 12.3

There is a relationship between process and product measures in some locomotor skills (running and jumping). As performers move from initial to emerging to proficient patterns of performance (process), they are able to apply these biomechanical efficiencies to achieve greater outcomes (product) such as speed of run and distance jumped.

DEVELOPMENTAL DILEMMA

Lesson Planning

You are an elementary school physical education teacher planning a four-day locomotor unit for children in preschool through second grade. The unit will include hopping, skipping, galloping, running, and jumping and each lesson period is 30 minutes long. Use the information you have learned about these skills and consider how you would arrange these skills in your unit. In each of the four lessons, what skills would you teach together? How much time would you spend on them? What progressions might you use? What individual constraints should you consider? How will you assess these skills to see if the children have learned? Write out your block plan like the following example:

Day 1	Day 2	Day 3	Day 4
List the skills you will teach here			

HOPPING

Hopping is a body projection locomotor skill that involves the child taking off and landing on the same foot. There is often some confusion as to the term. In childrenÕs stories we typically read that Òbunnies hop,Ó but this is not true, and as we should know by now, bunnies jump! Like jumping, hopping requires signiÞcant muscular strength, multilimb coordination, and dynamic balance in order to be performed proÞciently. However, hopping is more complex than jumping as the task demands for strength, coordination, and balance are signiÞcantly greater than in jumping. Hoppers have to take off and absorb the forces of landing on one foot. For the younger child, physical growth constraints such as smaller feet and higher center of gravity make the balance part of hopping particularly challenging. Although adults rarely hop in isolation, children need to develop this FMS in order to become proÞcient in the skill and apply it to different sports, games, and dances. Hopping is an integral part of childhood games, playground games such as hopscotch, and dances. Many folk dances, such as the schottische, incorporate the hop into the pattern of the dance. The International Perspective box on morris dancing portrays a culturally relevant form of hopping. However, elements of hopping are also found in sports skills such as the layup in basketball and the approach in triple jump. As such it is important that young children learn how to hop.

Proficient Hoppers

ProÞcient hoppers have also learned to control their body dynamics as their center of gravity moves over their base of support while they hop. ProÞcient hoppers use their nonsupport leg to swing forward and back in a pendular action to contribute to the power production of the hop. During the hop the childÕs arms act in opposition to the swinging leg in order to control the biomechanical forces generated by the leg. As the body leaves the ground in the projection phase of the hop the support leg extends and the body leans forward. ProÞcient hoppers can often hop with considerable speed. Table 12.9 illustrates the characteristics of a proÞcient hopper.

For the initial hopper, the task of hopping is exhausting, high in cognitive load (concentration), and often highly frustrating. Initial hoppers maintain more of a vertical body position. The foot of the swing leg is often held in front of the support leg to assist with the task of balancing and allows the child to step forward onto the nonsupport foot if she loses her balance. She relies on her arms to assist with the lift necessary to propel her off the ground. Distance hopped is small and almost all of the motion is vertical. Young hoppers often do not have requisite strength to get their body off the ground on one leg and may show extension and ßexion of the support leg as they try to get off the ground, to no avail. This is particularly true for children who are heavier.

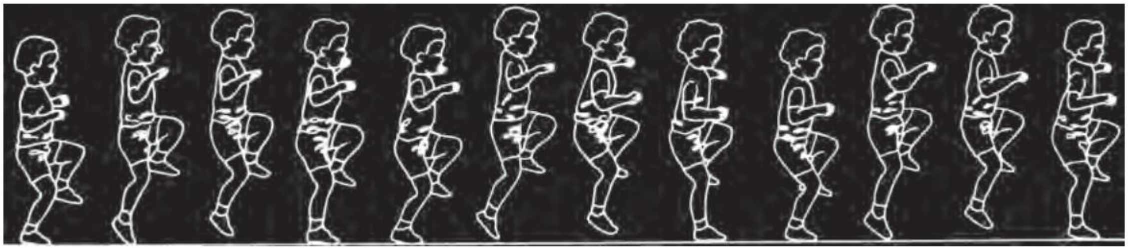
Development of Hopping

Hopping has been studied from a predominantly process perspective with both total body and component sequences identiÞed. As with other skills the total body and component sequences share many commonalities.

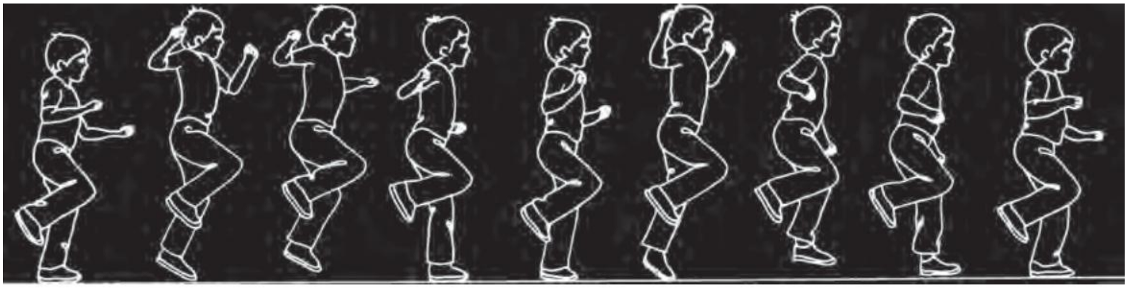
Total Body Developmental Sequence of Hopping

The total body approach has identiÞed a four-stage sequence of hopping (Haubenstricker, Henn, & Seefeldt, 1975; Haubenstricker et al., 1989; Seefeldt & Haubenstricker, 1974). Table 12.1 and Figure 12.5 depict information on the four stages of hopping. One of the keys to distinguishing between the four stages of hopping is the position of the swing leg and free foot. In the initial stage (stage 1) the foot of the swing leg is in front of the support leg and the thigh horizontal to the surface in order to provide greater balance. Children push off the surface with bent knees and hold their hands near the shoulders. As children progress, emerging hoppers begin to drop the foot of the swing leg alongside the support leg with the thigh at a 45 degree angle to the hip (stage 2). Arms are often used bilaterally. By stage 3, the foot of the swing leg is behind the support leg and the thighs are parallel in emerging hoppers. As described above, proÞcient (stage 4) hoppers use the swing leg as a means of force production and pump the swing leg in a pendular action. Hoppers

TABLE 12.9 Characteristics of a Proficient Hopper
¥ Balancee ffectivelyo nt he support foot
¥ Support leg extends fully at take-off and ßexes at landing
¥ The thigh of the nonsupport leg pumps back and forth with the hop
¥ Arms pump in opposition to the swing legÕs pendular motion
¥ Forwardl eano f theb ody

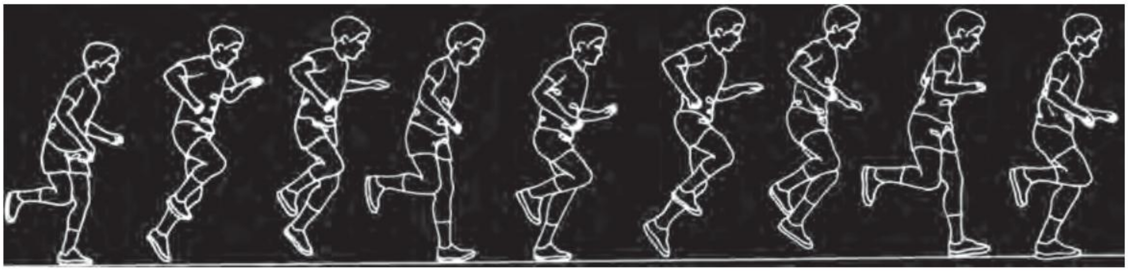


Stage 1



Stage 2

Stage 3



Stage 4

Figure1 2.5 Developmental Sequences of Hopping

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in these latter two stages demonstrate better balance, leg strength, and multilimb coordination. They also cover more horizontal distance in these stages as compared to stages 1 and 2. Their support leg extends fully at take-off and ßexes upon landing to absorb the forces of the hop.

Figure 11.4 shows the age at which 60% of children performed a speciÞc stage of hopping. Data show that the skill of hopping is initiated about 6 months to one year after the initial jumping pattern is begun (Seefeldt & Haubenstricker, 1982). Initial hopping patterns occur around 30 months of age and by around 42 months of age girls and boys show a stage 2. This skill is one of the few skills in which girls move ahead of boys, and by around 58 months girls show a stage 3 compared to boys, who do not do this until around 64 months. By approximately 84 months (7 years) girls show a stage 4 and boys follow shortly after around 90 months. The interskill sequence of running and hopping shows that the majority of children are at the stage 2 running pattern before they initiate the hopping skill. They have been jumping on two feet at least 6 months before mastering stage 1 of hopping. These interskill sequences are valuable to the elementary physical educator as she develops her annual plans and unit plans on locomotor skills.

Component Developmental Sequence of Hopping

Hopping has also been described using a two-component (arms and legs) body component perspective (Halverson & Williams, 1985). Table 12.10 identiÞes the four-level leg action and the Þve-level arms action.

Overall the action of initial hoppers is awkward, energy demanding, and inefÞcient. Young hoppers often lose their balance easily and are only able to demonstrate a few hops at a time without stepping onto the nonsupport foot, with few children who are younger than 3 years being able to hop at initial levels or hop repeatedly (Bayley, 1969; Haubenstricker, Branta, Seefeldt, & Brakora, 1989; McCaskill & Wellman, 1938; Seefeldt & Haubenstricker, 1982). In contrast, proÞcient hoppers can hop with mechanical efÞciency and speed.

Hopping can be performed on the right and left legs. Typically children have a foot preference for hopping with hopping on the nondominant side being inferior to the dominant side. Halverson and Williams (1985) reported that hopping on the nondominant side lagged developmentally behind hopping on the dominant side. They also found few children ages 3 to 5 who could be classiÞed at advanced levels of the hop. For the overweight child, hopping is speciÞcally challenging, as this

TABLE 12.10 Component Developmental Sequences of Hopping

LegC omponent	Arm Component
L1 *Momentary flight*Ñ Support leg and knee pull up with the swing leg held in front or to the side. Only 1Ð2 hops in a row possible.	A1 *Bilateral inactive*—Arms bilateral, high, and out to side.
L2 *Fall and catch with swing leg inactive*Ñ Slight lean forward with small knee and ankle extension that helps body ÒfallÓforward. Repeated hops possible.	A2 *Bilateral reactive*Ñ Arms swing upward and out to side in a winging action.
L3 *Projected take-off, swing leg assist*—Support leg extends on take-off and ßexes quickly on landing. Swing leg pumps slightly but little force production.	A3 *Bilateral assist*—Arms pump up and down together in front of body.
L4 *Projection delay, swing leg leads*—Weightt ransfer from landing to take-off on support foot is smooth. Strong pumping action in swing leg transmits power to support leg.	A4 *Semi-opposition*Ñ The arm on the opposite side to the swing leg moves in opposition, the arm on the other side is variable.
	A5 *Opposite Assist*—The arms swing in opposition to the swing leg, especially during hopping for speed.

childÕs strength-to-weight ratio is low. The preschool and early elementary years are important years in which to give children practice and feedback on good hopping techniques. Having said that, hopping as a skill requires signiÞcant energy expenditure, and entire lessons on hopping are not recommended as they would be exhausting and not motivating for the young child. Like jumping, hopping should be built into opening activities, games, and dances; or placed alongside other less energy-demanding skills in a locomotor skill unit.

INTERNATIONAL PERSPECTIVES

Hop, Skip, and Jump: Morris Dancers at Work

Morris dancing is an ancient form of English folk dance dating back perhaps to pre-Christian days and the relics of Druid society. Morris dancing today is a ritualized form of folk dance performed to music in the open air in villages in rural England by groups of specially chosen and trained men and women. Morris dancers have bells on their legs, hankies (English for handkerchief) or sticks in their hands, and hats on their heads. Traditional morris dances consist of all the locomotor skills in this chapter such as skipping, hopping, galloping, sliding, and jumping, and many of these dances are believed to be fertility dances. One of the earliest references to morris dancing is in Shakespeare's *All's Well that Ends Well* (II.ii.21). Morris dancing was commonly performed on May Day (May 1). King James I's *Book of Sports* in the early 17th century also mentioned morris dancing in May Day celebrations.

I remember May Day celebrations from my childhood in a small rural English village called Waltham St. Lawrence. The local morris dancing troop would perform in the center of the village in front of our 14th-century church and pub. The entire village community would gather to watch and celebrate the beginning of spring. The morris troop would hop, skip, jump, and gallop in rhythm to music, generally played by an accordion.

See http://www.youtube.com/watch?v=RZjLATAUwao&feature=related and http://www.britannia.com/wonder/modance.html (Jackie Goodway).

NATIONAL GUIDELINES AND FUNDAMENTAL MOTOR SKILLS

In chapter 11 we examined the development of manipulative skills and in this chapter we have read about locomotor skills. As we have previously emphasized, the development of FMS is important for sports, games, and lifetime physical activities. These FMS should be developed in the early childhood and middle childhood years. The National Association for Sport and Physical Education (NASPE) also highlights the importance of fundamental motor skills in the development of a physically educated person (NASPE, 2004) and in the promotion of preschool physical activity (NASPE, 2009). Standard 1 of the national standards for physical education (NASPE, 2004) states that students should be able to:

- ÒDemonstrate competency in motor skills and movement patterns needed to perform a varietyo fp hysicala ctivity.Ó

Similarly, NASPEÕs *Active Start* physical activity guidelines (NASPE, 2009) states, ÒAll children birth to age 5 should engage in daily physical activity that promotes movement skillfulness and foundations of health-related Þtness.ÓSpeciÞcally, guideline 3 for preschoolers states that preschoolers should:

- ÒDevelop competence in fundamental motor skills that will serve as the building blocks for future motor skillfulness and physical activity.Ó

These national standards for physical education and physical activity recognize that FMS are important and should be taught, practiced, and reinforced during the childhood years. In line with this perspective, assessing FMS is important in order that teachers, coaches and other practitioners can:

- Determine the developmental status of a childÕs FMS performance and if he or she is demonstrating age-appropriate skills or in need of adapted physical education.
- Monitor a childÕs progress across a unit of instruction or a motor skill program and report this progress to the child and parent.
- Examine their instructional effectiveness and ensure that there is a Ògoodness of ÞtÓ between the instructional activities and the childrenÕs developmentall evel.

Assessment of Fundamental Motor Skills

Throughout this chapter and the previous one we have referred to both process and product perspectives on FMS development. Before we provide a brief overview of the major assessment instruments used to evaluate FMS, we need to deÞne some terms that are important to the world of assessment and evaluation:

- **Product-oriented tests—**tests that look at the outcome of a skill, for example, how many out of 10 tosses can you catch or distance you can throw.
- **Process-oriented tests—**tests that examine the pattern of the performance such as form, style, or mechanics of the movement, for example, the developmental sequences identiÞed above.
- **Norm-referenced tests**Ñ testst hatc ompare the childÕs skills to those of a similar age and gender (and sometimes race and socioeconomic status). A norm-referenced test will typically provide a percentile rank for a child. For example, a child at the 75th percentile is better than 75% of other children hisa ge.
- **Criterion-referenced tests**Ñ tests that examine the quality of a childÕs movement compared to some predetermined criteria of performance. For example, does the child step with a contralateral (opposition) pattern when throwing?
- **Reliability**Ñ testst hatp rovidec onsistent scores from one testing period to another.
- **Validity**Ñ tests that measure what they claim tom easure.
- **Objectivity**Ñ tests that will give similar results when administered by different testers.

Concept 12.4

Assessments can be categorized as norm-referenced, criterion-referenced, product-oriented, and/or process-oriented.

We will provide a brief overview of three main approaches to assessing fundamental motor skills during childhood.

Test of Gross Motor Development-Second Edition (TGMD-2)

The TGMD-2 is a norm-referenced and criterion-referenced test designed to assess 12 FMS in children aged 3 to 10 years (Ulrich, 2000). The TGMD-2 includes two subscales, the locomotor and the object control (manipulative):

- 6 locomotor skills (run, gallop, hop, leap, jump,s lide
- 6 object control skills (strike, dribble, catch, kick,t hrow, roll)

Each fundamental motor skill in the TGMD-2 has between 3 and 5 performance criteria (see Figure 12.6). Children are evaluated on whether they meet the performance criteria (1 is awarded) or do not meet the criteria (0 is awarded). Two trials for each of the 12 FMS are attempted, and the total numbers of 1s and 0s are summed with a possible range between 0 and 48 points for the locomotor subscale and the object control subscale. From the raw score, standard scores that factor out age can be calculated in order to compare two children of different ages. Additionally, a percentile rank can be calculated based upon the childÕs age and gender. High skill scores and percentile rank indicate children met performance criteria and are motor competent. A child with a percentile rank below

Section VI. Subtest Performance Record

Preferred Hand: Right ☐ Left ☐ Not Established ☐
Preferred Foot: Right ☐ Left ☐ Not Established ☐

Locomotor Subtest

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Run	60 feet of clear space, and two cones	Place two cones 50 feet apart. Make sure there is at least 8 to 10 feet of space beyond the second cone for a safe stopping distance. Tell the child to run as fast as he or she can from one cone to the other when you say "Go." Repeat a second trial.	1. Arms move in opposition to legs, elbows bent			
			2. Brief period where both feet are off the ground			
			3. Narrow foot placement landing on heel or toe (i.e., not flat footed)			
			4. Nonsupport leg bent approximately 90 degrees (i.e., close to buttocks)			
					Skill Score	
2. Gallop	25 feet of clear space, and tape or two cones	Mark off a distance of 25 feet with two cones or tape. Tell the child to gallop from one cone to the other. Repeat a second trial by galloping back to the original cone.	1. Arms bent and lifted to waist level at takeoff			
			2. A step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot			
			3. Brief period when both feet are off the floor			
			4. Maintains a rhythmic pattern for four consecutive gallops			
					Skill Score	
3. Hop	A minimum of 15 feet of clear space	Tell the child to hop three times on his or her preferred foot (established before testing) and then three times on the other foot. Repeat a second trial.	1. Nonsupport leg swings forward in pendular fashion to produce force			
			2. Foot of nonsupport leg remains behind body			
			3. Arms flexed and swing forward to produce force			
			4. Takes off and lands three consecutive times on preferred foot			
			5. Takes off and lands three consecutive times on nonpreferred foot			
					Skill Score	
4. Leap	A minimum of 20 feet of clear space, a beanbag, and tape	Place a beanbag on the floor. Attach a piece of tape on the floor so it is parallel to and 10 feet away from the beanbag. Have the child stand on the tape and run up and leap over the beanbag. Repeat a second trial.	1. Take off on one foot and land on the opposite foot			
			2. A period where both feet are off the ground longer than running			
			3. Forward reach with the arm opposite the lead foot			
					Skill Score	

Figure 12.6 Test of Gross Motor Development 2 Score Sheet

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
5. Horizontal Jump	A minimum of 10 feet of clear space and tape	Mark off a starting line on the floor. Have the child start behind the line. Tell the child to jump as far as he or she can. Repeat a second trial.	1. Preparatory movement includes flexion of both knees with arms extended behind body			
			2. Arms extend forcefully forward and upward reaching full extension above the head			
			3. Take off and land on both feet simultaneously			
			4. Arms are thrust downward during landing			
					Skill Score	
6. Slide	A minimum of 25 feet of clear space, a straight line, and two cones	Place the cones 25 feet apart on top of a line on the floor. Tell the child to slide from one cone to the other and back. Repeat a second trial.	1. Body turned sideways so shoulders are aligned with the line on the floor			
			2. A step sideways with lead foot followed by a slide of the trailing foot to a point next to the lead foot			
			3. A minimum of four continuous step–slide cycles to the right			
			4. A minimum of four continuous step–slide cycles to the left			
					Skill Score	
			Locomotor Subtest Raw Score (sum of the 6 skill scores)			

Object Control Subtest

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Striking a Stationary Ball	A 4-inch lightweight ball, a plastic bat, and a batting tee	Place the ball on the batting tee at the child's belt level. Tell the child to hit the ball hard. Repeat a second trial.	1. Dominant hand grips bat above nondominant hand			
			2. Nonpreferred side of body faces the imaginary tosser with feet parallel			
			3. Hip and shoulder rotation during swing			
			4. Transfers body weight to front foot			
			5. Bat contacts ball			
					Skill Score	
2. Stationary Dribble	An 8- to 10-inch playground ball for children ages 3 to 5; a basketball for children ages 6 to 10; and a flat, hard surface	Tell the child to dribble the ball four times without moving his or her feet, using one hand, and then stop by catching the ball. Repeat a second trial.	1. Contacts ball with one hand at about belt level			
			2. Pushes ball with fingertips (not a slap)			
			3. Ball contacts surface in front of or to the outside of foot on the preferred side			
			4. Maintains control of ball for four consecutive bounces without having to move the feet to retrieve it			
					Skill Score	

Figure 12.6 *(Continued)*

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
3. Catch	A 4-inch plastic ball, 15 feet of clear space, and tape	Mark off two lines 15 feet apart. The child stands on one line and the tosser on the other. Toss the ball underhand directly to the child with a slight arc aiming for his or her chest. Tell the child to catch the ball with both hands. Only count those tosses that are between the child's shoulders and belt. Repeat a second trial.	1. Preparation phase where hands are in front of the body and elbows are flexed			
			2. Arms extend while reaching for the ball as it arrives			
			3. Ball is caught by hands only			
					Skill Score	
4. Kick	An 8- to 10-inch plastic, playground, or soccer ball; a beanbag; 30 feet of clear space; and tape	Mark off one line 30 feet away from a wall and another line 20 feet from the wall. Place the ball on top of the beanbag on the line nearest the wall. Tell the child to stand on the other line. Tell the child to run up and kick the ball hard toward the wall. Repeat a second trial.	1. Rapid continuous approach to the ball			
			2. An elongated stride or leap immediately prior to ball contact			
			3. Nonkicking foot placed even with or slightly in back of the ball			
			4. Kicks ball with instep of preferred foot (shoelaces) or toe			
					Skill Score	
5. Overhand Throw	A tennis ball, a wall, tape, and 20 feet of clear space	Attach a piece of tape on the floor 20 feet from a wall. Have the child stand behind the 20-foot line facing the wall. Tell the child to throw the ball hard at the wall. Repeat a second trial.	1. Windup is initiated with downward movement of hand/arm			
			2. Rotates hip and shoulders to a point where the nonthrowing side faces the wall			
			3. Weight is transferred by stepping with the foot opposite the throwing hand			
			4. Follow-through beyond ball release diagonally across the body toward the nonpreferred side			
					Skill Score	
6. Underhand Roll	A tennis ball for children ages 3 to 6; a softball for children ages 7 to 10; two cones; tape; and 25 feet of clear space	Place the two cones against a wall so they are 4 feet apart. Attach a piece of tape on the floor 20 feet from the wall. Tell the child to roll the ball hard so that it goes between the cones. Repeat a second trial.	1. Preferred hand swings down and back, reaching behind the trunk while chest faces cones			
			2. Strides forward with foot opposite the preferred hand toward the cones			
			3. Bends knees to lower body			
			4. Releases ball close to the floor so ball does not bounce more than 4 inches high			
					Skill Score	
			Object Control Subtest Raw Score (sum of the 6 skill scores)			

Figure 12.6 *(Concluded)*

the 25th percentile is considered developmentally delayed (Ulrich, 2000). This scale has documented reliability and validity. This test is one of the most commonly used assessment instruments for practitioners and also for researchers. The TGMD-2 is often used to identify children for Adapted Physical Education services and typically takes about 15m inutesp erc hildt oa dminister.

Movement Assessment Battery for Children-Second Edition

The Movement Assessment Battery for Children-Second Edition (Movement ABC-2) (Henderson, Sugden, & Barnett, 2007), a revision of the Movement Assessment Battery for Children, is used to identify students aged 3 years 0 months to 16 years 11 months who either have established movement difÞculties, or are believed to have problems in the movement domain, or are signiÞcantly behind their peers. The Movement ABC-2 test is a standardized assessment tool that requires a child to perform a series of eight motor tasks grouped under three headings: manual dexterity, aiming and catching, and balance. The tasks vary based upon the age of the child, and the test is divided into three age bands:

- Ageb and1 :3 Ð6y ears
- Ageb and2 :7 Ð10y ears
- Ageb and3 :1 1Ð16y ears

The Movement ABC-2 takes approximately 20Ð40 minutes to administer depending on the age of the child and degree of difÞculty experienced, as well as the experience of the examiner. This test is frequently used for identiÞcation, intervention planning, program evaluation, and as a research tool and has both reliability and validity (see associatedw ebsite).

Developmental Sequences

The developmental sequences (total body and component) described above and in chapter 11 can be used to assess the FMS of children. These assessments are fast, developmental, valid, and reliable. A variety of approaches can be used by the teacher to assess the FMS within a gymnasium environment. The teacher can set up a testing station and each child will rotate to that station where the child performs 3Ð5 trials of the skill and the teacher formally evaluates the stage. A less formal and perhaps more practical approach for a physical educator is to use colored stickers. Each color represents a stage, for example, green is stage 1. As the teacher rotates around skill stations providing feedback, she places a colored sticker on the child after observing the child perform a skill. Upon exiting the gym the child places his sticker on a chart by the door next to his name. When using developmental sequences in research, the researcher must be sure to standardize the testing equipment and environment as different tasks and equipment will vary the skill. The researcher should also videotape the performance in order to ensure interrater reliability (making sure that two different raters come up with the same stage). Videotape is particularly necessary with the component approach as it often takes multiple observations to be able to stage all of the components.

Which Assessment?

There are many different tests to measure FMS and the three described above are some of the most common ones. Others that we did not review are the Peabody Developmental Motor Scale (2nd edition), the Bruininks-Oseretsky Test of Motor ProÞciency, and the Fundamental Movement Pattern Assessment. There is no single response to which assessment should be selected to evaluate FMS. It will depend on many factors. Some considerations are:

- Purpose of the assessment, for example, identiÞcation for adapted physical education, research, or tracking instructional effectiveness
- Number of children being tested and the time available for testing
- Conditions in which the child will be tested, for example, alone, within a class setting, or in a research design
- Reliability and validity of the test and objectivity and training of the tester
- Whether a test has norms for it and if you need norms for your assessment purpose
- Characteristicsof t hepopula tiont obet ested

SUMMARY

Locomotor skills consist of a group of FMS that allow individuals to navigate through space or move their body from one point to another. Developing basic competence in locomotor skills is essential for engagement in meaningful physical activity for health and to move effectively in various sports, games, and dances. Running, galloping, hopping, skipping, jumping, leaping, and sliding are the most common forms of locomotor skills. Developmental sequences (total body and component) describe how children acquire locomotor skills through mechanically inefÞcient *initial* movement patterns and onto increasingly efÞcient *emerging* patterns of movement. The goal is that children will develop *proficient* and biomechanically efÞcient patterns of movement. Research in locomotor skills shows how improving these *process* measures of locomotor skill performance will result in better movement *product* such as faster run times or greater distance jumped. Knowledge of the developmental sequences and the constraints acting on the skills better prepare the teacher, coach, or clinician to design developmentally appropriate movement experiences for children. Assessments for FMS include process-oriented, criterion-referenced, and norm-referenced forms of tests. The selection of an appropriate assessment instrument depends on many different factors.

QUESTIONS FOR REFLECTION

1. Why is it important for children to have a lot of experiences in attempting fundamental motor skills?
2. Can you write a deÞnition in your own words for each of the Þve locomotor skills: run, skip, gallop, jump, and hop?
3. What do the terms *phylogenetic* and *ontogenetic* mean? What implications do these terms have for teachers and coaches?
4. Overall, for locomotor skills, what key features characterize initial, emerging, and proÞcient stages ofd evelopment?
5. For the skill of jumping, what is the difference in process and product measures of assessment? Which assessment is better to use for skill analyses in young children?
6. Describe how process and product measures of FMS are related.
7. Select a locomotor skill. What are some of the common quantitative, or product, measures of this skill?
8. Describe the interskill (between skill) sequences in locomotor skill development.
9. Explain the interrelationships among galloping, sliding, hopping, and skipping.
10. Select one assessment for FMS, describe it, and identify why you selected this assessment.

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WEB RESOURCES

National Associationf orS porta ndP hysical Education

h ttp://www.aahperd.org/naspe/

Website provides links to national standards in physical education and a host of resources for practitioners in promoting motor skills.

Testo fG rossM otorD evelopment-Second Edition

http://www.proedinc.com/customer/productView.aspx?ID=1776

Website provides a link to information on the test and purchase of the test.

Movement ABC

http://www.pearsonassessments.com/HAIWEB/Cultures/en-us/Productdetail.htm?Pid=015-8541-308&Mode=summary

Websitep rovidesp roducti nformationa nd purchase of this assessment.

Physicale ducationw ebsiteÑ PE Central

http://www.pecentral.org/

Websitep rovidesl essonp lans,a ssessment instruments, and other professional resources for physical education and health teachers.

InternationalO lympicC ommittee

http://www.olympic.org/en/

Websitep rovidea l isto f Olympics ports, information on athletes, and Olympic records along with a history of the Olympics.

CHAPTER 13

PHYSICAL DEVELOPMENT OF CHILDREN

KEY TERMS

Physicalfi tness
Health-relatedfi tness
Aerobice ndurance
Maximal oxygen consumption (VO_2m ax)
Accelerometer
Muscularst rength
Isometric
Isotonic
Isokinetic
Dynamometers
Musculare ndurance
Jointfl exibility
Staticfl exibility
Dynamicfl exibility
Bodyc omposition
Skinfoldc alipers
Anabolich ormones
Catabolich ormones
Testosterone
Neuromusculara daptation
Growthpla tes
Motorfi tness
Coordination
Balance
Speed
Agility
Power

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Demonstrate knowledge of data available on performance scores and motor pattern changes duringc hildhood
- Describe gender differences and similarities in motord evelopment
- Discuss changes in movement dimensions such as balance, timing, or force production/ control
- Demonstrate knowledge of major changes in body composition and physiological functioning in males and females
- Discuss the effect of exercise on body systems and body composition such as bone and muscle development and cardiorespiratory capacity
- Draw conclusions concerning the merits and/or liabilities of strength and endurance training for prepubescent males and females
- Distinguish betweenh ealth-relateda nd performance-related fitness during childhood
- Interpret velocity curves on various parameters of children's fitness
- Identify gender differences and similarities in motorp erformance

KEY CONCEPT

The physical fitness of children has been assessed through a variety of laboratory and field-based measures and may be improved through the application of appropriate training techniques.

The health-related fitness and motor fitness of children should be of great concern to all—not only the physical educator, coach, and physician. For the past several decades the fitness levels of boys and girls in North America have received considerable attention in the professional and lay literature. The American Alliance for Health, Physical Education, Recreation, and Dance (AAHPERD) became a leader in surveying the fitness of American youth through the development and promotion of a national youth fitness test. This test, with revisions, became the basis for decade-by-decade comparisons in 1965, 1975, and 1985. The AAHPERD Youth Fitness Test and the AAHPERD Health-Related Physical Fitness Tests were probably the most widely used standardized physical fitness tests throughout the United States during the 1980s. A new generation of field-based fitness measures are now the nation's premier youth fitness test. *The President's Challenge* from the President's Council on Fitness, Sports, and Nutrition and Fitnessgram from the Cooper Institute have emerged as the two most popular fitness batteries available for use by field professionals in the United States. Recently, various fitness characteristics of more than 2.5 million Texas students were assessed using Fitnessgram (Morrow et al., 2010).

CONCEPT 13.1

A variety of available field measures claim to measure various aspects of children's physical fitness.

Sufficient evidence over the past several years indicates that a great many children are unfit. According to the 2007–2008 National Health and Nutrition Examination Survey (Centers for Disease Control and Prevention, 2009), children in the United States are heavier and fatter than their counterparts from previous generations.

CONCEPT 13.2

At the national level many of today's children are considered unfit.

Defining *fitness* is a necessary first step toward establishing children's fitness standards. Although we do not have universal agreement on the term **physical fitness,** we will use the following definition as our guide: "Physical fitness is a positive state of well-being influenced by regular physical activity, genetic makeup, and nutritional adequacy." In more specific terms, physical fitness can be broken down into health-related fitness and motor- or performance-related fitness.

HEALTH-RELATED FITNESS

Extensive studies in the area of physical fitness have been conducted over the past several years, and what we know about the physical fitness of children has increased significantly. A review of the literature on fitness, however, reveals a marked lack of information on children under 6 years of age. The reasons for this are many. Most tests of physical fitness require the individual to go "all out" and perform at his or her maximum. Anyone familiar with young children will recognize the difficulty of this situation. The problems lie in: (1) being able to sufficiently motivate the youngster for maximal performance, (2) accurately determining whether a maximum effort has been achieved, and (3) overcoming the fears of anxious parents. Experts working with young children have a fertile area for the study of physical fitness. Carefully controlled, patient research will yield much valuable information. Aerobic endurance, muscular strength, muscular endurance, joint flexibility, and body composition are the components of **health-related fitness.** Each of these components is discussed briefly in the following paragraphs regarding what is known at present.

INTERNATIONAL PERSPECTIVES

Active Cultures (No, Not the Yogurt Kind)

We are all aware of the amazing benefits that come from technological advances, but when it comes to physical activity and fitness factors technology often represents a double-edged sword. Technology raises our health standards and helps with the treatment and eradication of certain diseases. It can also contribute to some diseases related to sedentary lifestyles. Technology often represents a defining characteristic in a culture. One research study compared the physical activity levels of children growing up in Old Amish Order and Old Mennonite Order homes with children raised in more contemporary homes. Lacking the technological advances seen in many modern homes, children living a more traditional lifestyle were found to engage in much higher levels of moderate-intensity and vigorous-intensity physical activity (Esliger et al., 2010). Similar results were found when the fitness levels of Chinese children living in Hong Kong were compared with those of Chinese children living in mainland China. The researchers suggested that while the children in Hong Kong share the same ethnicity as the children in mainland China, their lower fitness levels may be due to different education and entertainment experiences as well as an "Eastern-mixed-with-Western diet" (Chung, Chung, & Chen, 2008).

Cardiovascular Aerobic Endurance

Aerobic endurance is an aspect of muscular endurance specific to the heart, lungs, and vascular system. It refers to the ability to perform numerous repetitions of a stressful activity requiring considerable use of the circulatory and respiratory systems. **Maximal oxygen consumption (VO_2 max)** refers to the largest quantity of oxygen an individual can consume during physical work while breathing air at sea level. It is a measure of one's maximum ability to transmit oxygen to the tissues of the body. An increase in one's aerobic capacity is an excellent indicator of a higher energy output. It is generally considered that up to a 20% improvement in VO_2 max is possible, because one's genetic inheritance plays a crucial role in the capacity to consume oxygen. Maximal oxygen consumption tends to improve as a function of age until about 18 to 20 in males but tends to level off or drop at about 14 in females (Abernethy et al., 2005; Armstrong and Welsman, 2000). Declines at this point may be attributed to a combination of physiological and social factors while improvements are primarily a function of training. Due to size differences, females possess about 70–75% of the capacity of males to consume oxygen. More specifically, when comparing females and males at various age levels, boys' values are about 10–15% higher than those of girls at age 10. Sex differences, however, become more dramatic during the teen years, typically reaching 30–35% by age 16 (Abernethy et al., 2005; Armstrong and Welsman, 2000). The measurement of VO_2 max with children younger than 10 years of age tends to be less reliable. Some inherent problems exist when testing young children. Factors such as testing on equipment designed for adults as well as psychological or cognitive factors that inhibit a child from putting forth a maximal effort can result in less than reliable results (Malina, Bouchard, & Bar-Or, 2004). In addition, if a child performs the fundamental skill of running at the initial or emerging level rather than the proficient level, the economy of movement on a treadmill will be considerably less efficient.

Maximal aerobic power as measured by maximal oxygen consumption is a universally accepted means of measuring status and change in cardiovascular fitness. It is not, however, universally accepted or understood how to express maximal aerobic ability in relation to body size, a process referred to as scaling. Knowing how maximal aerobic power relates to body mass and body size is important when dealing with children. While a strong relationship between VO_2 max and the growth-related changes in body size has been demonstrated, the specific influence of growth and maturation on maximal aerobic power is not clear (Malina, Bouchard, & Bar-Or, 2004).

Over the years several laboratory studies have been conducted with children to determine their VO_2 max values. Armstrong and Welsman (2000) noted that VO_2 max relative to weight remains stable for males 8 to 18 years at about 48 to 50 ml/kg but declined for females from 45 to 35 ml/kg as they advanced in years. A minimum VO_2 max threshold value of 42 is generally recommended for adults, and according to Simons-Morton et al. (1987), in their review of children and fitness, "it appears that most children are well above this level" (p. 297).

Heart rate responses to exercise are sometimes used as crude measures of cardiovascular endurance in young children because of the difficulty in gathering accurate VO_2 max data. Average normal resting heart rates in children around the age of 6 years is approximately 80 beats per minute while at age 10 the average is about 70 beats per minute. Maximum exercise heart rates in children have been reported to range from about 150 to 230 beats per minute. In what should be considered a pioneering experiment because of its methodology, Mrzena and Macuek (1978) tested children 3 to 5 years old on the treadmill. Each subject was required to walk or run for 5 minutes at a level grade with the treadmill set at three different speeds (3, 4, and 5 km/h). The highest heart rates were recorded at 142 beats per minute. Another group performed the treadmill task at 4 km/h while the grade was increased from 5° to 10° to 15°. This group produced heart rates averaging 162 beats per minute. Investigators noted that when the treadmill speed was increased to 6 km/h and the inclination to 20°, "the children were not able to increase the step frequency and lost their balance" (p. 31). The average maximum aerobic capacity of preschool children is certainly greater than the scores obtained in this experiment, but maturity of movement as well as the psychological and emotional state of the young child determine the degree of cooperation and effort during testing.

For years, researchers have used a variety of techniques to measure physical activity. *Activity self-reports* in which the subject completes a form designed to aid in recalling several days of physical activity have been used extensively. Although valid instruments with adolescents and adults, they are not recommended for research purposes with children under age 10 because of the inability of most boys and girls under this age to cognitively recall, in detail, their physical activity. *Heart rate monitors* have also been used extensively to measure daily physical activity. Once again, validity is doubtful, especially with children, because heart rates below 120 beats per minute are not valid predictors of exercise intensity (Rowlands, Eston, & Ingledew 1997), and other factors, such as emotions, can elevate the heart rate.

The *accelerometer* represents a preferred means of assessing children's physical activity because it is valid and economical. An **accelerometer** is an electromechanical device worn by the subject that detects and records motion in a single plane or multiple planes. A number of studies have used the accelerometer to quantify the level of children's physical activity in a variety of settings (Jago et al., 2011; Pagels et al., 2011; Tudor-Locke et al., 2010).

CONCEPT 13.3

Although a variety of instruments purport to measure children's physical activity levels, accelerometers have emerged as the most valid and economical field measure.

Muscular Strength

Muscular strength is the ability of the body to exert force. In its purest sense, it is the ability to exert one maximum effort. Children engaged in daily active play are enhancing their leg strength by running and bicycling. Their arm strength is developed through such activities as lifting, carrying objects, handling tools, and climbing on playground equipment. Strength may be classified as **isometric, isotonic,** or **isokinetic.** *Isometric strength* involves exerting force on an immovable object. The muscle contracts, but there is little change in its length. *Isotonic strength* refers to the ability of a muscle to go through its full range of motion. The muscles involved contract, but they also shorten and lengthen during the activity. A barbell curl and a bench press are examples of isotonic strength activities. *Isokinetic strength* involves contracting a muscle and maintaining that contraction through its full range of motion. Isokinetic strength is measured by use of special machines that accommodate resistance at a set velocity as the muscle works.

In laboratory situations *strength* is commonly measured by using a dynamometer or tensiometer. These devices are highly reliable when used by trained personnel. **Dynamometers** are calibrated devices designed to measure grip strength, leg strength, and back strength. *Tensiometers* are more versatile than dynamometers in that they permit measurement of many different muscle groups. The classic longitudinal studies conducted by Clarke (1971) used eighteen different cable tensiometer tests and revealed yearly strength increments in boys between 7 and 17 years. Although information is limited on young children, Beunen and Thomis (2000) reported that from 3 to 6 years of age there are minimal sex differences and that strength gradually increases from year to year. These yearly increases are most closely associated with size increases and improvement in fundamental movement abilities. In boys from age 6 on to the onset of puberty (generally around age 12) there is a gradual linear increase in strength, with dramatic acceleration to age 17 and beyond. In girls, we see linear strength increases until about age 15, followed by a pronounced plateauing and regression in the late teens and beyond.

CONCEPT 13.4

Although incremental, strength gains during childhood are not linear; therefore, estimating strength scores in later years based on scores achieved during childhood offers little in the way of predictive validity.

Relatively few longitudinal investigations have been conducted on the development of strength in children at all ages. However, the available information indicates consistency in the development of strength in children over time. Strength has been shown to increase more rapidly than muscle size during childhood (Beunen and Thomis, 2000), suggesting an interrelationship between strength, coordination, and motor performance in children.

Although strength is a relatively stable quality throughout childhood, predicting strength levels at later years from measures taken in childhood has met with little success. The "strong" child at age 8, for example, will not necessarily make the greatest gains in strength from childhood through adolescence. Neither will the "weak" child necessarily make the least gains in strength from childhood through adolescence. Rapid change in body size, positively correlated with strength, and individual variability of growth patterns make prediction a precariousv enture.

Muscular Endurance

Muscular endurance is the ability of a muscle or a group of muscles to perform work repeatedly against moderate resistance. Muscular endurance is similar to muscular strength in the activities performed but it differs in emphasis. Strength-building activities require overloading the muscles to a greater extent than endurance activities. Endurance-building activities require less of an overload on the muscle but more repetitions. Therefore, endurance may be thought of as the ability to continue in strength performance. Children performing sit-ups, push-ups, and pull-ups are engaged in endurance activities, even though strength is required for any movement to begin. These three activities are among the most often used measures of muscular endurance and are among the best field measures available. There are, however, problems with pull-up measures because of body weight. The entire body weight must be lifted, and many children are unable to accomplish such a task. Therefore, a modified pull-up test is frequentlyu sed.

CONCEPT 13.5

Endurance levels of children approach and often exceed those of adults when adjusted for body weight.

The daily uninhibited play routines of young children are excellent examples of endurance that most adults would be unable to duplicate. *Relative endurance* refers to the child's endurance level adjusted to body weight. An adult's gross levels of endurance and fitness are generally greater than those of the child, but when body weight is factored into the total fitness score, the differences are less pronounced.

Throughout childhood both boys and girls tend to make steady year-to-year improvements on most measures of muscular endurance with boys only slightly outperforming girls prior to puberty. Girls reaching puberty ahead of their male counterparts (generally around age 10 or 11) often outperform them for a short period.

Joint Flexibility

Joint flexibility is the ability of the various joints of the body to move through their full range of motion. There are two types of flexibility: static and dynamic. **Static flexibility** is the range of motion achieved by a slow and steady stretch to the limits of the joints involved. **Dynamic flexibility** is the range of motion achieved when rapidly moving a body part to its limits.

Flexibility is joint specific and can be improved with practice. Dynamic flexibility in the shoulder, knee, and thigh joints tends to decrease with age among sedentary children.

CONCEPT 13.6

Activity levels offer a better guide to joint flexibility than chronological age, because of the highly specific nature of this fitness component.

The National Children and Youth Fitness Study II (Ross & Pate, 1987) tested thousands of children 6 to 9 years of age for flexibility. A sit-and-reach test was used as a measure of joint flexibility in the lower back and hip area. Mean scores clearly favored the girls. They tended to be slightly more flexible than boys at all ages. Girls showed little improvement with age, but neither did they regress. The boys, however, were on the average slightly less flexible at age 9 than they were at age 6.

Body Composition

Body composition is defined as the proportion of lean body mass to fat body mass. Relative fatness can be determined through a variety of means. Two of the most often used body composition assessments used with children are skinfold measurements and body mass index (BMI). Using **skinfold calipers**, skinfold thicknesses are measured at various sites on the body. With children those sites tend to be at the triceps, subscapular region, and the medial portion of the calf. BMI, however, is calculated using measures of height and weight. National surveys of body fatness have shown that children of all ages are fatter than they were twenty years ago. This trend toward increased fatness of American youth reflects dramatic changes in physical activity patterns and nutritional habits. Studies from both the United States and England indicate that beginning around the age of 6–7 years children gradually become less active as they grow older (Basterfield et al., 2011; Tudor-Locke et al., 2010).

CONCEPT 13.7

Over the past several decades, a number of factors have contributed to a secular trend toward higher body fat percentages among children living in the United States and other countries.

In a variety of countries it has been repeatedly documented that obese children are significantly less active than their lean peers (Danielsen et al., 2011; de Gouw et al., 2010; He et al., 2011).

The reasons for adoption of a sedentary lifestyle among children are many, but the implications are clear. Lower activity levels result in increased body fat percentages, whereas higher activity levels tend to promote lower body fat levels. The activity habits of a lifetime are formed during childhood. Parents, teachers, and other significant individuals in a child's environment can make a difference in activity levels both by example and by positivee ncouragement.

Children's Fitness Training

During the last several years our knowledge base has expanded dramatically in the area of children's fitness training. Although we still have many unanswered questions, research shows that children are capable of much more in aerobic conditioning, strength and endurance enhancement, and flexibility improvement than previously thought. Although we do not have adequate information to clearly delineate the physical activity patterns of children, we do know that the active child can make significant health-related fitness gains.

Concept 13.8

The potential for measurable aerobic trainability in prepubescent children has yet to be conclusively documented.

Aerobic Training

An area of study that has received increased attention deals with the *aerobic trainability* of prepubescent children in their potential for making significant gains in VO_2 max scores. Because it has been widely documented that adults respond to training protocols, it is commonly believed that children can produce similar physiologically measurable training effects.

In 1983 Katch proposed what has become known as the "*trigger hypothesis*" for aerobic trainability. This hypothesis contends that with prepubertal children efforts to improve aerobic endurance are likely to be wasted largely due to their low levels of androgens and growth hormone, metabolism, and muscular development. Rowland (1997) reviewed Katch's 1983 hypothesis with the benefit of fourteen years of accumulated evidence on the topic and found little reason to refute his claim. In fact, the evidence leads us to conclude that children do not respond as predicted to aerobic training. A number of explanations have been proposed, including: (1) the need for children to have a higher training intensity to demonstrate significant aerobic trainability, (2) that children are naturally more active and have higher fitness levels than adults resulting in the need for proportionally more activity to demonstrate a training effect, and (3) that children may be less motivated to train. All may have merit, but there is beginning to be an accumulation of evidence that "true biological differences may exist between children and adults that restrict improvement in aerobic fitness with training with immature compared to mature subjects" (Rowland, 1997).

Abernethy et al. (2005) support this position by pointing out that the respiratory system of children is less efficient than that of adults. They state that

> The respiratory muscles of children must work harder during exercise; and respiratory muscle fatigue contributes to the higher metabolic cost, feelings of discomfort and early fatigue during intense exercise. These differences in the cardiovascular and respiratory system responses to exercise limit oxygen delivery to working muscles, resulting in a lower endurance exercise capacity in children. This does not mean that children cannot perform endurance exercise or improve endurance exercise capacity; rather, it means that children cannot be expected to perform endurance exercise, or train for endurance events, at the level expected of adults. (p. 167)

Strength Training

In the past it was assumed that prepubescent children would not benefit significantly from a monitored strength-training program. (Please refer to

TABLE 13.1 Terms Commonly Used in Strength Training

Resistance training: Any method used to overcome or bear force.

Strength training: The use of resistance to increase the ability to exert or resist force. Various devices, including machines, weights, or one's body, may be used as a means of increasing strength.

Weight training: The use of free weights (barbells, dumbbells), stationary weights, or machines to increase strength.

Weight lifting: A competitive sport sometimes referred to as "power lifting" that involves lifting the maximum weight possible in prescribed events ("snatch," "clean and jerk," "squat," "bench press," and "dead lift").

Table 13.1 for a description of common terms used in resistance training [American Academy of Pediatrics, 2001; National Strength and Conditioning Association, 2009].) Early negative findings led many people to believe that strength-training programs were ineffective because of low levels of circulating androgens (male sex hormones) in prepubescent boys and in females of all ages (Legwold, 1982, 1983; Vrijens, 1978). A 1983 position paper by the American Academy of Pediatrics concluded that prepubescent strength training, although acceptable if properly supervised, was largely ineffective. However, Bar-Or (1983) asked: if women, who have low levels of testosterone, are capable of making significant strength gains, then why can't prepubescent children make similar gains? A number of studies clearly point out that children are capable of making significant strength gains in properly conducted and supervised programs of sufficient duration and intensity (Duda, 1986; Faigenbaum et al., 1996; Faigenbaum et al., 1993; Sewell & Micheli, 1984). These investigations and others prompted the American Academy of Pediatrics (2001, 2008) to regularly update their position statement to recognize the efficacy of prepubescent strengtht raining.

With proper supervision, strength training can benefit prepubescent children in strength enhancement, injury reduction, and improved performance (Payne et al., 1997). However, strength training is different from weight lifting. *Strength training* involves the use of progressive resistance techniques using the body, weights, or machines to improve one's ability to exert or resist a force. *Weight lifting* is a sport in which one attempts to lift the maximum number of pounds possible. Weight lifting is not recommended for prepubescent children. In fact, the American Academy of Pediatrics (2008) states that "Because of the limited research regarding prepubertal injury rates in competitive weightlifting, the AAP remains hesitant to support participation by children who are skeletally immature and is opposed to childhood involvement in power lifting, body building, or use of the 1-repetition maximum lift as a way to determine gains in strength" (p. 837).

CONCEPT 13.9

Prepubescent children can, under certain conditions, make significant gains in muscular strength in properly designed and carefully supervised resistance-training programs.

Hormonal control of protein synthesis in muscle tissue involves the complex interaction of many **anabolic hormones** (muscle-enhancing) and **catabolic hormones** (muscle-destroying). One of the most important anabolic hormones is *growth hormone* (GH), found in prepubescent children. According to Bernuth et al. (1985): "Exercise has been found to be the most potent stimulus for GH release in children" (p. 100). It seems, therefore, that children have at least some of the hormones necessary for muscle hypertrophy. Most studies examining prepubescent weight training, however, have found no evidence of muscle hypertrophy following a training program (Blimkie et al., 1989; Ozmun, Mikesky, and Surburg, 1994; Weltman et al., 1986). Only one investigation has claimed to have observed muscle hypertrophy in a prepubescent population (Mersch and Stoboy, 1989). These results, however, require verification as the research participants involved only two sets of identical twins.

Testosterone has been the primary sex hormone associated with the tremendous gains in muscular strength seen in adolescent males. Like growth hormone, testosterone is an anabolic hormone, but whether it enhances muscular development by direct action on muscle tissue or by an indirect inhibition of the catabolic action of other hormones is unclear. It is the combination of testosterone and growth hormone, however, that enhances protein synthesis and inhibits protein destruction in muscle tissue, contributing to an increase in muscle size and strength. Therefore, although females of all ages and prepubescent males have low levels of circulating androgens, they possess other anabolic hormones such as growth hormone that can facilitate protein synthesis and result in significant strength increases under sufficiently enhanced levels of training.

Prepubescent children can increase their strength through resistance training due to enhanced stimulation of the central nervous system beyond that which would occur with normal growth and maturation. The term **neuromuscular adaptation** is used for changes that result from training. When the body is subjected over time to significant amounts of anatomical or physiological stress, the natural reaction is to adapt to the new conditions. It has been demonstrated that a short-term weight-training program results in neuromuscular adaptations with prepubescent participants (Blimkie et al., 1989; Ozmun et al., 1994). There are, however, special considerations for the preadolescent involved in a strength-training program.

The possibility that weight training harms the still-growing epiphyseal **growth plates** in young bones is a concern. Indeed, these cartilaginous structures, by their soft and spongy nature, are susceptible to injury, especially from excessive weight-bearing, shearing forces, and chronic stress. The potential vulnerability of the growth plates through excessive stress must not be minimized. A high correlation exists between damage to these areas and children involved in weight lifting. As a result, the American Academy of Pediatrics (2001) recommends that prepubescent athletes avoid the sport due to the immaturity of their bones.

Another prime cause of epiphyseal damage in children engaged in weight training and chronic stress activities is improper training techniques. In addition, some weight-training equipment may be unsuitable with or without proper technique. Most machine-type resistance equipment is made to adult body proportions, with little or no consideration given to youth proportions. Epiphyseal growth plate injuries due to overuse have also been reported in children participating in certain sports. Distance running, gymnastics, and distance swimming have the potential for causing overuse injuries in the prepubescent athlete. As children grow older the potential for overuse injuries increases as seasonal sports, such as soccer, move toward year-round endeavors.

In summary, it appears that prepubescent strength training can, if properly supervised, produce significant strength gains in boys and girls. One must be careful, however, to use this information wisely. Damage to the epiphyseal growth end plates of the long bones may occur if the young body is exposed to a continual increase in stress. At this juncture it is not possible to determine the extent to which any one individual may be pushed in training before damage is done. As a result, carefully supervised weight-training programs that emphasize proper technique and actively discourage maximal lifts are recommended. Programs should also use equipment adapted to the child's size and stress low resistance training. In no case should prepubescent athletes be encouraged or permitted to engage in competitive aspects of weight lifting including the attempting of maximal lifts.

Flexibility Training

Besides strength and endurance training, another key health-related fitness component considered essential to injury prevention is joint flexibility.

Developmental Dilemma

My Buddy and Me

It is common knowledge that overweight/obesity and general physical inactivity are real concerns for children not only in the United States but in multiple countries around the world. We look to parents, schools, park districts, and other government agencies for assistance, and they, of course, each play a significant role in combating these concerns. But one aspect that has not been explored much in regard to its influence on a child's level of physical activity is the child's best friend. Some researchers in England recently asked that question (Jago et al., 2011). They asked more than 470 10–11-year-old boys and girls several questions such as "Who is your best friend?", "How often do you and your best friend engage in physical activity?", and "Where do you and your best friend engage in physical activity?" They also had each child wear an accelerometer for five days to monitor his or her actual physical activity. They found that both girls and boys who had active best friends spent more time being active themselves than those whose best friends were more sedentary. They also found that much of the physical activity with their best friends took place at home and in the neighborhoods. Parents and teachers should tap into this friendship bond to create and foster opportunities for best friends to be more physically active.

Improving the range of motion about the various joints of the body plays an important role in enhancing movement performance.

Concept 13.10

Children frequently exhibit decreased levels of joint flexibility during the prepubescent growth spurt because bone growth precedes muscle and tendon growth.

Micheli and Micheli (1985) reported less flexibility in males and females during the prepubescent growth spurt. The reason is that bone growth precedes muscle and tendon growth. As a result, musculotendinous units tighten. It is essential for the prepubescent athlete to engage in a good stretching program along with any form of strength or endurance training to help counter the tendency for reduced flexibility. Overuse injuries such as "swimmer's shoulder" are related to a lack of flexibility. Do not assume that endurance activities such as running and swimming promote flexibility. The young performer must be encouraged to engage in a proper stretching program prior to and after any endurance workout to minimize the possibility of injury to the area around the joints.

Health-Related Fitness and Movement Abilities

The interaction between the components of health-related fitness and physical activity is obvious. Performance of any movement task, whether it be at the rudimentary, fundamental, or specialized skill level, requires varying degrees of cardiovascular fitness, muscular strength, muscular endurance, and joint flexibility. All movement involves exerting force to overcome inertia. To exert that force, one must possess some degree of muscular strength. If a movement task is to be performed repeatedly, as in dribbling a ball, muscular endurance is also required. If the action is to be repeated over an extended period at a rapid pace, as in dribbling a ball up and down a basketball court, both cardiovascular endurance and flexibility are required. Reciprocity in building the components of physical fitness is evident in that performance of movement activities maintains and develops higher levels of physical fitness. The components of physical fitness are inseparable from movement activity. Rarely, if ever, is a movement activity performed that does not involve some aspect of strength, muscular endurance, or flexibility.

CONCEPT 13.11

One's health-related fitness, motor fitness, and movement abilities are interrelated; each influences the other in the "real" world and operates in isolation only in the research laboratory.

It is not possible under normal conditions to isolate the basic components of skill performance. However, tests have been devised that require more of one component of fitness than of another. Through this indirect means of measuring health-related fitness we are able to determine estimates of one'sfun ctionalh ealth(Table13. 2).

TABLE 13.2 Common Measures of Children's Health-Related Fitness and a Synthesis of Findings

Health-Related Fitness Components	Common Tests	Specific Aspect Measured	Synthesis of Findings
Cardiovascular endurance	Stept est Distancer un Treadmill stress test Bicyclee rgometer Heartr atem onitor Accelerometer	Physical work capacity Aerobic endurance Max VO_2 Max VO_2 Heart rate Heart rate	VO_2 max estimates are tenuous with young children. Children can achieve maximum VO_2 values at or above adults when corrected for body weight. Maximal heart rates decrease with age. Trend for improved VO_2 max values in both boys and girls with age. Girls level off after age 12 or so. Boys continue to improve.
Muscularst rength	Hand dynamometer Backa nd leg dynamometer Cable tensiometer	Isometric grip strength Isometric back and leg strength Isometric joint strength	Annual increase for boys from age 7 on. Girls tend to level off after age 12. Boys slow prior to puberty, then gain rapidly throughout adolescence. Boys superior to girls at all ages.
Musculare ndurance	Push-ups Sit-ups Flexeda rm hang Pull-ups	Isotonic upper body endurance Isotonic abdominal endurance Isometric upper body endurance Isotonic upper body endurance	Similar abilities throughout childhood slightly in favor of boys on most items. Lull in performance prior to age 12. Large increases in boys from 12 to 16, then a leveling off. Girls show no significant increases without special training after age 12.
Flexibility	Benda ndr each Sit and reach	Hip joint flexibility Hip joint flexibility	Flexibility is joint specific. Girls tend to be more flexible than boys at all ages. Flexibility decreases with reduced activity levels.
Bodyc omposition	Skinfoldc alipers Body mass index	Estimate of percent body fat Estimate of percent body fat	Children at all ages have higher percentages of fat than their age-mates of twenty years ago. Active children are leaner than obese children at all ages. Obese children are less active than nonobese children.

Motor Fitness

Considerable research has been conducted on the motor skill performance of the adolescent, adult, and skilled performer. The literature is replete with information dealing with their performance levels, biomechanics, and neurophysiological capabilities, but relatively little has been done with preschool and elementary school age children. The situation is much the same as with health-related fitness. *Movement control factors* of balance (both static and dynamic balance) and coordination (both gross motor and eye-hand coordination), coupled with the *force production factors* of speed, agility, and power, tend to emerge as the components that most influence motor performance. The movement control factors (balance and coordination) are of particular importance during early childhood when the child is gaining control of his or her fundamental movement abilities. The force production factors (speed, agility, and power) become more important after the child has gained control of his or her fundamental movements and passes into the specialized movement phase of later childhood.

Studying 5- to 7-year-olds, Fjortoft (2000) found differences in **motor fitness** to be dependent mainly on age and to a lesser extent on sex. Differences in height and weight at these ages do not seem to correlate with measures of motor fitness.

> **CONCEPT 13.12**
>
> The components of motor fitness may be grouped into movement control factors and force production factors.

As with the components of health-related fitness, one's motor fitness is intricately interrelated with movement skill acquisition. One depends in large part on the other. Without adequate motor fitness, a child's level of skill acquisition will be limited, and without adequate skill acquisition, the level of motor fitness attainment will be impeded. The components of motor fitness are discussed here andsy nthesizedi n Table13. 3.

Coordination

Coordination is the ability to integrate separate motor systems with varying sensory modalities into efficient patterns of movement. The more complicated the movement tasks, the greater the level of coordination necessary for efficient performance. Coordination is linked to the motor fitness components of balance, speed, and agility but does not appear to be closely aligned with strength and endurance. Coordinated behavior requires the child to quickly and accurately perform specific movements in a series. Movement must be synchronous, rhythmical, and properly sequenced to bec oordinated.

> **CONCEPT 13.13**
>
> Coordinated movement requires integration of sensory and motor systems into a congruent and harmonious action pattern.

Eye-hand and eye-foot coordination are characterized by integrating visual information with limb action. Movements must be visually controlled and precise to project, make contact with, or receive an external object. Bouncing, catching, throwing, kicking, and trapping all require considerable amounts of visual input integrated with motor output to achieve efficient coordinated movement.

Gross body coordination in children involves moving the body rapidly while performing various fundamental movement skills. Measures such as the shuttle run, 30-yard dash, various hopping and skipping tests, and the standing long jump require high levels of gross body coordination. Gross body coordination and eye-hand and eye-foot coordination appear to improve with age in a roughly linear fashion. Also, boys tend to exhibit better coordination than girls throughout childhood (Van Slooten, 1973). More recent research examining coordination tends to focus on children

TABLE 13.3 Common Measures of Children's Performance-Related Fitness and a Synthesis of Findings

MotorF itness Component	Common Tests	Specific Aspect Measured	Synthesis of Findings
Coordination	Cablej ump Hopping for accuracy Skipping Ball dribble Footd ribble	Gross body coordination Gross body coordination Gross body coordination Eye-hand coordination Eye-foot coordination	Year-by-year improvement with age in gross body coordination. Boys superior from age 6 on in eye-hand and eye-foot coordination.
Balance	Beamw alk Stick balance One-foot stand Flamingo stand	Dynamic balance Static balance Static balance Static balance	Year-by-year improvement with age. Girls often outperform boys, especially in dynamic balance activities, until about age 8. Abilities similar thereafter.
Speed	20-yardd ash 30-yard dash	Running speed Running speed	Year-by-year improvement with age. Boys and girls similar until age 6 or 7, at which time boys make more rapid improvements. Boys superior to girls at all ages.
Agility	Shuttler un Side straddle	Running agility Lateral agility	Year-by-year improvement with age. Girls begin to level off after age 13. Boys continue to make improvements.
Power	Verticalj ump Standing long jump Distance throw Velocity throw	Leg strength and speed Leg strength and speed Upper-arm strength and speed Upper-arm strength and speed	Year-by-year improvement with age. Boys outperform girls at all age levels.

with coordination deficits such as developmental coordination disorder and cerebral palsy (Feltham et al., 2010; Gabbard & Bobbio, 2011; Mak, 2010).

Balance

Balance is the ability to maintain the equilibrium of one's body when it is placed in various positions. Balance is basic to all movement and is influenced by visual, tactile-kinesthetic, and vestibular stimulation. Use of the eyes enables the child to focus on a reference point to maintain balance. The eyes also enable the young child to visually monitor the body during a static or dynamic balance task. It has been known for some time that vision plays an important role in balance with young children (Cratty & Martin, 1969). It has been demonstrated that boys and girls age 6 and under could not balance on one foot with their eyes closed. By age 7, however, they were able to maintain balance with their eyes closed, and balancing ability continued to improve with age.

CONCEPT 13.14

Balance is critical to all movement behavior and is influenced by a variety of sensory mechanisms.

Balance is profoundly influenced by the vestibular apparatus. The fluid contained in the *semicircular canals* and the *otolith* plays a key role in helping an individual maintain equilibrium. The receptors in the semicircular canal respond to changes in angular acceleration (dynamic and rotational balance), whereas the otolith receptors respond to linear accelerations (static balance). The movements of *macula* (hairs) in either the otolith or the semicircular canals trigger nerve impulses by changing the electrical potential of adjoining nerve cells. Movement of the body and gravity are sensed by these vestibular receptors to keep the individual aware of both static and dynamic postural changes and changes in acceleration. The vestibular apparatus coordinates with the visual, tactile, and kinesthetic systems in governing balance. It appears that vestibular development of balance occurs early in life and that the vestibular apparatus is structurally complete at birth. However, the body musculature and the other sensory modalities involved in maintaining balance must mature and be integrated with vestibular clues to be of any use to the child in maintaining either static or dynamic balance.

Balance is often defined as static or dynamic. *Static balance* refers to the ability of the body to maintain equilibrium in a stationary position. Balancing on one foot, standing on a balance board, and performing a stick balance are common means of assessing static balance abilities. Laboratory measures of static balance often incorporate the use of force plates that measure postural sway. Research on the static balance abilities of children shows a linear trend toward improved performance from ages 2 through 12 (DeOreo, 1971; Van Slooten, 1973; Rival et al., 2005). Prior to age 2 children generally are not able to perform a one-foot static balance task, probably because of their still-developing abilities to maintain a controlled upright posture.

In regard to gender differences with static balance in children, there appear to be some discrepancies. DeOreo (1980) indicated that clear-cut boy-girl differences are not as apparent in static balance performance tasks as they are with other motor performance tasks. Girls tend to be more proficient than boys until about age 7 or 8, whereupon the boys catch up. Both sexes level off in performance around age 8. Holm and Vøllestad (2008) and Humphriss et al. (2011), on the other hand, noted gender differences with older children (10 years and older) with girls continuing to perform better than boys on static balance tests.

Dynamic balance refers to the ability to maintain equilibrium when moving from point to point. Balance beam walking tests are used most often as measures of dynamic balance in children. The available literature on dynamic balance indicates a trend similar to that for static balance. Girls are often more proficient than boys until age 8 or 9, whereupon they perform at similar levels. Both slow in their progress around age 9, before making rapid gains to age 12 (DeOreo, 1971; Frederick, 1977).

Speed

Speed is the ability to cover a short distance in as brief a time as possible. Speed is influenced by *reaction time* (the amount of elapsed time from the signal "go" to the first movements of the body) as well as *movement time* (the time elapsed from the initial movement to completion of the activity). Reaction time depends on the speed with which the initial stimulus is processed through the afferent and efferent neural pathways and is integrated with the initial response pattern. Reaction time improves in children as they get older.

Information available on simple reaction time indicates that it is about twice as long in 5-year-olds as it is in adults for an identical task and that there is rapid improvement from age 3 to age 5. These developmental differences are probably due to neurological maturation, variations in the information-processing capabilities of children and adults, as well as to environmental and task considerations.

Speed of movement in children is most generally measured through various tests of running speed. Frederick (1977), who tested the running speeds of five groups of children 3 to 5 years of age on the 20-yard dash, found linear improvement with age but no gender differences. In a study of the running speed of elementary school children, Keogh (1965) found that boys and girls are similar in running speed at ages 6 and 7, but boys were superior from ages 8 to 12. Both boys and girls improve with age at a rate of about 1 foot per second per year from ages 6 to 11 (Cratty, 1986). Keogh also found similar improvements and boy-girl differences in the 50-foot hop for speed, although girls tended to perform better than boys on hopping and jumping tasks requiring greater precision and accuracy of movement.

Prior to the Amateur Athletic Union (AAU) joining with the President's Council on Fitness, Sports & Nutrition to administer the President's Challenge Physical Fitness Test, the AAU administered its own fitness test battery, which included the measurement of fifty-yard sprint run scores (1993). These data are viewed as highly representative of the running speed of children and adolescents because of the large sample size, geographical distribution, and randomization techniques used. Both boys and girls were reported to make annual incremental improvements with males slightly outperforming females at all ages. Similarity in performance on the sprint run does not appear to carry over into the adolescent years. Males continued to make dramatic improvements throughout the teen years, whereas females tended to regress slightly after age 14. Both factors were associated with pubescent male strength increases, limb length increases and body fat decreases, and female body fat increases.

Generally speaking, speed of movement improves until about age 13 in both boys and girls. After this, however, girls tend to level off and even regress, whereas boys tend to continue improving throughout the adolescent years. The movement speed of both boys and girls may be encouraged during childhood and beyond through vigorous physical activity that incorporates short bursts of speed.

CONCEPT 13.15

Reaction time and movement time influence movement speed, agility, and power, which tend to advance linearly during childhood but require special training afterward for continued improvement.

Agility

Agility is the ability to change the direction of the body rapidly and accurately. With agility, one can make quick and accurate shifts in body position during movement. An assortment of agility runs have been used as indirect measures of agility. Unfortunately, the wide variety of ways in which these scores have been obtained makes it extremely difficult to compare studies. Scores from shuttle runs of various distances are typically used as a measure of agility. A recent study by Olds et al. (2006) attempted to compare the shuttle run results of multiple data sets from 37 different countries. Their results indicated that there were annual incremental improvements throughout childhood with males performing better than females at all ages. A second study by Tomkinson et al. (2003) compared the shuttle run scores of children and adolescents (6–9 years) from 11 different countries from 1981–2000. The investigators found that the agility performance of the most recent generation declined in almost every age group and for both boys and girls when compared to the scores recorded decades earlier.

Power

Power is the ability to perform a maximum effort in as short a period as possible. Power is sometimes referred to as "explosive strength" and represents the product of force divided by time. This combination of strength and speed is exhibited in children's activities that require jumping, striking, throwing for distance, and other maximum efforts. The speed of contraction of the muscles involved, as well as the strength and coordinated use of these muscles, determines the degree of power of the individual. It is difficult, if not impossible, to obtain a pure measure of this component because power involves a combination of motor abilities. The often-used throwing and jumping measures give only an indirect indication of power because of the skill required for both of these tasks. Frederick (1977), however, found significant yearly increments in vertical jump, standing long jump, and distance throwing tasks for children ages 3 through 5. The boys outperformed the girls on all measures at all age levels.

The same results were found by Keogh (1965) for boys and girls from 6 to 12 years of age and by Van Slooten (1973) for children 6 to 9 years of age on the throw for distance but with gender differences magnified beyond age 7. These findings are supported by a more recent study in which over 2,500 Spanish children aged 6–18 years were measured on 9 different muscular strength and power tests (Castro-Piñero et al., 2009). For most of the muscular strength tests (push-ups, pull-ups, sit-ups, curl-ups) there were improvements throughout the childhood years with minimal differences between boys and girls. However, for most of the muscular power tests (standing long jump, vertical jump, ball throw) there were also improvements with each age group, but the boys' scores were significantly higher than those recorded for the girls.

It is important to remember that differences from age to age and between sexes are closely related to yearly strength and speed of movement increments as well as to the varying sociocultural influenceson bo ysa ndg irls.

Summary

Although questions remain, there is general agreement regarding the advisability of vigorous physical activity in children. The growth patterns of almost all the internal organs are in proportion to the remainder of the body. Hence the lungs, heart, and so forth are able to cope with the demands placed on them. Proportional to their mass, young children can transport and use oxygen volumes comparable to or above adults.

Muscular strength, muscular endurance, joint flexibility, and body composition are also components of health-related fitness. They affect one's state of health in much the same way as does aerobic endurance. Good levels of fitness tend to reduce vulnerability to numerous physical ailments. The components of health-related fitness improve with age but not always in a linear fashion. There is a strong tendency to make small gains during early and later childhood, followed by a lull during the preadolescent period. Throughout adolescence, boys often make rapid gains in all measures of fitness, whereas girls tend to level off and sometimes decline in their performance scores after midadolescence.

The motor fitness components of coordination and balance are closely aligned with the development of movement control during early childhood. Once good control has been established, the child is able to focus on improvement in the force components of motor fitness. Speed, agility, and power improve dramatically during later childhood, as balance and coordination improve during early childhood. There is a linear trend for improvement in all measures of motor fitness.

Questions for Reflection

1. What factors either separately or in combination can contribute to a decline in health-related fitness components through childhood?
2. Why is childhood obesity such a significant concern?
3. Why do societal institutions (i.e., schools, government agencies, etc.) tend to emphasize health-related fitness rather than motor fitness?
4. In your opinion, which of the health-related fitness components have a greater impact on a child's overall health status? Why?

Critical Readings

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WEB RESOURCES

http://www.cdc.gov/physicalactivity/everyone/guidelines/children.html

Webpage linked from the Centers for Disease Control and Prevention promoting physical activity for children. Information includes importance of physical activity, recommendations, measuring, components, physical activity links, and information for health professionals.

http://www.fitnessgram.net/home/

Website containing information about *Fitnessgram*fi tness testing material. *Fitnessgram* emphasizes measures of health-related physical fitness and compares scores to carefully developed health standards.

http://www.cdc.gov/nccdphp/sgr/sgr.htm

The Centers for Disease Control and Prevention link to the Surgeon General's report on physical activity and health. Included are the executive summary, report contents, facts sheets, and related information.

http://www.cdc.gov/obesity/childhood/index.html

Information on childhood overweight and obesity from the 2007–2008 National Health and Nutrition Examination Survey. Includes tables, charts, and fact sheets discussing increase of overweight children in the United States.

http://www.presidentschallenge.org/challenge/physical/index.shtml

The President's Challenge physical fitness program produced by the President's Council on Fitness, Sports & Nutrition webpage. Site includes an overview of the program, link to the President's Challenge Website, and information on attaining the program packet.

http://kidshealth.org/parent/

A link from KidsHealth.org discussing a variety of issues related to children's fitness. Includes articles on exercise, sports, information for parents, and nutrition. Site also includes additional resources forf urtherr esearch.

CHAPTER

14 Perceptual-Motor Development and Motor Skill Intervention

KEY TERMS

Visuala cuity
Figure-groundp erception
Depthp erception
Visual-motorc oordination
Perceptual-motor
Perception
Bodya wareness
Spatiala wareness
Directionala wareness
Temporal awareness
Rhythm

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Discuss changes in perceptual functioning during childhood
- Analyze the relationship and interaction between perceptual and motor development
- Identify motor behavioral characteristics of children with developmental lag
- Analyze the effect of cognitive processing differences within and across age groups on motor skill development and performance
- Evaluate cognitive processing demands on motor skill performance
- Discuss the developmental aspects of visual acuity, figure-ground perception, depth perception, and visual motor coordination, and their interaction with motor performance
- Define the term *perceptual-motor* and diagram the perceptual-motor process
- Describe the perceptual-motor components and give examples of each

KEY CONCEPT

All voluntary movement involves an element of perception; as such, childhood motor development is closely associated with perceptual-motor functioning.

Study of the perceptual process and perceptual-motor development attempts to answer the age-old question of how we come to know our world. The nature of the perceptual process and its impact on movement and cognition have been topics of considerable interest to researchers and educators for years. From the moment of birth, children begin to learn how to interact with their environment. This interaction is a perceptual as well as a motor process. As described earlier in this text, perception takes place when sensory input is monitored and interpreted. Perception takes place in various sections of the brain and allows a person to establish meaning to the sensory data (Lavay & Winnick, 2011). Figure 14.1 illustrates the various locations of the brain where sensory information is processed.

This chapter focuses on various developmental aspects of perception, with particular emphasis on vision, and perceptual-motor behavior during childhood. The importance of developing both perceptual and perceptual-motor abilities is discussed along with factors that influence their emergence. This chapter will conclude with a summary of motor skill interventions for young children.

PERCEPTUAL DEVELOPMENT IN CHILDHOOD

By the time children reach 2 years of age, the ocular, or visual, apparatus is mature. The eyeball is near its adult size and weight. All anatomical and

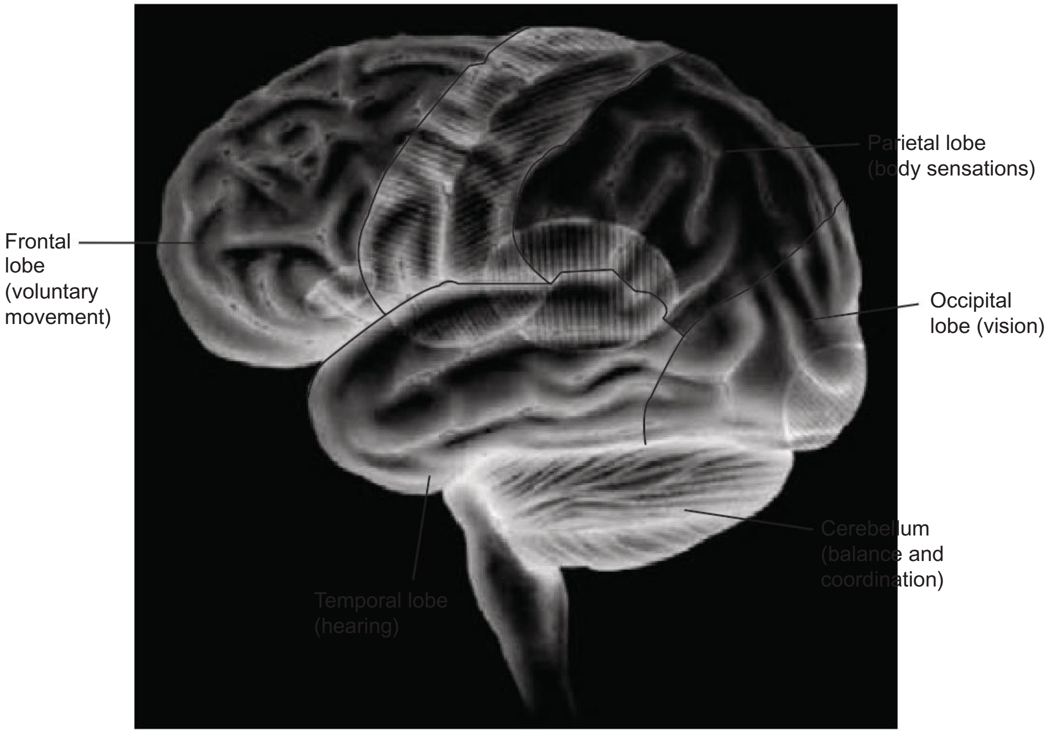

Figure1 4.1
Processing locations of the brain.

physiological aspects of the eye are complete, but the perceptual abilities of young children are still incomplete. Although children are able to fixate on objects, track them, and make accurate judgments of size and shape, numerous refinements still need to be made. A young child is unable to intercept a tossed ball with any degree of control. Difficulty with letter and number reversals is common, and a child's perception of moving objects is poorly developed, as are figure-ground perceptual abilities, perception of distance, and anticipatory timing.

CONCEPT 14.1

Children's perceptual and motor abilities are influenced by one another even though they develop at different rates.

The extent to which movement plays a role in visual perceptual development is debatable. In the past, investigators speculated on the importance of movement in the development and refinement of visual perceptual abilities. Investigations were conducted based on the hypothesis that self-produced movement is both necessary and sufficient for *visual-motor adjustment* to occur within a visually altered environment. It was contended that without movement, visual perceptual adjustments will not occur, and that the muscles and the motor aspect of the nervous system are intimately involved with perception and as such are dependent on one another. The concept of a relationship between movement activity and perceptual development has also been indirectly supported by the decline in performance on perceptual and motor deprivation experiments and experiments testing visual perceptual adjustments to optically rearranged environments. The gist of this research has led to what Payne & Isaacs (2008) refer to as the *motion hypothesis,* which contends that to develop a normal repertoire of visual-spatial skills, one must pay attention to objects that move.

CONCEPT 14.2

Movement has been shown to be a sufficient condition for the development of selected visual perceptual abilities, but it has not been demonstrated to be a necessary condition.

However, the results of years of experimentation are speculative at best when applied to the development of perceptual abilities in children. We still do not know the extent to which movement plays a role in perceptual development. It is probably safe to say, however, that movement is a "sufficient" condition for encouraging the development of perceptual abilities. Whether it is a "necessary" condition is doubtful.

Although it is doubtful that self-produced movement is a necessary condition for development of a child's visual perceptual abilities, there is little doubt that the developmental level of his or her visual perceptual abilities will affect the performance levels of movement skills. It is important that we become familiar with the child's developing perceptual abilities and understand the impact of perception on movement skill learning and refinement. Visual acuity, figure-ground perception, depth perception, and visual-motor coordination are important developmentally based visual qualities and influence movement performance. Table 14.1 provides a summary of these qualities and a hypothesized developmental sequence.

Visual Acuity

Visual acuity is the ability to distinguish detail in objects. The finer the details that can be distinguished, the better one's visual acuity, and vice versa. Visual acuity may be measured in both static and dynamic settings. *Static visual acuity* is the degree of distinguishable detail that one is able to detect when both the individual and the object of visual regard are stationary. Static visual acuity is most commonly measured by use of a Snellen eye chart. A Snellen assessment is expressed

TABLE 14.1 Selected Developmental Aspects of Children's Visual Perception

VisualQ uality	Selected Abilities	Approximate Age
VISUAL ACUITY		
The ability to distinguish detail in static and dynamic settings	Rapid improvement	5–7
	Plateau	7–8
	Rapid improvement	9–10
	Mature (static)	10–11
	Plateau (dynamic)	10–11
	Mature (dynamic)	11–12
FIGURE-GROUND PERCEPTION		
The ability to separate an object from itss urroundings	Slow improvement	3–4
	Rapid improvement	4–6
	Slight spurt	7–8
	Mature	8–12
DEPTH PERCEPTION		
The ability to judge distance relative to oneself	Frequent judgment errors	3–4
	Few judgment errors	5–6
	Rapid improvement	7–11
	Mature	By age 12
VISUAL-MOTOR COORDINATION		
The ability to integrate use of eyes and hands inobj ectt racking and interruption	Rapid improvement	3–7
	Slow slight improvement	7–9
	Mature	10–12

in fractions. An individual with a 20/20 rating is able to distinguish objects at a distance of 20 feet (6.1 m) in the same manner as others with normal vision at the same distance of 20 feet. An individual with a 20/200 rating is able to distinguish at 20 feet what others with normal vision could distinguish at 200 feet (60.9 m).

Dynamic visual acuity is the ability to distinguish detail in moving objects. It is less frequently assessed than static visual acuity for various reasons, but it is of interest to anyone required to make precise judgments based on visually guided tracking. The baseball player preparing to strike or catch a ball needs to have good dynamic visual acuity, as does the volleyball player or skeet shooter. Dynamic visual acuity is measured by flashing checkerboard targets with varying levels of grid precision on a screen. These targets travel horizontally at varying speeds, and the individual indicates when the "small checks" can be seen in the moving object.

Williams (1983) reported that static visual acuity is mature by age 10 and, in general, is less well developed in 5- and 6-year-olds. Rapid improvement occurs between 5 and 7 years of age, with little change seen from ages 7 to 9, followed by rapid improvement between ages 9 and 10. By age 12 static visual acuity is generally adultlike.

Dynamic visual acuity appears to mature somewhat later than static visual acuity. Morris (1977) found improvement in individuals up to 20 years of age. Williams (1983) reported that dynamic visual acuity becomes increasingly refined during three separate periods: 5 to 7 years, 9 to 10 years, and 11 to 12 years of age. Furthermore, boys display better visual acuity (both dynamic and static) than girls at all ages. This information may help us better understand why it is essential to adjust the skill requirements in a sport such as baseball if we expect children to sustain their interest over time. Adult leaders must modify the rules to enhance the potential for success and sustained participation for both boys and girls at various developmentall evels.

Concept 14.3

Vision is the primary sensory modality and plays an important role in the process of motor development.

Figure-Ground Perception

Figure-ground perception is the ability to separate an object of visual regard from its surroundings. With regard to the developmental nature of visual figure-ground perception, Williams (1983), interpreting data from Frostig et al. (1966), reported stable figure-ground perception between 8 and 10 years of age. Prior to that, however, slow improvement occurs between 3 and 4 years, with large improvement seen from 4 through 6 years. Smaller changes were reported from ages 6 to 7 followed by a slight spurt between 7 and 8 years. Williams further suggested that figure-ground perception becomes increasingly refined from 8 to 13 years and may even continue to improve to 17 or 18 years of age. One may conclude that mature figure-ground perception involves elements of attention as well as visual-motor maturation.

Along with good dynamic visual acuity, figure-ground perception enables the performer not only to clearly distinguish an object but also to separate it from its background. Such a highly refined skill is essential to the batter or outfielder in baseball, the wide receiver or quarterback in football, or the performer on the uneven bars in gymnastics. The ability to clearly extract the object of regard (*figure*) from its background (*ground*) is essential for success. It is important to recognize that this perceptual quality is still developing in children. Modifications of the task requirements or manipulating the background against which certain movement tasks are performed may do much to enhance motor performance.

Depth Perception

Depth perception is one of the most intriguing aspects of visual perception. Depth perception allows us to see three-dimensionally, an astonishing feat when you consider that separately our retinas function two-dimensionally but when combined provide a visual image complete with minute depth cues. These cues to depth are both monocular and binocular.

Monocular depth cues are those that can be picked up by one eye. Such things as size, texture gradient, shading, convergence, overlap, proportionality, and linear perspective are common monocular cues to depth. All of these are used by the artist to give the "illusion" of depth on canvas. They also give us important three-dimensional visual cues to depth.

Binocular depth cues require both eyes to work in concert. *Retinal disparity,* an important component of depth perception, refers to an object of visual regard being viewed from a slightly different angle by each eye. Therefore, the image projected on each retina is slightly different, and the information passed on to the visual area of the cortex results in binocular disparity. Hence, the images that we receive have depth.

Little is known about the developmental aspects of depth perception. Williams (1983) reported, however, that binocularity and depth perception improve from 2 through 5 years of age. She also indicated that by age 7 children can accurately judge depth with monocular cues. Based on this and the extensive literature on infant depth perception, it is probably safe to conclude that depth perception begins developing in a basic way during the first months of infancy but that it continues to improve throughout early childhood. It is doubtful whether depth perception in general can be improved through special training. It is possible, however, that depth perception in specific situations can be improved (Sage, 1984).

Teachers, parents, and coaches need to consider the visual perceptions of depth when teaching new ball skills. Ball size, color, and texture as well as distance, trajectory, and speed play important roles in providing depth cues for successful object interceptions (Isaacs, 1980; Payne, 1985; Payne & Isaacs, 2008). One need only observe the child who turns his or her head to avoid an approaching ball to see why depth cues are important to successful catching. Turning the head to one side eliminates binocular vision and forces the child to depend on monocular cues. Too often these monocular cues are insufficient to make the accurate and refined adjustments required for mature catching. As a result the child reverts to a less mature scooping catching pattern, or the ball hits the child's face or chest before it is stopped or dropped. Successful object interception requires making use of all the depth cues available, especially during the early stages of skill development.

Visual-Motor Coordination

Visual-motor coordination refers to the ability to track and make interception judgments about a moving object. The development of visual abilities begins early in infancy and continues to improve with age. Morris (1980) indicated that by age 5 or 6 children can accurately track moving objects in a horizontal plane, and that by age 8 or 9 they can track balls moving in an arc. Payne & Isaacs (2008) noted that

> as dynamic visual acuity improves, so does the ability to track fast-moving objects because whenever an object is moving at an angular velocity at which smooth eye movements are no longer possible, the pursuit task becomes a function of dynamic visual acuity. (p. 235)

Williams (1983) reported that accurate perception of movement continues to develop to about 10 to 12 years of age.

Object interception is the second aspect of visual-motor coordination. Object interception, or *coincidence-anticipation timing* as it is frequently referred to in motor learning literature, involves the ability to match estimates of an object's location with a specific motor response. For example, the batter in baseball must estimate where the ball will be at a certain time and simultaneously activate the motor system to bring the bat into contact with the ball at the right moment. Object interception abilities improve greatly with age and practice. At this point it is difficult to propose a developmental model for object interception ability because of the vast number of confounding variables. However, observation of numerous children attempting to hit pitched balls leads us to conclude that younger children and less-experienced individuals make numerous judgment errors, but older children and more-experienced persons make fewer errors. Experience clearly appears to be an essential element in making accurate estimates of object interception. The question of whether experience alone or maturation of the visual-motor apparatus in conjunction with experience is responsible for improved judgments awaits further study.

PERCEPTUAL TRAINING

An individual's visual perceptual sophistication is intricately related to success in the performance of numerous movement skills, so it is essential for the teacher or coach to be aware of the developmental nature of children's visual abilities. The perceptual requirements of fundamental manipulative skills that involve imparting force to an object or receiving force from an object are especially great. When working with young children, we must make appropriate adjustments in the equipment to accommodate the developmental levels of their perceptual abilities. Changing the weight or size of balls by using foam, fleece, plastic, or soft rubber is likely to have a dramatic influence on the degree of success experienced. Making modifications in the color and size of the objects will also have an impact. Information from environmental constraints presented in chapter 11 on manipulative skills serves to inform these modifications.

Changing task constraints by modifying the rules of play to permit greater clarity and consistency of perception, time to react, or ease of tracking is also recommended. For example, in baseball, using a pitching machine set at a predetermined speed and trajectory will help children develop their tracking skills. Hitting a ball off a tee will enable younger children to experience greater success and to focus on developing a level swing without compounding the complexity of the task with object-tracking.

A third consideration in perceptual training is to recognize that the mechanics of the movement are influenced by the perception levels required for successful performance. If the visual requirements are great, the mechanics are more likely to be complicated. The mechanics of a tennis serve are more complex than those for swimming or skipping.

Finally, individuals who work with children must recognize that a child's perceptual development *and* motor development are interconnected and crucial to successful movement performance. We must adjust task and environmental constraints and our level of expectations to the perceptual as well as the physical maturity of each individual.

Perceptual-Motor Development in Children

The visual perceptual abilities of young children are not the same as those of adults. The child's visual world is in the developmental stages and is therefore restricted. The development of perceptual abilities significantly inhibits or enhances a child's movement performance. From the previous section we have seen that the converse of this may be true; that is, movement performance may significantly inhibit or enhance the development of children's perceptual abilities. The child restricted in perceptual development often encounters difficulties in performing perceptual-motor tasks.

The realization that the process of perception is not entirely innate prompts one to hypothesize that the quality and quantity of movement experiences afforded young children are related to some extent to the development of their perceptual abilities. The initial responses of young children are motor responses, and all future perceptual and conceptual data are based, in part, on these initial responses. Young children must establish a broad base of motor experiences for higher learning to develop properly. Thus, motor skill interventions early in life are important and necessary to both motor development and perceptual-motor development.

Concept 14.4

Practice in perceptual-motor activities may enhance perceptual-motor abilities, but there is insufficient evidence to claim that improved perceptual-motor abilities will enhance academic achievement.

Unfortunately, the complexity of our modern society often deters the development of many perceptual-motor abilities. The environment in which today's children are raised is so complex that they are constantly being warned not to touch or to avoid situations that offer great amounts of motor and perceptual information. The environment of today's children is increasingly passive and sedentary. Many children grow up in large cities, apartment buildings, cramped day-care centers, and school environments that do not encourage or promote learning through movement. Too few children in contemporary society climb trees, walk fences, jump streams, or ride horses. They miss many of the experiences that children ought to have to develop their movement repertoire. Children who spend too much time watching television or playing computer games develop sedentary, passive habits. The absence of varied movement experiences and the adaptations that come with practice and repetition can stifle children's motor development in skills like fundamental motor skills (FMS).

Concept 14.5

Children frequently lag in their perceptual-motor learning because of environmental restrictions.

Artificial means must be devised to give children additional experiences and practice in the perceptual-motor activities that modern society cannot provide naturally. The National Association for Sport and Physical Education (NASPE 2009) has reflected this stance by developing "Active Start," national physical activity guidelines for children age 0–5 years. These guidelines highlight the importance of caregivers providing many opportunities for structured and unstructured physical activities throughout a child's day in order to promote motor and perceptual-motor development. The physical education teacher should be an essential person in the educational curriculum. A sound, developmentally based physical education program will encourage children's perceptual-motor skills and promote many of the basic readiness skills required for success in school.

What Is "Perceptual-Motor"?

The hyphen in **perceptual-motor** is there for two reasons. First, it signifies the dependency of voluntary movement activity on some forms of perceptual information. All voluntary movement involves an element of perceptual awareness resulting from some sort of sensory stimulation. Second, the hyphen indicates that the development of one's perceptual abilities depends, in part, on motor activity. Perceptual-motor abilities are learned. As such, they use movement as an important medium in which learning occurs. The quality of movement performance depends on the accuracy of an individual's perceptions and his or her ability to interpret these perceptions into a series of coordinated movement acts. *Eye-hand coordination* and *eye-foot coordination* have been used for years to express the dependency of efficient movement on the accuracy of sensory information. The individual on the free throw line has numerous forms of sensory input that must be sorted out and expressed in the final perceptual-motor act of shooting the basketball. If the perceptions are accurate, and if they are blended into a coordinated sequence, the basket is made. If not, the player misses the shot. All voluntary movements involve the use of one or more sensory modalities to greater or lesser degrees.

Perception means "to know" or "to interpret information." Perception is the process of organizing incoming information with stored information, which leads to a modified response pattern. Perceptual-motor development may be described as a process of attaining increased skill and functional ability by using sensory input, sensory integration, motor interpretation, movement activation, and feedback. These elements are described as follows:

1. Sensory Input: receiving various forms of stimulation by way of specialized sensory receptors (visual, auditory, tactile, and kinesthetic receptors) and transmitting this stimulation to the brain in the form of a pattern of neural energy.
2. Sensory Integration:o rganizing incoming sensory stimuli and integrating it with past or stored information (memory).
3. MotorI nterpretation: making internal motor decisions (recalibration) based on the combination of sensory (present) and long-term memory (past) information.
4. Movement Activation: executingt he movement (observable act).
5. Feedback: evaluating the movement by way of the various sensory modalities (visual, auditory, tactile, and/or kinesthetic), which in turn feed information back into the sensory input aspect of the process, thus beginning thec ycle again.

The Perceptual-Motor Components

Although movement experiences in regular physical education programs are by general definition perceptual-motor activities, programs that focus on reinforcing perceptual-motor quality are significantly different in emphasis from those that focus on gross motor quality. In remedial and readiness programs, emphasis is on improving specific perceptual-motor components, so movement activities are grouped according to the perceptual-motor qualities they enhance, namely, body awareness, spatial awareness, directional awareness, and temporal awareness. Activities designed to enhance these abilities are used in regular physical education programs, but the primary objective is movement skill acquisition and increased physical activity rather than perceptual-motor acquisition.

The development and refinement of children's *spatial worlds* and *temporal worlds* are two of the primary contributions of perceptual-motor training programs. The jargon used in programs across North America varies greatly. There seems to be general agreement, however, that the following perceptual-motor qualities are among the most important to be developed and reinforced in children.

CONCEPT 14.6

Developmentally based physical education programs have the potential to enhance perceptual-motor functioning.

Body Awareness

Body awareness is often used in conjunction with *body image* and *body schema*. Each term refers to the developing capacity of a child to accurately discriminate among her body parts. The ability to differentiate among body parts and to gain a greater understanding of the nature of the body occurs in three areas. The first is knowledge of the body parts—being able to accurately locate the parts of the body on oneself and on others. Second is knowledge of what the body parts can do. This refers to the child's developing recognition of how the body performs a specific act. Third is knowledge of how to make the body parts move efficiently. This refers to the ability to reorganize the body parts for a particular motor act and to perform a movement task.

Body image has to do with the internalized picture that a child has of his or her body and the extent to which that image matches reality. Self-perceptions of height, weight, shape, and individual features affect how we compare ourselves with others. Establishing a realistic body image is important in childhood and thereafter. Anorexia and bulimia have been clearly linked to unrealistic body images and are now concerns for children.

Spatial Awareness

Spatial awareness is a basic component of perceptual-motor development that may be divided into two subcategories: (1) knowledge of how much space the body occupies and (2) the ability to project the body effectively into external space. Knowledge of how much space the body occupies and the body's relationship to external objects may be developed through a variety of movement activities. With practice and experience, the child progresses from his egocentric world of locating everything in external space relative to himself (*subjective localization*) to establishing an objective frame of reference (*objective localization*). The child also learns to deal with the concepts of self-space and general space. *Self-space* refers to the area immediately surrounding an individual bounded by how far one can extend his or her body from a fixed point on the ground. *General space* refers to that which is beyond a person's self-space. For example, preschoolers tend to determine the locations of objects relative to where they are standing (subjective localization in one's self-space). Older children are able, however, to locate objects relative to their proximity to other nearby objects without regard to the location of their bodies (i.e., objective localization in general space). The concepts of subjective localization and self-space are closely akin to Piaget's preoperational thought phase of development. The concepts of objective localization and general space are identified with higher cognitive structures in his concrete operations phase. Refer to chapter 2 for a discussion of Jean Piaget's phases and stages of cognitive development and the role that movement plays in each of his developmental phases.

The spatial awareness of adults is generally adequate, despite occasional difficulties in locating the relative positions of various objects. For example, when reading a road map while traveling through unfamiliar territory, many people become confused as to whether they are traveling north, south, east, or west. It can be difficult to turn either way while looking at a map, without almost literally placing oneself on the map. The absence of familiar landmarks and the impersonality of the road map make it difficult to objectively localize oneself in space relative to this particular task. Young children encounter much the same difficulty but on a broader scale. They must first learn to orient themselves subjectively in space and then proceed carefully to venture into unfamiliar surroundings in which subjective clues are useless. Providing children with opportunities to develop spatial awareness is an important attribute of a good, developmentally based physical education program and early motor skill interventions that recognize the importance of perceptual-motor development.

Directional Awareness

An area of great concern to many classroom teachers is that of **directional awareness.** Through directional awareness children are able to give dimension to objects in external space. The concepts of left–right, up–down, top–bottom, in–out, and front–back are enhanced through movement activities that place emphasis on direction. Directional awareness is commonly divided into two subcategories: laterality and directionality.

Laterality refers to an internal awareness or feel for the various dimensions of the body with regard to their location and direction. A child who has adequately developed the concept of laterality does not need to rely on external cues for determining direction. She does not need, for example, to have a ribbon tied to her wrist as a reminder about which is left and which is right. She does not need to rely on cues such as the location of a watch or a ring to provide information about direction. The concept seems so basic to most adults that it is difficult to conceive how anyone could fail to develop laterality. However, we need only look into the rearview mirror of a car to have directions reversed and sometimes confused.

Directionality is the external projection of laterality. It gives dimension to objects in space. True directionality depends on adequately established laterality. Directionality is important to parents and teachers because it is a basic component of learning how to read. Children who do not have fully established directionality will often encounter difficulties in discriminating among various letters of the alphabet. For example, the letters *b, d, p,* and *q* are all similar. The only difference lies in the direction of the "ball" and the "stick" that make up the letters. The child without fully established directionality encounters considerable difficulty in discriminating among several letters of the alphabet. Entire words may even be reversed. The word *cat* may be read as *tac,* or *bad* may be read as *dab* because of the child's inability to project direction into external space. Some children encounter difficulty in the top–bottom dimension, which is more basic than the left–right dimension. They may write and see words upside down and are totally confused when it comes to reading.

Establishing directional awareness is a developmental process that relies on both maturation and experience. It is normal for the 4- and 5-year-old to experience confusion in direction. We should, however, be concerned for the 6- and 7-year-old child who consistently experiences these problems because this is the time when most schools traditionally begin instruction in reading. Adequately developed directional awareness is one important readiness skill necessary for success in reading, and movement is one way in which this important perceptual-motor concept may be developed.

Temporal Awareness

The preceding discussion of the various aspects of perceptual-motor development dealt with the child's spatial world. Body awareness, spatial awareness, and directional awareness are closely interrelated and combine to help children make sense of their spatial dimensions. **Temporal awareness,** on the other hand, concerns the acquisition of an adequate time structure in children. It is evoked and refined at the same time the child's spatial world is developing.

Temporal awareness is intricately related to the coordinated interaction of various muscular systems and sensory modalities. *Eye-hand coordination* and *eye-foot coordination* reflect the interrelationship of these processes. Catching, kicking, and batting all involve prerequisite levels of eye-hand and eye-foot coordination. We refer to an individual with a well-developed time dimension as coordinated. One who has not fully established this dimension is often regarded as clumsy or awkward. Everything that we do possesses an element of time. There is a beginning and an end, and no matter how minute, there is a measurable span of time between the two. It is important that children learn how to function efficiently in this time dimension as well as in the space dimension. Without one, the other cannot develop to its fullest potential.

Rhythm is the basic and most important aspect of developing a stable temporal world. The term has many meanings but is described here as the synchronous recurrence of events related in such a manner that they form recognizable patterns. Rhythmic movement involves the synchronous sequencing of events in time. Rhythm is crucial in the performance of any act in a coordinated manner. Skipping and galloping are common locomotor skills that involve a rhythmical element.

The activity possibilities are endless. Moving to various forms of musical accompaniment, ranging from drumbeats to instrumental selections, contributes to temporal awareness and can enhance the learning of FMS. Table 14.2 provides a summary of the various aspects related to the perceptual-motor components.

TABLE 14.2 Factors Associated with Perceptual-Motor Components

- Body Awareness
  - Knowledgeo f bodyp arts
  - Knowledge of what body parts can do
  - Knowledge of how to make body parts move efficiently
- Spatial Awareness
  - Subjectivel ocalization
  - Objectivel ocalization
  - Self-space
  - Generals pace
- Directional Awareness
  - Laterality
  - Directionality
- Temporal Awareness
  - Synchronization
  - Sequence
  - Rhythm

INTERNATIONAL PERSPECTIVE

Sepak Takraw—Perceptual-Motor Giants

Sitting in a park in the back streets of Bangkok one evening, I watched the most amazing display of perceptual-motor development, the sport of sepak takraw. Takraw, as it is commonly known, is like volleyball. This is like saying hockey is just soccer on ice. The sport of takraw involes huge vertical jumps and bicycle kicks of the legs slamming the ball across the net. According to legend, sepak takraw was first played by a Hindu god and his gang of monkeys. The game grew in popularity throughout Southeast Asia, transforming from an informal circular game resembling hacky sack into a team game more closely resembling volleyball. Today there is an International Sepak Takraw Foundation and the United States has its own takraw sports organization. The formal level of the sport involves competition at the highest level, but it is in the parks and schoolyards and on the beaches of Southeast Asia that you see this game played every day. It is played with three players on each side and a woven wooden ball (rattan ball) that can reach speeds of 100 km per hour. The ball is served to the other team, which attempts to get it back over the net using a combination of feet, chest, knees, and head. An amazing display of eye-foot coordination, body awareness, and spatial awareness ensues. It needs to be seen to be believed, so check out a video clip online.

Source:ht tp://bleacherreport.com/articles/289280-what-sport-do-ninjas-play-sepak-takraw
http://takrawusa.com/

Perceptual-Motor Activities

Many of today's perceptual-motor programs and curricula incorporate an ecological approach. Specified movement activities or skills are intentionally practiced under a variety of environmental and task conditions. In that way, perception is specific to an individual child, and the environment is perceived in the context of what affordances it provides. Regular and adapted physical education teachers and pediatric physical and occupational therapists tend to serve as the primary program developers and deliverers for children with perceptual-motor difficulties. Many of these children have been diagnosed as having clumsy child syndrome, developmental dyspraxia, or developmental coordination disorder (Sherrill, 2004). Teachers and therapists require activities that focus on the specific delays demonstrated in their students or clients and incorporate an ecological approach. Claudine Sherrill, one of the leading contributors to the field of adapted physical activity, suggests some of the activities and instructional strategies in Table 14.3.

INTERVENING IN THE MOTOR SKILLS OF YOUNG CHILDREN

In chapters 11 and 12 we learned about the development of manipulative and locomotor skills in childhood. In these chapters we developed an understanding of age-related changes in the patterns of movement. Additionally, we considered the role of constraints imposed by the task and the environment in the performance of FMS, in interaction with learner characteristics. These individual, task, and environmental constraints may account, in part, for the inter- and intraindividual variations found in the FMS performance of children. In this chapter we further learned about perceptual-motor characteristics and how

TABLE 14.3 Suggested Perceptual-Motor Activities

Deficit Area—Body, directional, spatial, and temporal awareness
- Playf ollow thel eaderw ithm ovement
- Construct obstacle courses with narrow openings, over and under barriers, and uneven surfaces
- Useb lindfoldsw ith locomotora ndm anipulative activities
- Scatter parts of dismembered dolls around the room/gym and have child retrieve parts to make a complete doll
- Perform locomotor skills at different tempos to follow the tempo of a musical instrument

Deficit Area—Using multiple sources of sensory information
- Perform movement activities in and out of water; compare movements
- Performb ody rolling onv ariouss urfaces and angles
- Useb arefootm ovemento n differentt ypes of surfaces
- Play games where two bodies or body parts must be touching and moving in unison
- Perform movements wrapped in blankets, oversized clothing, or sacks of various textures

Deficit Area—Crosslateral and midline problems
- Play games that incorporate agility (changing directions rapidly and accurately)
- Perform exercises such as sit-ups with trunk twists (allows the right hand to touch the left foot, and vice versa)
- Use beanbag exploration that requires placing a beanbag held in the right hand on a part of the body located on the left side
- Reinforcem idline crossingw ith throwing and striking activities
- Playa n oneliminationS imonS ays game emphasizing midline and opposition movements

Deficit Area—Balance and coordination
- Incorporate equipment such as tiltboards, balance boards, and balance beams
- Performs tatic balancep ositions with eyes open, eyes closed, and eyes focused on a target (stationary and moving)
- Perform statica ndd ynamicb alance activities while holding a weighted object in only one hand
- Teach students to say verbal cues that coincide with their movements
- Have students perform a particular movement under varying environmental and task conditions

Data from Sherrill, C. (2004). *Adapted Physical Activity, Recreation and Sport: Crossdisciplinary and Lifespan.* 6th ed., St. Louis: McGraw-Hill.

perceptual-motor skills emerge over childhood. It may be that these emerging perceptual motor skills also account for variations in FMS performance. The final section of this chapter will briefly summarize atypical development (delays) in the FMS of a group of young disadvantaged children and the ways in which instructional interventions may positively impact their delayed motor skill development.

Developmental Delays in FMS

Research in motor development has consistently found that at a time when FMS should be developing rapidly, young children who come from disadvantaged environments demonstrate significant delays in their FMS (Goodway & Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999; Martin, Rudisill, & Hastie, 2009; Robinson & Goodway, 2009; Valentini & Rudisill, 2004). A child is identified with a developmental delay when she performs below the 25th percentile on the TGMD-2 (Ulrich, 2000). A large-scale study evaluated the FMS of 275 disadvantaged preschool children from the Midwest and Southwest using the Test of Gross Motor Development-2 (Goodway et al., 2010). This study found that overall preschoolers were developmentally delayed between the 10th to 17th percentile for locomotor skills and around the 16th percentile for manipulative skills (Goodway et al., 2010). A review of the frequency data revealed that overall, 85% of the African American Midwestern preschoolers were developmentally delayed in manipulative skills (92% of the girls and 78% of the boys). The same was true for locomotor skills, with 88% of Midwestern participants being delayed (90% of girls and 87% of boys). Similar findings were true for Southwestern Hispanic participants with 84% of participants being delayed in manipulative development (95% of girls and 72% of boys) and 91% in locomotor skills (92% of girls and 89% of boys). From this study, clearly a sizeable number of disadvantaged preschool children were delayed in manipulative and locomotor skill development. Location or ethnicity was not a factor and the delays were consistent from the Midwest to the Southwest. This study is not in isolation, and patterns reported for this study have remained fairly consistent for both African American and Hispanic populations, across regions of the United States, cities within the same region, and time (Goodway & Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999; Martin, Rudisill, & Hastie, 2009; Robinson & Goodway, 2009; Valentini & Rudisill, 2004).

Similar to the findings in chapters 11 and 12, gender differences were also found in disadvantaged children's manipulative skills but not locomotor skills (Goodway et al., 2010). Boys had better manipulative skills than girls. Other researchers support this perspective and suggest that without intervention, gender differences exist in manipulative skills but not locomotor skills (Amui, 2006; Goodway & Branta, 2003; Hamilton et al., 1999; Robinson & Goodway, 2009; Savage, 2002). Work by Garcia (1994) may shed some light on these findings. She qualitatively studied how preschool children of different genders engage in FMS programs. Garcia's work described how girls were much more cooperative in their interactions during instruction, and liked to "share" equipment, watch one another perform, and encourage one another's efforts. Meanwhile, boys were more focused on their individual performance and were competitive with their male peers. These kinds of interactions result in boys getting more practice trials than females in the practice environment. A recent study by Robinson, Goodway, Williams, and colleagues (2006) provides additional evidence to suggest that boys may get more practice than girls. Robinson and colleagues found that high-skilled males had more practice trials than all other groups (high-skilled females and low-skilled males and females) during a throwing intervention with preschoolers. Also, high-skilled females had more practice trials than low-skilled males and females. There were no differences between low-skilled males and females.

The consistent findings for delayed FMS and gender differences in FMS suggest that individual and environmental constraints are operating on these young children that are consistent across populations. One of the most consistent and powerful environmental constraints is that the child is being reared in an economically impoverished environment. Other work has hypothesized that disadvantaged preschool children are exposed to a variety of other environmental constraints that influence their motor development negatively (Goodway & Branta, 2003; Goodway et al., 2003). For example, lack of safe places to play and be active in the community, limited activity role models (especially for females), lack of access to motor skill programs, thus no instruction or feedback on their motor skills, may all contribute to these delays (Branta & Goodway, 1996; Goodway & Smith, 2005). Biological factors that stem from infancy such as poor prenatal care, small for gestational age at birth, and prematurity could be other individual constraints influencing the children. There is most likely a correlation between the delayed FMS of these children and their perceptual-motor skills. We have read in this chapter how environmental stimulation appears necessary to adequately develop perceptual motor skills, but these children may lack such environmental enrichment due to the nature of their disadvantaged backgrounds. The evidence on FMS delay strongly supports the notion that young disadvantaged children require motor skill intervention to remediate the developmental delays found.

But why are developmental delays in FMS of particular long-term concern for this population of children? The delays reported above suggest that these populations of young children do not demonstrate the requisite competency in FMS to be able to break through Seefeldt's (1980) hypothetical proficiency barrier. That is, delays in motor development are a limiting factor in supporting children's success in ongoing sport and physical activity behaviors. It is interesting to note the parallel between the FMS delays found with African American/Hispanic preschool children who live in urban centers and their adolescent counterparts (poor, urban, African American, Hispanic) who demonstrate low levels of physical activity and high levels of obesity during the adolescent years (Anderson & Butcher, 2006; U.S. Department of Health & Human Services [USDHHS], 1996). We have yet to understand the underlying mechanisms and implications of low motor competence in the early years, but it may be that such low competence tracks into the adolescent years, resulting in these children dropping out of sport and physical activity as it is not enjoyable nor are they successful (refer to Stodden et al., 2008 and Stodden & Goodway, 2007 for further elaboration of these ideas).

CONCEPT 14.7

Young children from disadvantaged backgrounds demonstrate developmental delays in FMS with girls also having significantly worse manipulative skills than boys. These delays may be a result of individual and environmental constraints.

Motor Skill Interventions

A growing body of research in motor development has examined the role of instructional programs or motor skill interventions on the development of FMS in young children. The positive impact of motor skill intervention has been reported in a variety of settings: (1) *physical education settings* (Martin, Rudisill, & Hastie, 2009; Savage, 2002; Sweeting & Rink, 1999; Valentini & Rudisill, 2004); (2) *preschool environments* such as Head Start (Amui, 2006; Conner-Kuntz & Dummer, 1996; Goodway & Branta, 2003; Hamilton et al., 1999; Robinson & Goodway, 2009); and (3) *children who are disadvantaged* (Amui, 2006; Conner-Kuntz & Dummer, 1996; Goodway & Branta, 2003; Hamilton et al., 1999; Martin, Rudisill, & Hastie, 2009; Robinson & Goodway, 2009; Savage, 2002). The instructors for motor skill interventions have ranged from motor development experts (Amui, 2006; Conner-Kuntz & Dummer, 1996; Goodway & Branta, 2003), to parents as instructors with a motor development expert facilitator (Hamilton et al., 1999) to physical educators (Savage, 2002;

DEVELOPMENTAL DILEMMA

Feed the Chicks— A True Story of Task Negotiation

A group of preschoolers are participating in a throwing station as part of their SKIP (Successful Kinesthetic Instruction for Preschoolers) Program. The throwing station is set up using the TARGET structures described below with:

- 3 different kinds of throwing objects—beanbags, yellow fleece balls, and tennis balls
- 3 distances from the target—close distance, medium distance, and far distance
- 2 different size targets—larger and mid-sized

The children are told the goal of the station is to throw as hard as possible. There are four children at the station: Aiesha, Sharonda, Delaunde, and Kalim. Immediately the girls and boys form gender-identified pairs and begin to work together. The teacher looks over and watches Delaunde and Kalim throwing rapidly and with force. They quickly move back to the furthest distance and throw the tennis balls at the smaller target. Kalim can be heard telling Delaunde, "Look at me throw, I can beat you." In the 10-minute skill station timeframe Kalim throws 55 balls and Delaunde throws 47 balls. At the same time Aiesha and Sharonda can be seen close to the wall, each holding one yellow fleece ball in their hands. They appear to have their hands cupped around the fleece ball and are talking to their hands. The teacher calls across the gym for the girls to start throwing. They gently drop the fleece ball on the floor, pick it up, kiss it, and place it carefully back in their hands. Bemused, the teacher walks over to the girls and asks them why they are not throwing. Aiesha and Sharonda proudly lift their hands up and tell the teacher, "Look, this is Charlotte" and "This is Sunshine." Even more confused, the teacher says, "What?" Take a moment to guess what might be going on here!

You may well have guessed that the girls had tapped into their creativity and turned the yellow fleece balls into baby chicks. They wouldn't throw the "chicks" as the "chicks would get hurt" so they held them, named them, and dropped them when told to throw. The teacher quickly entered their fantasy world and handed each girl a bunch of beanbags. She told them their chicks were really hungry and had lots of brothers and sisters and they needed to throw the beanbags at the targets to knock down the bags of grain to feed their chicks. The harder they threw, the more food their chicks would get and the more chicks they could feed. The girls excitedly began to throw with force and frequency and to move away from the wall. As they threw harder and harder the teacher dropped a few more "chicks" (yellow fleece balls) and said, "Keep throwing, you have more mouths to feed."

We have many more stories like this from our motor programs with young children. This story raises some interesting considerations for teachers. The first is to recognize that as teachers we may feel we have set a clear task for children, but children frequently negotiate these tasks to fit their own view of the world. If children are not performing the way we want, we need to ask what other factors might be in the picture such as the "chick factor." Also, young children are inherently creative and love to weave stories around their motor activities. In the SKIP program we typically teach motor skills around themes such as winter wonderland, the farm, the zoo, and superheroes to tap into this creativity and utilize it to our advantage. The other consideration is that often girls get less practice trials than boys and over time this may influence a girl's ability to become proficient in motor skills, especially manipulative skills. We need to consider our instructional environment and find ways to motivate both boys and girls.

Sweeting & Rink, 1999). Overall, these studies show that when motorically delayed preschool children receive well-designed motor skill instruction, they can remediate these delays in FMS (Conner-Kuntz & Dummer, 1996; Goodway & Branta, 2003; Goodway & Rudisill, 1996; Hamilton et al., 1999; Martin, Rudisill, & Hastie, 2009; Robinson & Goodway, 2009; Valentini & Rudisill, 2004). Much of this work is focused on children during the early childhood years as it is during this age group that children should be developing a broad base of proficiency in FMS (Clark & Metcalfe, 2002; Stodden et al., 2008).

Many of these motor skill interventions have taken place over 8 to 12 weeks with 16 to 24 sessions in total. The majority of motor interventions have focused on manipulation skills, although some have also included locomotor skills. A variety of instructional techniques have been utilized to deliver the motor skill interventions including: (1) *direct instruction* (Amui, 2006; Connor-Kuntz & Dummer, 1996; Goodway & Branta, 2003; Goodway et al., 2003; Robinson & Goodway, 2009; Savage, 2002); (2) *mastery motivational climate* (Amui, 2006; Martin, Rudisill, & Hastie, 2009; Robinson & Goodway, 2009; Valentini & Rudisill, 2004a; 2004b); and (3) *parents as teachers* (Hamilton et al., 1999).

Teacher-Centered Approach to Motor Skills Programs

Direct instruction in motor skills involves a teacher-oriented approach to teaching motor skills where the teacher clearly describes and demonstrates the task to be performed and children respond accordingly (Graham, Holt-Hale, & Parker, 2007). In this setting the children do not have any choices or preferences in selecting a task or activity and the teacher instructs each element of the lesson (Graham et al., 2007). An example of a direct instruction motor skill program is some of the work by Goodway and her colleagues. The intervention has been coined "*SKIP*" for *Successful Kinesthetic Instruction for Preschoolers* (Amui, 2006; Goodway & Branta, 2003; Goodway et al., 2003; Goodway & Robinson, 2006; Robinson & Goodway, 2009; Savage, 2002). One 45-minute *SKIP* lesson might look like this:

- Children enter and perform a 10-minute warm-up to music or a simple game to promote instant activity and get the heart rate up.
- Childrena red ividedi ntot hreeg roups and assigned to 1 of 3 skill stations (e.g., kick, catch,t hrow).
- Tasksa ta lls tationsa ree xplaineda nd demonstrated by the teacher.
- Childreng ot o thefi rst station and engage in 10 minutes of skill activity/development at that station. The teacher rotates around providing feedback and refining tasks to meet the children's needs.
- Childrenc ompletet hree1 0-minute rotations going to each station.
- At the end of the lesson the teacher gathers the children for a debriefing of the activities and finalf eedback.

Child-Centered Approach to Motor Skills Programs

Another more child-centered approach has been implemented, termed *mastery motivational climate*. This child-centered approach to instruction, which has been investigated by Rudisill and her colleagues, has high child autonomy to complete tasks and activities based on their preferences (Valentini & Rudisill, 2004a, 2004b). Several levels of challenge are also incorporated into the instruction (Valentini, Rudisill, & Goodway, 1999). The mastery motivation climate is developed by organizing instruction around six "TARGET" structures within the lesson, where the acronym TARGET stands for Task, Authority, Reward, Grouping, Evaluation, Time. The rationale behind this mastery motivational approach is that the instructional climate promotes students' motivation to engage in tasks and regulate their own pace of learning. For further information on motor-based mastery motivational climate refer to Valentini, Rudisill, and Goodway (1999). A 45-minute lesson example of mastery motivational climate might involve the following elements (Amui, 2006; Robinson & Goodway, 2009;

Valentini & Rudisill, 2004a; 2004b; Valentini, Rudisill, & Goodway, 1999):

- The teacher sets up three skills stations (e.g., kick, catch, throw) and at each station there are 3–5 levels of a task that vary the difficulty of the task (e.g., in catching different size balls, differentd istances).
- Children perform a large group 10-minute warm-up to music or a simple game to promote instant activity and get the heart rate up.
- Tasksa ta lls tationsa ree xplaineda nd demonstrated by the teacher.
- Over the next 30 minutes children are free to go to any station, select any task, and work with any other child while the teacher acts as a facilitator providing feedback, suggesting new tasks, and encouraging the children to attempt different levels of tasks most appropriate to their level.
- At the end of the lesson, the teacher gathers the children for a debriefing and finalf eedback.

Parents as Teachers in Motor Skill Programs

Parental involvement is another approach for delivering motor skill instruction (Hamilton et al., 1999). Parent-assisted instruction utilizes "parents" (i.e., mother, father, or primary caregiver) as the primary instructors of their children. Parents undergo parent training to learn about motor skill development and ways in which to work with their child. A lead teacher develops the lesson plans (which are very similar to the direct instruction discussed above) and acts as a facilitator to parents who instruct their child. The lead teacher moves around the gymnasium and makes sure the parent and child are performing the activities according to the lesson plan, and may step in and model appropriate instruction for parents when necessary.

Influence of Motor Skill Programs on FMS Development

All the motor skill intervention approaches identified above have been successful in significantly impacting the FMS development of disadvantaged preschoolers (Amui, 2006; Goodway & Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999; Martin, Rudisill, & Hastie, 2009; Robinson & Goodway, 2009; Savage, 2002; Valentini & Rudisill, 2004). In all of these interventions maximum opportunities to respond were provided, and as much as possible children had their own piece of equipment and tasks that were individualized to their own developmental needs. Goodway and Branta (2003) reported that African American preschoolers in a compensatory preschool program in the motor intervention group significantly increased their locomotor skills from the 15th to 80th percentile ($p < .001$) and their manipulative skills from the 17th to the 80th percentile ($p < .001$) from pre- to posttest. In contrast, the comparison group consisting of children in the same compensatory preschool who received the regular preschool curricula made no significant change. Goodway et al. (2003) showed similar findings with Hispanic preschoolers in the intervention group significantly improving their locomotor skills from the 7th to 50th percentile and their object control skills from the 11th to 60th percentile ($p < .001$). Again, no significant change occurred in the comparison group children who received the regular Head Start curriculum. The parent-taught motor skill intervention (Hamilton et al., 1999) resulted in manipulative skills improving from the 20th to the 67th percentile. In contrast, the control participants did not improve their manipulative skills. A recent study (Robinson & Goodway, 2009) compared mastery motivational climate intervention to direct instruction (low autonomy). The findings showed that both mastery and low autonomy interventions yielded significantly better manipulative skills as compared to the control group that participated in the regular Head Start program. However, there were no significant differences between the two intervention groups, demonstrating that both direct instruction and mastery motivational approaches to motor skill instruction were equally effective.

Some general conclusions can be provided from a review of the motor skill intervention work:

- Preschoolc hildrenw hoa re disadvantageda re delayed in their motor skills and need motor skilli ntervention.

- Whenp rovidedw ithd evelopmentally appropriate motor instruction in their early childhood programs these children can make significant and often large gains in their motor skills, remediating their prior delays.
- Childreni nt hec ontrolg roupswh or eceived only the typical early childhood curricula, where physical activity opportunities were often nonfacilitated and play-based, showed no improvements in FMS development.

The latter point is particularly important as it suggests that play-based approaches to promoting motor skills in preschools across the country are unlikely to yield any positive effects. That is, just providing children with opportunities to play on the playground (even with motor equipment such as balls and bats) does not change the children's motor development (NASPE, 2009). One area of research that has limited empirical evidence is the issue of how much instructional time it takes to bring about positive changes in FMS. The motor skill intervention literature suggests that interventions ranging between 8 and 12 weeks yield significant changes in FMS development (Amui, 2006; Conner-Kuntz & Dummer, 1996; Goodway & Branta, 2003; Hamilton, et al., 1999; Savage, 2002; Sweeting & Rink, 1999). Generally, if a skill is taught for 90–120 minutes of instruction young children seem to significantly improve these skills. It is wise to plan at least 90 minutes of instructional time for each of the FMS in an elementary physical education program.

Like any other academic skill, if motor skills are to be improved teachers must use a systematic approach to instruction. Based upon a review of the intervention literature and consideration of the *SKIP* program the following instructional recommendations are made:

- Carefullyp lanm otors killa ctivitiesu sing knowledge of the children's current level of motor development and motor development principles.
- Selecta v arietyo fm otivatingt asksa ligned with the developmental level of the children.
- Providem anyo pportunitiest op racticea w ide range of skills with maximum opportunities to respond such as each child having his or her own piece of equipment.
- Providea ccurated emonstrationo f skillsa nd teacher facilitation of activities.
- Providei ndividualf eedbacko np erformance that is aligned to the developmental sequences and the child's actual performance.
- Install reward structuresa nd/oro ther motivational techniques such as thematic units to motivate children to engage at high levels.
- Allow childrent om akec hoicesw ithint he instructional environment, self-monitor, and engagei nself- assessment.

Overall, the intervention literature suggests that motor skill intervention is necessary and valuable to FMS development for young children. A variety of instructional approaches (teacher and student centered) with a variety of populations (preschool through school age) have effectively demonstrated that children's FMS development significantly improves with instruction. Instructional interventions should provide at least 8 weeks of instruction and approximately 90 minutes of instruction per skill. Gender differences exist in manipulative skills but not locomotor skills, and these gender differences persist despite motor skill intervention. There is much to learn about the instructional approaches in which children learn best, and specifically in naturalistic conditions with regular physical educators. However, what we currently know can help teachers guide the planning of their curriculuma ndp hysicale ducationp rograms.

Concept 14.8

Motor skill interventions using direct instruction, mastery motivational climate, and parents as teachers brings about significant changes in the FMS of young children who are disadvantaged. Children receiving the regular early childhood curriculum did not improve their motor skills.

SUMMARY

Perceptual-motor training programs possess many of the same elements as reputable developmentally based physical education programs. Many of the movement skills taught in a perceptual-motor curriculum, either readiness or remedial, parallel those taught in regular developmental physical education classes. The goals of each program are different. A primary goal of the developmental physical activity program is to enhance movement control through practice and instruction in a variety of movement skills, while the goal of the perceptual-motor program is to enhance perceptual-motor qualities through practice and instruction in a variety of movement activities. Perceptual-motor training programs that purport to enhance academic achievement or to promote specific readiness for schoolwork do so amid considerable controversy and a lack of research support. Public testimony and opinion have served for years as the basis of support for perceptual-motor training programs. This is not adequate. However, the value of perceptual-motor experiences to a general state of readiness should not be dismissed. Enhancement of body, spatial, directional, and temporal awareness as a means of guiding the child toward improved movement control and efficiency in fundamental movement is worthwhile. Practice in perceptual-motor activities may, under certain conditions, enhance perceptual-motor abilities. Whether these abilities have a direct effect on academic performance is highly questionable. One can be assured, however, that they do play an important role in developing and refining the child's movement abilities.

Young children who are disadvantaged demonstrate delays in their FMS that are consistent across regions of the country, ethnicity (African American and Hispanic), cities within a region, and time. Although both locomotor and manipulative skills are delayed, girls have significantly worse manipulative skills than boys. Motor skill intervention ranging from 8 to 12 weeks can bring about significant improvements in the FMS of the children served. Different approaches have been used: direct instruction, child-centered, and parents as teachers; all have been found to be effective.

QUESTIONS FOR REFLECTION

1. Why do you think that young children who are disadvantaged demonstrate development delays in their FMS? What individual and environmental constraints do you think might be impacting them?
2. What kinds of motor skill interventions have been used with young children at risk? And how successful were they?
3. If you were a policy maker for the United States, what policies would you institute relative to the physical activity and motor skill development of young children who are disadvantaged?
4. What are the perceptual modalities and why is visual perception considered to be so important?
5. What are the primary elements of visual perception and how might each be improved through practice?
6. Why is there a hyphen in the term *perceptual-motor*?
7. What are the perceptual-motor components and how can they be enhanced in children?

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Web Resources

http://ione.psy.uconn.edu/~cespaweb/info.html

This website is a link from the University of Connecticut. The site discusses the ecological approach to perception and action in psychology.

http://www.pecentral.org/

An extension of the PE Central website, this site provides information on adapted physical education including perceptual-motor activities. Research, books, assessment instruments, and national standards are included.

http://www.naspspa.org/

The homepage of the North American Society for the Psychology of Sport and Physical Activity. The society functions to study human behavior when engaged in sport and to improve the quality of research in sport psychology, motor development, and motor learning. Website includes newsletter, journal abstracts, and conference information.

Head Start Body Start
http://www.aahperd.org/headstartbodystart/

Website provides ideas to promote physical activity and motor skills in preschool-age children.

Takraw USA website
http://takrawusa.com/

Website provides the rules and background of takraw.

UNIT IV

Adolescence

Youth comes but once in a lifetime.

—Henry WadsworthL ongfellow

CHAPTER

15 ADOLESCENT GROWTH, PUBERTY, AND REPRODUCTIVE MATURITY

KEY TERMS

Puberty
Genotype
Phenotype
Adolescent growth spurt (circumpubertal period)
Peakh eightv elocity
Peak weight velocity
Paceo fs exualm aturation
Menarche
Ejaculation
Timingo fp uberty
Gonadotropic(GnRH)h ormones
Estrogens
Amenorrhea
Tanners tages
Relatives terilityo fp uberty
Secondarys exc haracteristics
Maturitya ssessment

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Describe and interpret the normal curve and displacement and velocity graphs of human growth
- Describe variations in biological maturity within and across genders
- Discuss characteristics of the adolescent growthspur t
- List and discuss factors associated with the onset of puberty
- Describe hormonal factors associated with the onset of puberty
- Distinguishb etween “puberty” and “reproductivem aturity”
- Chart the sequence of events leading to reproductivem aturation
- Discuss the concept of adolescent reproductive sterility
- List and describe how the stages of sexual maturation are used as a maturity assessment technique

KEY CONCEPT

The transition from childhood to adolescence is marked by a number of significant physical and cultural events that, in combination, contribute markedly to growth and motor development.

The period that makes up what we know as "adolescence" is affected by both biology and culture. Santrock (2010) defines adolescence as the transitional period of time that occurs between childhood and adulthood that involves biological, cognitive, and socioemotional changes. In other words, adolescence is preparation for adulthood that begins in biology (i.e., puberty), and ends in culture (i.e., economic independence). It is affected by biology in that the end of childhood and the onset of adolescence are marked by the beginnings of sexual maturation. It is affected by culture in that the end of adolescence and the beginning of adulthood are marked by financial and emotional independence from one's family.

The adolescent years have been reshuffled over time. In North American society today the period of adolescence is significantly longer than it was a hundred or even fifty years ago. The earlier onset of **puberty** (the start of sexual maturation) coupled with a longer period of economic dependence on family has caused us to view adolescence in a much broader perspective.

Secular trends in biological maturation over the past hundred years have dramatically lowered the average age of puberty. However, economic and sociocultural trends over that same period have dramatically extended the average age of dependence beyond the "teen" years. Whereas adolescence used to roughly span the middle and high school years, sexual maturation now begins as early as age 8, and economic dependency often extends until age 20 or beyond.

CONCEPT 15.1

The period of adolescence has lengthened due to the combined effects of biology and culture.

Tremendous changes are occurring during adolescence. The adolescent growth spurt, the onset of puberty, and sexual maturation are the primary biological markers of adolescence. Each of these will be discussed in the sections that follow.

ADOLESCENT GROWTH

The onset of adolescence is marked by a period of accelerated somatic increases in both height and weight. The age of onset, duration, and intensity of this growth spurt are genetically based and will vary considerably from individual to individual (Adair, 2001). One's **genotype** (genetic inheritance) establishes the boundaries for individual growth. However, an individual's **phenotype,** that is, how one's genotype is expressed in observable and measurable characteristics such as height and weight, can be influenced by environmental conditions such as nutrition and exercise. For each genotype a wide variety of phenotypes may be expressed. Even if we could account for all of the genetic factors that contribute to one's height and weight, it would not be possible to perfectly predict measured height and weight because both are shaped to some degree by one's unique phenotype (i.e., environmental factors).

CONCEPT 15.2

One's genotype controls the onset, duration, and intensity of the growth spurt, whereas one's phenotype influences growth potential.

An adolescent's genotype will, however, play the primary role in linear body measures, skeletal maturation, sexual maturation, and body type. Final adult standing height, trunk, arm, and leg length are ultimately determined by genetic factors.

Similarly, bone ossification, the onset of puberty, and how fat is distributed around the body are products of genotype. Each of these may be modified to a certain extent, but an individual cannot go beyond his or her inherited potential. On the other hand, the environment will influence how close one comes to his or her genetic potential. Such things as body weight, skinfolds, and circumferences are subject to significant modification.

CONCEPT 15.3

Secular trends in biological maturation have lowered the average age of puberty in North America.

Height

Because of the interaction of genotype with the environment, considerable variability in the growth process occurs among individuals during the adolescent period. However, a definite period of accelerated growth takes place at the end of childhood; this period is known by a variety of terms, including *adolescent growth spurt, period of preadolescent acceleration*, and *circumpubertal period.* This period of "growing like a weed" begins prior to sexual maturation; therefore, for our purposes, we will refer to it as the *adolescent growth spurt.*

CONCEPT 15.4

The adolescent growth spurt marks the first visual indicator of the onset of puberty.

The **adolescent growth spurt** (**circumpubertal period**) is a period that lasts about four and a half years. Males, on the average, begin their growth spurts around age 11, reach their **peak height velocity** by age 13, taper off by age 15, and finish by age 17 or 18. Peak height velocity refers to the maximum annual rate of growth in height during the adolescent growth spurt. Females are about two years advanced, beginning their spurt around age 9, peaking in velocity at age 11, tapering off by age 13, and finishing by age 16 (Malina, Bouchard, & Bar-Or, 2004). Figure 15.1 depicts the normal age range and peak velocity year in height for both boys and girls. Note how females begin, peak, taper, and end their growth in stature on the average two years earlier than their male counterparts. It is not uncommon to show a one-year incremental gain in height during the period of peak velocity of 6 to 8 inches (15.2–20.3 cm) or more. Further growth continues at the end of the adolescent growth spurt but at a much slower rate. Males appear to reach their mature adult heights at around age 18. Females are reported to attain their maximum heights at around age 16 (Malina, Bouchard, & Bar-Or, 2004). These ages, however, are only approximate indicators of when maximum heights are attained. There is considerable variation among individuals in the attainment of maximum statures, and most growth studies cease when the research participants leave high school, preventing follow-up beyond the school years. Growth in stature frequently continues at a modest rate for both males and females several years beyond high school.

CONCEPT 15.5

The adolescent growth spurt lasts about four years, beginning in females about two years earlier than in males.

The adolescent growth spurt is highly variable from individual to individual. Some will have completed the process before others have begun. The results are clearly evident in the typical youth sport setting where "men" and "boys" are frequently grouped together with little or no accommodation for maturation variations. Remember, development is age-influenced but it is not age-dependent. Overreliance on chronological age as a guide for youth sport team selection is unwise and inconsistent with what we know about motor development and quality education. We must, therefore, use standards other than age for team selection.

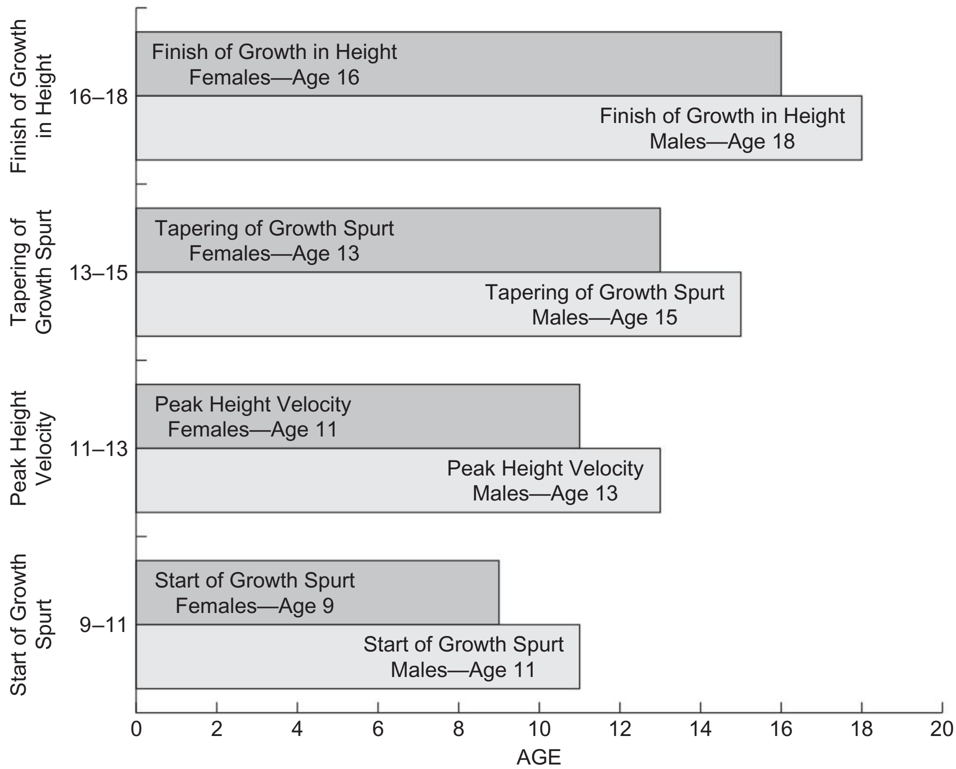

Figure1 5.1

Normal range and peak height velocities in males/females.

Events within the adolescent growth spurt are interdependent. For males the period of most rapid growth coincides with the appearance of secondary sex characteristics such as axillary and pubic hair. For females the peak velocity in growth tends to occur prior to menarche. Females with an early growth spurt tend to reach menarche earlier than those with a later growth spurt (Tanner, 1989). Furthermore, early-maturing girls and late-maturing boys are frequently thought to have more adjustment problems than their age-mates.

CONCEPT 15.6

Adult height can be predicted from adolescent growth data with reasonable accuracy.

The attainment of maximal adult height is of interest to most adolescents. Males are frequently concerned about being too short, and females often fret about being too tall. A number of prediction formulas are available, and mature adult height is correlated with height prior to the preadolescent growth spurt. Therefore, if a child was in the 50th percentile prior to puberty, he or she is likely to continue to be at the same percentile after puberty. Attainment of adult height is dominated by one's genotype, and under normal circumstances, only minimally influenced by the environment. (On the other hand, environmental factors strongly influence one's attained adult weight.)

Table 15.1 provides a percentile equivalent chart for height in inches/centimeters for males and females 12 to 18 years of age. This chart may be used to predict adult height and to determine

TABLE 15.1 Height in Inches/Centimeters of Youths Aged 12–18 Years by Gender and Age

Gender and Age	Mean	Percentile 10th	25th	50th	75th	90th
MALES						
12y ears	60.9/154.7	57.2/145.2	58.9/149.5	60.6/153.9	63.1/160.3	64.9/164.8
13y ears	63.7/161.9	58.9/149.7	60.7/154.1	63.9/162.2	66.3/168.3	68.3/173.5
14y ears	66.4/168.7	62.3/158.4	64.2/163.1	66.5/169.0	68.8/174.7	70.5/179.0
15y ears	68.3/173.6	64.4/163.5	66.6/169.2	68.8/174.8	70.1/178.0	71.7/182.0
16y ears	69.2/175.9	65.7/166.9	67.1/170.4	69.3/176.0	71.0/180.2	73.6/186.9
17y ears	69.5/176.6	65.9/167.5	67.4/171.2	69.6/176.8	71.5/181.7	72.9/185.2
18y ears	69.6/176.8	65.8/167.1	67.9/172.4	69.4/176.4	71.4/181.3	73.3/186.3
FEMALES						
12y ears	61.7/156.7	58.4/148.3	59.8/152.0	61.7/156.7	63.3/160.8	65.6/166.6
13y ears	62.4/158.6	59.1/150.0	60.5/153.8	62.1/157.7	64.2/163.0	66.1/167.9
14y ears	63.2/160.5	59.3/150.7	61.3/155.7	63.4/161.0	65.0/165.0	66.7/169.3
15y ears	63.8/162.1	60.7/154.3	62.4/158.4	63.8/162.0	65.3/165.8	67.0/170.1
16y ears	64.1/162.9	60.5/153.6	61.8/157.0	64.1/162.8	66.4/168.7	67.9/172.4
17y ears	63.9/162.2	61.3/155.6	62.4/158.5	63.8/162.2	65.4/166.2	66.6/169.2
18y ears	64.2/163.0	60.9/154.7	62.3/158.4	64.1/162.8	66.0/167.6	67.3/171.1

Source: Data from McDowell et al. (2008). Anthropometric reference data for children and adults: United States, 2003–2006, *National Health Statistics Reports, 10,* National Center for Health Statistics.

an individual's percentile equivalent in comparison with other youth from the United States. For example, a male at the 25th percentile at age 12 (58.9 in./149.5 cm) will probably remain within that percentile and can expect to attain a height of about 68 inches (172 cm) by age 18. This would make him about 1.5 inches (4.5 cm) shorter than the average 18-year-old North American male (69.6 in./176.8 cm) and about 3.5 inches (9.5 cm) taller than the average North American female (64.2 in./163.0 cm). Santrock (2010) indicated that height during the elementary school years may be a good predictor of height during adolescence; however, as much as 30% of an individual's height in late adolescence cannot be explained by the child's height in elementary school. The genetic influence on stature is strong, and unless significant long-term changes are made in diet and lifestyle during the growing years there will be little variability from the predicted growth channel. Figures 10.1 and 10.2 (pp. 170 and 171) depict mean height for age scores for males and females from 2 to 20 years old using data from the National Center for Health Statistics [NCHS] (2000).

Steroid use by adolescents during the growing years may have permanent effects on stature. Steroid use by prepubertal children may cause the epiphyses of the long bones to fuse prematurely (American Academy of Pediatrics, 2005; American College of Sports Medicine, 1987). Certain steroid products, however, have been safely prescribed by physicians for years to stimulate growth in males with uncomplicated short statures. Growth retardation, however, is seen in asthmatic children due to heavy usage of corticosteroid drugs to expand the bronchial passages. Further research is necessary to determine the long-term effects of steroid use on adolescent stature. The dosage, duration, and types of steroids used must be investigated before conclusions can be drawn.

CONCEPT 15.7

Steroid use for therapeutic and growth-enhancing purposes can affect the growth potential of the adolescent in as yet unexplained ways.

Weight

Weight changes during adolescence are great. For both males and females, increases in weight tend to follow the same general curves as for increases in height. Dramatic weight gains occur during puberty, with approximately 50% of adult body weight being gained during adolescence (Susman and Dorn, 2009). Figure 15.2 depicts the normal age range and peak velocity year in weight for both boys and girls. Note how females, on the average, are one year ahead of their male counterparts at the start of their weight spurt as well as their peak weight velocity year. Note also that the female weight spurt ends at approximately age 16, whereas males finish their weight spurt by about age 14. For both females and males weight gain increases throughout adolescence but at a slower pace.

Peak weight velocity, the period during the adolescent growth spurt when weight gain is the greatest, is generally greater in boys than in girls, with that of girls occurring about 6 to 12 months earlier. Also, it appears that peak weight velocity occurs closer to peak height velocity in boys than in girls (Malina, Bouchard, & Bar-Or, 2004). Peak weight velocity in boys is about 20 pounds in one calendar year at about age 13 to 14. Peak weight velocity in girls is approximately 18 pounds in one year at roughly age 12 to 13 (Santrock, 2010). On the average, females tend to be taller and heavier than their male counterparts during

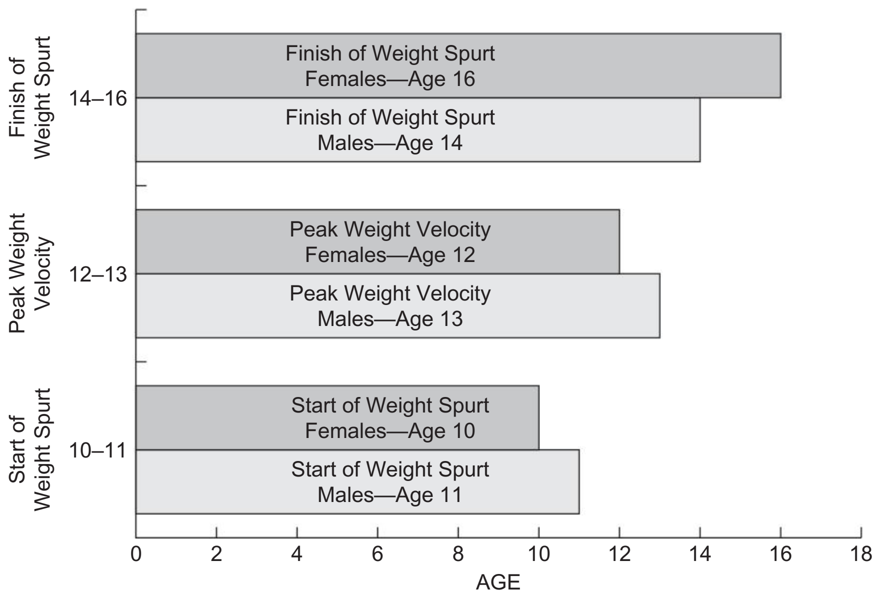

Figure1 5.2
Normal range and peak weight velocities in males/females.

early adolescence. By age 14, however, boys begin to outdo girls in both weight and height.

Weight gain in adolescent males is primarily due to increases in height and muscle mass. Fat mass tends to remain relatively stable at this time. In females, however, adolescent weight gain is due largely to increases in fat mass and height, and to a lesser degree to increases in muscle mass. Skeletal maturation, increases in both muscle and fat tissue, and organ growth contribute to the weight gains of adolescence for both males and females.

CONCEPT 15.8

Weight gains during adolescence roughly approximate the curves for height, but weight is much more affected by environmental factors.

Overreliance on adolescent weight curves is unwise because weight reflects a combination of developmental events and as a result is limited in its information value. For example, failure to gain weight or actual loss of weight may be a reflection of an adolescent's increased attention to diet and exercise and not a cause for alarm. Failure to make incremental gains in height, however, would be a cause for concern. Weight gain throughout adolescence will be affected by diet, exercise, gastric motility, and general lifestyle factors as well as by hereditary factors. We know that youth in the United States have greater percentages of body fat than their counterparts of twenty years ago. This average higher body fat percentage has been attributed to the sedentary lifestyle and unhealthy eating patterns of many members of our society. Approximately 11% of adolescents (12 to 17 years) are reported to be overweight (85th percentile of weight for height), up from 5% in the 1960s and 1970s (Kipke, 1999). From 1960 to 2002 among 12- to 17-year-old teens, the mean weight for males increased more than 15 pounds, from 125 to 141 pounds. The mean weight for female adolescents increased from 118 to 130 pounds for the same period (NCHS, 2004).

By the age of 10, males have attained approximately 55% of their final adult weights, and females have attained 60% (National Center for Health Statistics [NCHS], 2000). Prior to age 10 the average weights of both males and females are almost identical, with males being only slightly heavier. However, during the adolescent growth spurt, females are frequently heavier than their male age-mates. Females tend to weigh more than males until about age 14 whereupon their weight gains begin to level off. Males, however, continue to make significant gains in weight until about age 22. Figures 10.3 and 10.4 (pp. 172 and 173) depict a definite secular trend in weight from childhood through adolescence for both males and females (NCHS, 2000).

The reasons for this include changes in the health and nutritional status of youth, socioeconomic factors, genetic factors, and changes in activity patterns. Whatever the case, weight is of considerable importance to the adolescent. The constant bombardment from the media and our obsession with the "perfect body" have raised the weight consciousness of the typical adolescent to the point of obsession. Care must be taken to help the adolescent understand the changing nature of his or her body and not to overstep the fine line between a healthy regard for weight control and an obsessive preoccupation with weight gain.

Heart and Lungs

The remarkable changes in height and weight are easily observed during adolescence, but what about other less apparent but equally important changes? Growth of the heart and lungs is dramatic and is a primary factor in the increased functional capacity of the adolescent (Rowland, 2005).

The heart increases by about one-half in size and almost doubles in weight during adolescence (Malina, Bouchard, & Bar-Or, 2004). Females have slightly smaller hearts than males during childhood, begin accelerated growth of the heart earlier, and attain significantly smaller total growth by the end of adolescence. Although heart rate is related to overall body size, we see a gradual lowering of heart rate throughout the entire growth process. By age 10, male resting heart rates are on the average 3 to 5 beats per minute slower than those for females.

INTERNATIONAL PERSPECTIVE

Setting the International Standards

One out of every five human beings across the globe is of adolescent age. Of these individuals approximately 85% live in developing countries. Many of these young teens entered adolescence undernourished, leaving them susceptible to a variety of developmental and medical concerns including compromised physical growth. International health care officials and policy makers require developmental data on the growth of infants, children, and adolescents so they can establish and monitor health-related policies and interventions. Recognizing the need for international growth data, the World Health Organization (WHO) initiated efforts to establish beneficial growth reference tools. The WHO Multicentre Growth Reference Study (MGRS), conducted from 1997–2003, established growth charts for children from birth to 5 years. The study involved the measurement of approximately 8,500 children from the countries of Brazil, Ghana, India, Norway, Oman, and the United States. Because the study specifically targeted healthy children living in an environment likely to allow them to reach their full genetic growth potential, the standards represent how children *should* grow rather than simply indicating *how* they grew at a particular time. The MGRS was followed by the establishment of growth curves for school-aged children and adolescents. Data from the 1977 National Center for Health Statistics were merged statistically with the MGRS data to establish a smooth transition between the two data sets. The process resulted in current international growth charts for height/length, weight, and BMI for those between the ages of birth and 19 years. They can be accessed at the WHO website: http://www.who.int/childgrowth/en/

By late adolescence, males have an average resting heart rate of 57 to 60 beats per minute, compared with females at 62 to 63 beats per minute (Malina, Bouchard, & Bar-Or, 2004). Systolic blood pressure rises steadily throughout childhood and accelerates rapidly during puberty before settling down to its adult value by the later period of adolescence.

Growth of the lungs parallels heart growth during adolescence. Both the size of the lungs and their respiratory capacity increase rapidly during puberty after a period of gradual growth during childhood. Respiration rates decrease throughout childhood and puberty for both males and females. However, *vital capacity* (the amount of air that can be inhaled with a single breath) increases much more rapidly in boys from about age 12 onward even though males and females are almost identical in this measure prior to puberty (Rowland, 2005). Dramatic gender differences may be attributed to the larger heart size and until relatively recently more aerobically active lifestyles of males.

Physical differences between males and females are just that—differences, and nothing else. For one to ascribe "superiority" or "inferiority" to one gender over the other on the basis of biological differences is absurd. On the other hand, those who deny the relevance of basic physical gender differences apart from reproductive functions are naive. Fundamental genetic differences between males and females are irrevocably established at conception and heightened during the adolescent period. Significant differences in height, weight, body proportions, and functional capacity of the heart and lungs can be expressed only in terms of population averages, and there is considerable overlap between the sexes. The only way in which males and females are truly unique is in reproductive functions. To understand this uniqueness we must understand the process of puberty and reproductive maturity.

PUBERTY

The onset of puberty is generally termed *pubescence.* Pubescence is the earliest period of adolescence, generally about two years in advance of sexual maturity. During pubescence secondary sex characteristics begin to appear, sex organs mature, changes in the endocrine system begin to occur, and the adolescent growth spurt begins. Adolescent females are considered to have delayed puberty when breast development (Tanner stage 2) has not started by 13.3 years of age (Sperling, 1996). Medical texts have traditionally reported that only about 1% of girls show signs of puberty before age 8 (Kaplowitz & Oberfield, 1999). Recent research, however, has raised speculation that the onset of puberty is occurring earlier in girls than previous studies have shown. Based on examination of 17,000 girls (not randomly selected) by Herman-Giddens and colleagues (1997), it was concluded that

> In the United States the onset of puberty in girls is occurring earlier than previous studies have documented, with breast and pubic hair development appearing on average 1 year earlier in white girls and 2 years earlier in African-American girls. (Kaplowitz & Oberfield, p. 940)

Caution is advised in concluding that the normal age of sexual maturation is earlier today than a generation ago (Rosenfield, 2000; Lee, Kulin, and Guo, 2001), primarily because the **pace of sexual maturation** leading to menarche has not changed since the 1960s in the United States. Rowland (2005) states that "age of menarche despite a trend toward younger years in the past is not significantly different from that reported 30 years ago" (p. 45).

CONCEPT 15.9

Menarche is the primary event of female puberty, but it does not mark reproductive maturity, which may be delayed by as much as two years.

The highlight of puberty in females is marked by a clearly distinguishable event, menarche. On the average, in the United States, **menarche**, or the first menstrual flow, occurs at 12.1 and 12.9 in African American and white girls, respectively (Brown et al., 1998) and 12.4 overall (Rowland, 2005). The reasons for this discrepancy are largely unknown. African American girls begin pubertal development (i.e., breast and pubic hair development) one year to fifteen months earlier than their white peers, (Wu et al., 2002) (see Figures 15.3 and 15.4). From a historical perspective it is interesting to

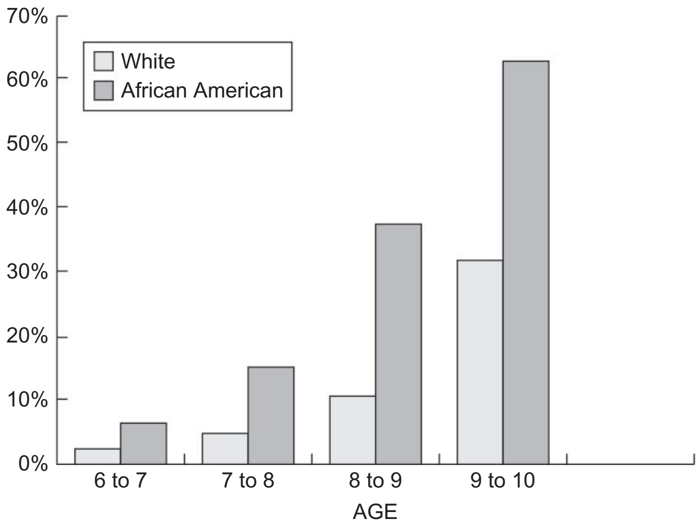

Figure 15.3
Prevalence of breast development at Tanner stage 2 or greater by age and race.
Source: Herman-Giddens et al. Pediatrics 1997; 99-505-512.

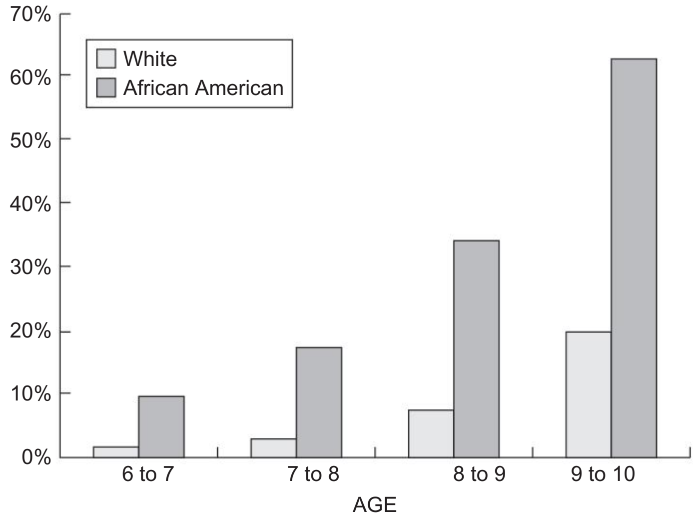

Figure 15.4

Prevalence of pubic hair at Tanner stage 2 or greater by age and race.

Source: Herman-Giddens et al. Pediatrics 1997; 99-505-512.

note that the average age of menarche in the mid-1800s was about age 15 (Malina, Bouchard, & Bar-Or, 2004.) and in the early 1900s it was about age 14 (Santrock, 2010). The development of mature ova follows menarche by as much as two years; therefore, puberty is not complete in females until sexual maturity has been attained.

The potential for delayed menarche and the hypothesized causes have been a topic of intense debate. Historically, it has been observed that as the intensity of physical training increases the age of menarche also increases, with the latest age of menarche found in the most elite performers (Stager, Robertshaw, & Miescher, 1984). This view is supported by retrospective data comparing the age of menarche of athletic and nonathletic samples, in which it has been found that the mean age of menarche in athletes is later than in their nonathletic counterparts (Malina, 1994).

Malina (1994) offers several explanations for the possibility of the later age of menarche in athletic samples. He suggests that late maturers are taller and leaner than early maturers and many sports select for these body build characteristics. Leanness in certain sports is often viewed as a desirable performance-related quality. Dietary practices incorporated to reduce body fat may be associated with delayed onset of menarche. Socialization factors, psychological and emotional stresses, family history, even the number of siblings in one's family (Malina et al., 1997) are possible factors in later onset of menarche.

Malina, however, is quick to point out most investigations in this area are subject to error due to their retrospective nature. Research participants in these studies must rely on their memories in reporting when they began menstruating. For some, those memories may be accurate. Others may be more vague in remembering when this event occurred. Malina also states that due to the standard deviations of a year or more in these investigations, they do not show that all female athletes experience late menarche.

The highlight of puberty in males is less distinct than it is for females. In a clinical sense, it is marked by the first **ejaculation** (the sudden discharge or ejection of semen), but, as with menarche, this milestone does not truly mark reproductive maturity. Only when live sperm are produced is reproductive maturity attained. Live sperm generally appear in boys between 13 and 16 years of age.

Sequence of Puberty

During the period of infancy and childhood, both boys and girls develop at highly similar rates. They have few differences in height, weight, and heart and lung size, and body composition is essentially the same. By age 10 children have attained about 80 % of their adult height and a little over half of their adult weight. But as children begin their second decade, dramatic changes occur not only in measures of growth but in sexual maturation as well. The onset of puberty marks the transition from childhood to sexual adulthood. Exactly when this process begins and what starts the process is not clearly understood. We do know, however, that the timing of the process is highly variable and may begin as early as age 8 or earlier in females and age 9 in males, or as late as ages 13 and 15, respectively (Kipke, 1999). The general sequence of events that mark puberty is much more predictable than the specific dates on which they will occur.

Sequentially, for the male adolescent, growth spurt is preceded by testicular growth and coincides with enlargement of the penis. This is generally followed by the first appearance of pubic hair. *Axillary hair* (hair under the arms) formation soon follows, along with a deepening of the voice. Mature sperm formation and sexual maturation occur shortly after, followed by the appearance of facial hair and increased body hair.

The sequence of puberty for females is also predictable. There is a close correlation between the female growth spurt and breast development (Herman-Giddens et al., 1997). Budding of the nipples occurs prior to budding of the breasts. Breast bud development coincides with the beginning of pubic hair formation, followed by growth of the genitalia. Axillary hair formation and menarche soon occur, followed by the development of mature ova and the capacity for becoming pregnant. A tendency toward acne and slight deepening of the voice are the final events of female sexual maturation. Table 15.2 provides a visual representation of the sequence of events marking puberty and an approximate timetable. Many of the events of puberty overlap and should not be expected to occur in specific time frames.

Hormonal Influences

The onset of puberty may be influenced by a variety of factors, but genetics plays a dominant role. For example, southern Chinese females tend to achieve menarche earlier than females of European origin (Huen et al., 1997), and African American females are ahead of whites (Brown et al., 1998). Furthermore, the events of puberty are much more closely related between identical twins than among nonidentical twins and nonrelated age-mates (Tanner, 1989). Factors within the environment may also have a dramatic impact on puberty. Although incompletely understood, stress, nutritional status, general health, and metabolism all appear to affect the onset and duration of puberty in some as yet unexplained manner. While stress alone does not trigger puberty, it does play an important role in modulating the **timing of puberty** (Susman et al., 1989; Susman, 1997).

CONCEPT 15.10

The onset of puberty is regulated by heredity and may be influenced by nutrition, illness, climate, and emotional stress.

The endocrine system plays a critical role in the growth and maturation process. Malina (1986) reports that "endocrine secretions are themselves strongly influenced by genetic mechanisms. . . . The nervous system, in turn, is intimately involved in regulating endocrine secretions" (p. 24). There appears to be a complex interaction among the endocrine system, the nervous system, and the gonads leading to puberty.

The pituitary gland, located below the brain, appears to be of critical importance. When the *hypothalamus* (a central regulating nerve center in the brain) matures, it secretes hormones that in turn stimulate the anterior pituitary gland to

TABLE 15.2 Sequence of Events Marking Puberty

Males	Females	Approximate Age of Onset
Firstt esticularg rowth	Beginning of growth spurt	9–10
	Budding of nipples	10–11
Beginningo fg rowth spurt	Budding of breasts	11–12
Start of pubic hair growth	Start of pubic hair growth	
	Growth of genitalia	
	Peak of growth spurt	12–13
	Axillary hair formation	
	Menarche	
Penilea ndt esticular peako fg rowth spurt		13–14
Axillaryh airf ormation	Mature ova production	14–15
Deepenedv oice	(End of puberty)	
Matures permp roduction	Acne	15–16
(Endo fp uberty)	Deeper voice	
	Mature pubic hair & breast development	
Facialh air	Cessation of skeletal growth	16–17
Bodyh air		
Maturep ubich aird evelopment		
Cessationo f skeletal growth		18–19

begin releasing **gonadotropic (GnRH) hormones.** The hormones released by the anterior pituitary gland have a stimulating effect on other endocrine glands, resulting in the release of other growth and sex hormones. The release of sex-related hormones initiates maturation of the gonads. **Estrogens** (female hormones) account for initiation of the events of female puberty. In summary, multiple factors influence the onset and duration (i.e., pace) of puberty including: (1) genetic and biological influences, (2) stress, (3) nutrition, (4) diet, (5) exercise, (6) percentage body fat, (7) chronic illness, (8) socioeconomic status, and (9) environmental toxins. The precise triggers are unknown (Kipke, 1999; American Academy of Pediatrics, 2000), but the outcome is clearly modulated by secretion of GnRH.

Sometimes hormonal imbalances can result in a condition known as **amenorrhea**. *Primary amenorrhea* occurs when a girl has yet to experience her first menstrual period by the age of 16 years. *Secondary amenorrhea* is a more common occurrence and refers to the temporary or permanent cessation of menstrual periods of an adolescent or adult female who previously experienced a regular cycle. Usually the absence of three or more periods in a row constitutes secondary amenorrhea. Primary amenorrhea may occur as a result of issues with the endocrine system, genetic factors, or environmental influences such as poor nutrition. Secondary amenorrhea may occur as a result of natural processes such as pregnancy or stress-related factors such as continuous strenuous physical exercise, excessive weight loss, and certain medications such as antidepressants or tranquilizers. Some adolescent athletes such as ballet dancers and gymnasts may be more prone to secondary

> **DEVELOPMENTAL DILEMMA**
>
> **Growing Up Too Soon**
>
> As noted in this chapter puberty can begin in girls as early as 8 years of age and 9 years for boys. Pubertal changes observed prior to these ages are referred to as central precocious puberty (CPP). In some cases signs of the onset of puberty have been noted during the early childhood years. CPP occurs in girls five times more often than boys and is present in approximately 4–5% of the female population. Usually the cause of CPP is difficult to determine, but it may be associated with changes in the brain as a result of a tumor or injury. Genetic issues may also play a role. The condition is often treated through medications that inhibit the release of sexual hormones. When tumors represent an underlying cause they may be surgically removed. Physically CPP is often associated with accelerated skeletal maturation resulting in bone growth that ends earlier than normal. Adult height potential is often not realized. Socially and emotionally children dealing with CPP may be teased by their same-age peers due to their physical differences. As a result self-esteem issues, depression, and/or behavioral problems may be manifested. Medical interventions as well as parental, school, and peer support are critical factors for the child with CPP.

amenorrhea due to their training and nutritional behaviors. Prolonged amenorrhea can lead to medical problems such as infertility and osteoporosis. Treatment for both primary and secondary amenorrhea is directed by their diagnostic origins.

REPRODUCTIVE MATURITY

The onset of the preadolescent growth spurt and puberty marks the transition from childhood to reproductive maturity. The physical changes and appearance of secondary sex characteristics are frequently a cause for heightened interest in one's body and a dramatically increased level of self-consciousness. If young adolescents appear preoccupied with matters of sex, it is because a whole host of dramatic and rapid changes are occurring right before their eyes. The young adolescent frequently feels like a spectator in his or her growth process. Each day seems to bring about changes that are whispered about, giggled over, and closely scrutinized. The wise adult will be sensitive to these physical changes and the impact that they have on the social and emotional development of the individual. The journey from childhood to reproductive maturity follows a predictable pattern for both males and females.

The student of motor development will want to be knowledgeable about these events and will learn to recognize physical changes that offer cues to physical maturity. Many of these have been discussed in the previous sections on growth and puberty. This section will, therefore, focus on a brief overview of sexual maturation in females and males, and a reliable technique for maturational assessment.

In the paragraphs that follow, we will repeatedly refer to the work of J. M. Tanner. Although decades old, the **Tanner stages** are still used as the universal standard for classifying sexual maturity.

Females

Breast growth marks the first visible sign of the female journey to sexual maturity. *Breast development* begins around age 11 and is completed around age 15, although it may begin as early as age 8 and not end until age 18 (Katchadourian, 1977; Sperling, 1996; Santrock, 2010). Breast development has been described by Tanner (1962) and is outlined in Table 15.3, along with female pubic hair development. These stages can be useful as reliable developmental landmarks of sexual maturity.

Pubic hair is usually the second sign of progress toward sexual maturity. On the average, hair growth begins between 11 and 12 years of age,

TABLE 15.3 Stages in Female Breast and Pubic Hair Development

STAGE	BreastD evelopment	Pubic Hair Development
1.	Prepubertal—Flat appearance like that of a child	Prepubertal—Absence of pubic hair
2.	Small raised breast bud	Sparse amount of downy hair mainly at sides of the labia
3.	Enlargement and raising of the breast and areola	Increased amount of hair with pigmentation, coarsening, and curling
4.	Areola and nipple form a contour separate from the breast	Adult hair, but limited in area
5.	Adult breast—areola is in the same contour as the breast	Adult hair with horizontal upper border

Source: Adapted from photographs in J. M. Tanner, *Growth at Adolescence* (Oxford, England: Blackwell Scientific, 1962).

and the triangular adult pattern of growth is established by about age 14. The stages of pubic hair development developed by Tanner (1962) provide useful indices of sexual development.

Changes in the *female genitalia* are usually the third step in progress toward reproductive maturity. The external sex organs (i.e., the vulva, mons, labia, and clitoris) increase in size and become sensitive to stimulation. Changes in a female's exterior genitalia are not as useful for clinically assessing maturity as indices of pubic hair growth and breast development. The internal sex organs of the female also undergo considerable change. The uterus and ovaries increase in weight. The uterus makes dramatic weight gains, becomes larger, and "develops an intricate and powerful musculature" (Katchadourian, 1977, p. 59). The vagina increases in size, and the ovaries, although structurally complete at birth, continue to moderately gain weight throughout adolescence.

Menarche occurs after the peak of the growth spurt and about two years after the start of breast development, but it does not mark the beginning of reproductive maturity. Generally, up to 1.5 years may pass from the first menstrual cycle until the young female is physiologically capable of conception. This lag is known as the period of **relative sterility of puberty.** It is, however, unwise to assume that this is a "safe" period from conception. Individual differences between menarche and reproductive maturity are great, and no safe period can be guaranteed.

Males

Puberty begins in males with growth of the testes. Increased testicular growth begins around 11.5 years of age and may range from ages 10 to 14 (Tanner, 1962). Growth continues until somewhere between ages 14 and 18 (Santrock, 2010). As the male reproductive gland, the testes produce *sperm* and male sex hormones. The ability of the male to ejaculate seminal fluid is largely a function of the prostate gland, which becomes much larger during puberty. Ejaculation is a psychological as well as a physiological event and occurs most frequently in the young male through nocturnal seminal emissions and masturbation beginning at about age 12. Clearly this increase in sexual behavior is associated with rising levels of testosterone. Mature sperm are not contained in the ejaculate until approximately ages 15 to 17.

CONCEPT 15.11

The ability to ejaculate seminal fluid is a primary event of male puberty, but reproductive maturity requires mature sperm production.

Pubic hair growth begins as early as age 10 or as late as 15. As with female sexual maturation, Tanner (1962) developed a five-stage scale for males (Table 15.4). Mature, stage 5, pubic hair distribution continues into the mid-20s in males, and the area is less clearly defined than in females. It has been noted that the use of pubic hair alone for Tanner staging may lead to inaccurate classification of some males in the earliest phase of pubertal maturation. There may be testicular development without the presence of pubic hair (Biro et al., 1995).

The *external male genitalia*, the penis and scrotum, change little in appearance throughout childhood. Penis growth begins about a year after the first onset of testicular and pubic hair growth. The scrotum first becomes larger, followed by lengthening and then thickening of the penis. See Table 15.4 for the stages of male genital development described by Tanner (1962). The size and shape of a male's penis are unrelated to physique, race, and virility (Masters and Johnson, 1970).

Secondary sex characteristics such as axillary hair, facial hair, and deepening of the voice are all associated with progress toward reproductive maturity. Axillary and facial hair usually begin to appear about two years after the growth of pubic hair. Facial hair, an important "badge" of manhood, first appears on the upper lip. It then starts to grow on the upper cheek in an area parallel with the lower ear, and then under the lower lip. In the final stage, facial hair growth spreads to the lower face and chin, creating a full beard (Katchadourian, 1977; Santrock, 2010). Axillary hair appears in concert with facial hair, and body hair continues to spread until well after puberty.

Maturity Assessment

A **maturity assessment** is a means of determining how far one has progressed toward physical maturation. A variety of techniques, including circumpubertal, skeletal, and dental assessments, measure the progress of a particular body part or system toward maturity. Unfortunately, these maturity assessments are seldom used in routine preparticipation physical examinations of young athletes. The omission is unfortunate because young athletes could be more fairly equated for competition. Chronological age is the most frequently used measure of maturity. Throughout this text we have continually referred to the individuality and extreme variability of the growth process, particularly during later childhood and early adolescence. Although existing maturity assessments can be expensive, time consuming, and inconvenient, developmental standards based

TABLE 15.4 Stages in Male Genital and Pubic Hair Development

Genital Development	Pubic Hair Development
STAGE	
1. Prepubertal—Size of testes and penis like that in early childhood	Prepubertal—Absence of pubic hair
2. Testes enlarge and scrotal skin darkens and becomes coarse	Sparse amount of downy hair mainly at the base of the penis
3. Continuation of stage 2, along with increase in penis length	Increased amount of hair with pigmentation, coarsening, and curling
4. General enlargement in penis size and scrotal skin pigmentation	Adult hair, but limited in area
5. Adult genitalia	Adult hair with spread to the thighs and horizontal upper border

Source: Adapted from photographs in J. M. Tanner, *Growth at Adolescence* (Oxford, England: Blackwell Scientific, 1962).

on factors other than chronological age should be used to assess and place young athletes. Some process of equating youth for participation and competition should be devised to reduce the incidence of athletic injuries by equalizing competition (Malina, 2000).

CONCEPT 15.12

Maturity assessment scales offer reliable and valid devices for equating athletes, limiting training, and reducing injuries.

Caine and Broekhoff (1987) presented a convincing argument for including a standardized maturity assessment in the preparticipation physical examination that every youth should undergo prior to sports participation. They argued that maturity assessments can be used to match adolescents for contact sports, and to determine when youth are experiencing growth spurts, which make them more susceptible to injury. They further argued that the stages of circumpubertal maturation proposed by Tanner (1962) can be easily and effectively used. To accommodate social-cultural mores and avoid embarrassment, parents can be asked to assess the circumpubertal maturity of their children or young athletes can rank their maturity levels with reference to the pubic hair scales. Duke et al. (1980) and Kreipe and Gewanter (1983) reported moderate to high correlations between self-assessed stages and physician-assessed stages of pubic hair development.

The benefits of maturity assessment are obvious. First, it can aid in injury reduction, serving as a basis for matching athletes for contact sports. Second, it can serve as a means of limiting or disqualifying individuals for participation in contact sports. Third, it can be used to identify rapid growth periods and to justify reductions in training regimens in long-term, high-intensity sports such as cross-country, swimming, gymnastics, and ballet.

SUMMARY

The period of adolescence has gradually expanded due to biological and cultural factors to the point where it now encompasses the child's second decade. Dramatic growth increments, the onset of puberty, and reproductive maturation are highlights of the adolescent period.

Adolescent growth in height and weight follows a predictable pattern, although there is considerable variability in the onset and duration of the preadolescent growth spurt. Wide variations in stature are typical among preadolescents and have many ramifications for athletic participation and social acceptance.

The onset of puberty is generally considered to coincide with the start of the growth spurt. Puberty is influenced by a variety of genetic factors operating in concert with environmental circumstances.

Puberty and reproductive maturity are not the same thing. Reproductive maturity occurs somewhat after the onset of puberty. Menarche in females and ejaculation in males do not indicate the arrival of reproductive maturity. The development of mature ova and the production of sperm are the hallmarks of reproductive maturity.

Maturity assessments can be used as an effective aid for equating young athletes for competition and reducing the risk of injury. Circumpubertal assessment measures, although not without difficulties, are reliable and valid means of determining maturity levels.

QUESTIONS FOR REFLECTION

1. How can one's lifestyle influence his or her physical growth?
2. What are some of the factors that contribute to the variation of time of onset of puberty and how might each play an influential role?
3. How might the time of onset of puberty affect the self-concept and self-esteem of a preadolescent or adolescent boy or girl?

Critical Readings

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Web Resources

www.cdc.gov/growthcharts/

This site, linked from the Centers of Disease Control and Prevention, contains information regarding the 2000 CDC growth charts in the United States. The information provided ranges from the growth charts, data tables, educational materials, computer programs, and reports.

http://www.healthychildren.org/English/ages-stages/gradeschool/puberty/Pages/default.aspx

The American Academy of Pediatrics information on puberty. Information on multiple topics related to puberty for both boys and girls.

http://www.keepkidshealthy.com/adolescent/puberty.html

This site contains information provided by keepkidshealthy.com about various topics related to puberty. Provides related sources within keepkidshealthy.com, Internet resources, and links about related topics such as breast budding and bodyo dor.

CHAPTER 16

SPECIALIZED MOVEMENT SKILLS

KEY TERMS

Specializedm ovements kills
Proficiency barrier
Transitions tage
Applications tage
Lifelongu tilizations tage
Cognitives tage
Associatives tage
Autonomouss tage
Getting thei deast age
Fixation/diversification stage
Beginning/novicel evel
Awarenesss tage
Exploratorys tage
Discoverys tage
Intermediate/practicel evel
Combinations tage
Advanced/fine-tuning level
Performances tage
Individualizeds tage

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Discuss the relationship between fundamental movement skills and specialized movement skills
- Describe the steps in changing a well-learned but improperly performed movement technique
- Demonstrate knowledge of important characteristics of the learner that will affect your interaction as an instructor
- Discuss the effects of athletic competition on growth and development of children and adolescents
- Describe knowledge about the developmental sequence of specialized movement skills
- Describe the process of learning a new movement skill based on both the cognitive state of the learner and the goals of the learner
- Demonstrate knowledge of how to intervene effectively in the learning process based on one's level of movement skill learning
- Demonstrate knowledge of the concept of fostering improvement through movement control, emotional control, and learning enjoyment

KEY CONCEPT

The development of specialized movement skills is highly dependent upon opportunities for practice, encouragement, quality instruction, and the ecological context of the environment.

Specialized movement skills are mature fundamental movement patterns that have been refined and combined to form sport skills and other specific and complex movement skills. Specialized movement skills are task specific, but fundamental movements are not.

Most children have the potential by about age 6 to perform at the proficient stage of most fundamental movement skills and to begin the transition to the specialized movement phase. Neurological makeup, anatomical and physiological characteristics, and visual perceptual abilities are sufficiently developed to function at the proficient stage in most fundamental movement skills. There are a few exceptions to this generalization—striking a moving object as in batting and volleying, because of the sophisticated perceptual-motor requirements of these tasks. However, many adolescents lag in their movement capabilities because of limited opportunities for regular practice, poor or absent instruction, and little or no encouragement. We are all familiar with teens and adults who throw balls at the elementary stage or jump for distance using movement patterns characteristic of typical preschoolers.

Older children, adolescents, and adults should be able to perform fundamental movements at the proficient stage. Failure to develop proficient forms of fundamental movements has direct consequences for an individual's ability to perform task-specific skills at the specialized movement phase. Successful progression through the transition, application, and lifelong utilization stages in a particular movement task depends on proficient levels of performance at the fundamental movement phase (Figure 16.1). A person could hardly expect to be successful at softball if his or her fundamental striking, throwing, catching, or running skills were not at proficient levels. There is a hypothesized **proficiency barrier** (Seefeldt, 1980) between the fundamental movement phase and the specialized movement phase of development. The transition from one phase to another depends on the application of proficient patterns of movement to a wide variety of movement skills. If the patterns are less than proficient, ability will be impaired.

CONCEPT 16.1

Mature fundamental movement skill development is prerequisite to successfully incorporating corresponding specialized movement skills into one's movement repertoire.

This chapter focuses on the specialized movement skill phase of development. Two important points should be kept in mind. First, even though a person may be cognitively and affectively ready to advance to this phase, progression depends on successful completion of specific aspects of the previous phase. Second, progress from one phase to another is not an all-or-none proposition. One is not required to be at the proficient stage in all fundamental movements before advancing to subsequent stages. Although a 14-year-old who specialized early in gymnastics may be performing at highly sophisticated levels in several locomotor and stability skills, she may not be able to throw, catch, or kick a ball with the proficiency expected for her age and developmental level. So too, a high school football player may be an adept lineman or running back but unable to enjoy the aerobic benefits of swimming, basketball, or soccer because of failure to develop the requisite fundamental movement skills.

Developmental Sequence of Specialized Movements

After the child has achieved the proficient stage in a particular fundamental movement pattern, little change occurs in the "form" of that movement ability during the specialized movement phase. Refinement of the pattern and stylistic variations

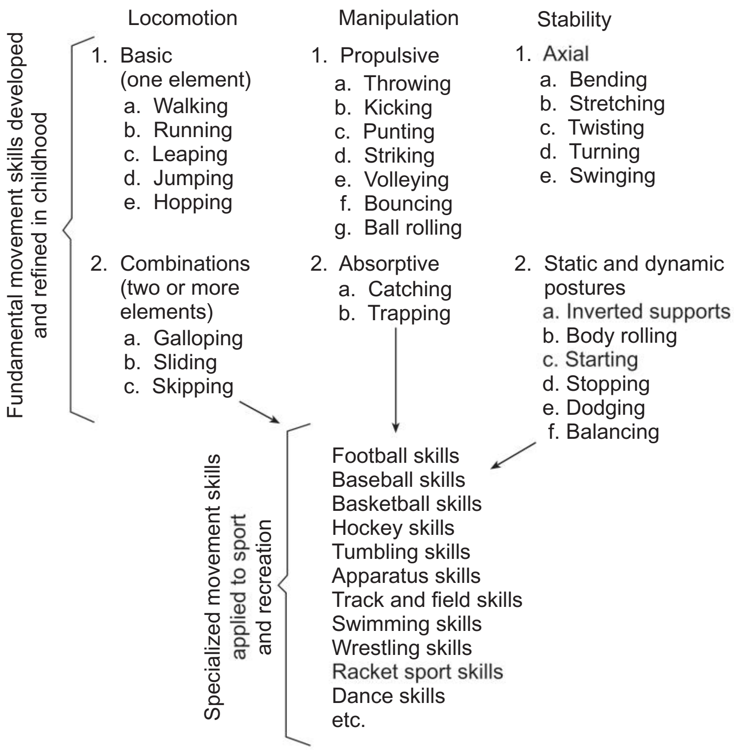

Figure1 6.1

Fundamental movement skills should be proficient prior to the introduction of specialized movement skills.

in form occur as greater skill (precision, accuracy, coordination, and control) is achieved, but the basic pattern remains unchanged. However, dramatic improvements in performance based on increased physical competence may be seen from year to year. As the adolescent improves in muscular strength, endurance, reaction time, speed of movement, coordination, and so forth, we can expect to see improved performance scores. Chapters 12 and 17 provide detailed discussions of the physical abilities of children and adolescents, respectively. One is led to the conclusion that there is a link between skillful movement and physical activity levels. For the past 20 years it has been repeatedly documented that there is steady decline in vigorous physical activity among males and females from age 12 onward. Certainly, some of this decline is due to the lack of physical education programs, in quantity and quality. A CDC report (CDC, 2000) indicates that only 19% of high school students are physically active for 20 minutes or more, five days a week, in physical education classes. The Shape of the Nation Report (NASPE 2010) clearly and forcefully points out the, now more than ever, critical need for meaningful and developmentally appropriate physical education instruction throughout the USA: Instruction that provides learners with ample opportunities for practice, positive encouragement and quality instruction in an environment that is conducive to learning life's important motor and physical skills. These skills will provide learners with the "tools" for participation in and enjoyment of a lifetime of health enhancing physical activity.

Within the specialized phase, there are three separate but often overlapping stages. The onset of stages during this phase of development depends on neuromuscular, cognitive, and affective factors within the individual. Specific constraints within the movement task and the biology of the individual as well as conditions within the environment stimulate movement from one stage to another.

A person's fundamental movement skills are little changed after they reach the proficient stage, and physical capabilities influence only the extent to which specialized movement skills are acted out in sport, recreational, or daily living situations. Therefore, specialized movement skills are proficient fundamental movements that have been adapted to the specific requirements of a sport, recreational, or daily living activity. The extent to which these skills are developed depends on a combination of conditions within the task, the individual, and the environment.

A key to successful teaching at the specialized movement skill phase, whether the students are skilled adolescents or unskilled adults, is recognizing conditions that may limit or enhance development. Once these conditions have been identified for each individual, teaching becomes more a matter of reducing the constraints (limiting conditions) and maximizing the affordances (enhancing conditions) than simply stressing mechanically "correct" execution of the skill. The three stages within the specialized movement phase are outlined next.

CONCEPT 16.2

Progress through the stages within the specialized movement skill phase depends on the foundation of movement skills previously established during the fundamental movement phase.

Transition Stage

The **transition stage** is characterized by the individual's first attempts to refine and combine proficient movement skills. This is the period of time during which would-be athletes learn how to train for increased skill and performance. For most upper elementary and middle-school children (ages 8–12) this is a critical period during which proficient fundamental movement skills are refined and applied to the sports and games of the culture. With children, there is heightened interest in sport and standards of performance. Children generally enjoy pitting their developing movement skills against those of others. During this stage children are attracted to several different types of sports and do not feel limited by physiological, anatomical, or environmental factors. Instructors begin to emphasize accuracy and skill in the performance of games, leadup activities, and a wide variety of sport-related movements. During this stage the individual works at "getting the idea" of how to perform the sport skill. Skill and proficiency are limited. Effort begins to make sense to aspiring young athletes. In fact, some research has shown that it takes eight to twelve years of training for a talented athlete to reach elite levels (Balyi & Hamilton, 2004), and it is at the transition stage where this long process begins.

Application Stage

Young athletes in the middle school years and beyond who have successfully navigated the previous phases and stages of motor skill development are now at the application or training-to-train stage. During the **application stage** the individual becomes more aware of personal physical assets and limitations and, accordingly, focuses on certain types of sports in both recreational and competitive settings. Emphasis is on improving proficiency. Practice is the key to developing higher degrees of skill. The movement patterns characteristic of the beginner during the transition stage smooth out. More complex skills are refined and are used in official sports and designated recreational activities for both leisure and competition. Individuals at this stage have entered a period of biological maturation that enables them to benefit from increased training routines designed to increase muscular strength and endurance as well as aerobic endurance. This is a stage where the requisite skills and the required tactics of various sports are consolidated and mastery attempts are intensified. Therefore, it is especially important at this stage that the activity is matched to the individual in such a manner that interests, abilities, and potential for success are given careful consideration.

Lifelong Utilization Stage

In the **lifelong utilization stage** individuals generally reduce the scope of their athletic pursuits by choosing a few activities to engage in regularly in competitive, recreational, or daily living settings. Further specialization and skill refinement occur in this training to compete and to participate stage. Maximizing performance is the key goal of this stage. Of the sport skills that have been mastered, emphasis is placed on optimal preparation in terms of fitness preparation, psychological preparation, and tactical preparation. Lifetime activities are chosen on the basis of personal interests, abilities, ambitions, availability, and past experiences. Opportunities to participate are frequently limited in this stage because of increased responsibilities and time commitments.

Many individuals do not go through the development and refinement of specialized movement skills in the sequence presented. Children are often encouraged to refine their skills in a particular sport at an early age. Early participation in sports is not detrimental per se, but premature specialization may have a high cost. The development of a broad range of proficient fundamental movement skills could be sacrificed, thereby limiting the potential for participation in a wide variety of games, play, and sport activities.

YOUTH SPORT

Under ideal conditions, the transitional movement skill stage begins around age 7 or 8. With their growing interest in performance capabilities and sport, increasing cognitive sophistication, and improved group interaction, children are more attracted to organized competition. Early specialization sports such as gymnastics and alpine skiing require early sport-specific training, whereas late specialization sports such as all team sports require a more generalized approach to early training. Table 16.1 presents a partial list of early and late specialization sports.

DEVELOPMENTAL DILEMMA

The Dropout Rate Is Too High. Why?

The growth in youth sport participation over the past twenty-five years has been phenomenal. An estimated 20 to 35 million children in the United States participate in youth sports (Poinsett, 1996). Nearly every community in the sample group provided some form of competitive activity for youth. It would be hard to find any sizable community in North America today that does not provide competitive sport experiences for its youth outside the school setting as well as school-sponsored programs. Youth sport is big, it is popular, and it is here to stay. Furthermore, sport has been touted for generations to “build character” and teach a myriad of valued life lessons including teamwork, persistence, cooperation, and the value of hard work.

Under the best of circumstances, organized sport provides a wonderful opportunity to learn new skills, make new friends, and accept the challenge of becoming proficient in an activity that not only promotes good health and valuable life skills but is also a means of fun and personal enjoyment. Conversely, under the worst of situations the outcomes of youth sport can be the negative side of each of these virtues.

The dilemma lies in the still unacceptable dropout rate among the millions who give youth sport a try. It has been estimated that over 80% of youth in America drop out of sport by age 12. Think about it: Only 20% or so remain engaged in sport during their teen years and beyond. How can this be? How can an activity so popular just a few years prior become such a “turn-off” to so many youth? What steps can we take to help reconcile this unfortunate dilemma?

TABLE 16.1 Early and Later Specialization Sports

EarlyS pecialization Sports (Prior to Age 10)	LaterS pecialization Sports (After Age 10)
—Gymnastics	—All Team Sports
—FigureS kating	—RacquetS ports
—Diving	—CombativeS ports
—AlpineS kiing	—Track and Field
	—Cycling
	—Equestrian
	—Most AquaticS ports

TABLE 16.2 Suggested Training (Skill and Performance Enhancement) to Competition Ratio

Phase/Stage of Development	Recommended Training to Competition Ratio
Fundamental Movement Phase	
—Initial Stage	100%/0%
—Emerging Elementary Stages	90%/10%
—Proficient Stage	80%/20%
SpecializedM ovementP hase	
—TransitionS tage	70%/30%
—ApplicationS tage	60%/40%
—LifelongU tilizationS tage	40%/60%

The key to successful youth sport participation is in respecting the developmental level of the young athlete. This can be done by carefully manipulating the training to competing ratio (Table 16.2). Because of the difficulty in determining biological maturity in the young performer, many experienced coaches use 12–18 months *following* peak height velocity as their guide. Although early and late maturers may vary considerably, peak height velocity occurs on the average in girls at about age 11 and in boys at about age 13. Therefore age 12 and 14 for females and males, respectively, is an ideal time for placing increased emphasis on aerobic, strength, and endurance training (Balyi & Hamilton, 2004).

CONCEPT 16.3

Sport participation is important to millions of children and adolescents, who need competent leadership and developmentally appropriate experiences.

Youth compete in sport for a variety of reasons. Weiss (2004) identifies "the most prominent among them being developing physical competence (*learning and improving skills*), attaining social acceptance and approval (*be with and make friends, interactions with parents and coaches*), and enjoying one's experiences (*having fun, doing something interesting*)" (p. 15). These three reasons are vital in developing and sustaining a genuine interest and participation in sport activities. A fourth way to sustain interest in sport participation is to carefully monitor the ratio between training for sport (i.e., skill and performance enhancement) and actual competition itself. Table 16.2 provides a helpful guide to maintain a healthy and developmentally appropriate training to competition ratio. Youth sport can have detrimental as well as beneficial effects, all of which have been fully discussed over the years. See the *American Sport Education Program: ASEP* (Human Kinetics, 2011) and the American Academy of Pediatrics position statement on organized sports for children and preadolescents (Washington, et al., 2001) for highly practical sources of information.

Sport allows individuals at the transition and application stages to improve their skills and get plenty of vigorous physical activity in competitive situations. Competitive sport, however, should not be regarded as the only skill outlet for children. Noncompetitive and leisure-time activities such as hiking, canoeing, fishing, jogging, and the like, as well as various forms of cooperative recreation and dance, are also beneficial for youth. Tables 16.3 through 16.11 provide an overview of several sport skills and the various fundamental locomotor, manipulative, and stability movements involved in the performance of these skills. The goal in all cases is fosteringi mprovement.

TABLE 16.3 Basketball Skills

FundamentalM ovements	Specialized Movement Skills	
MANIPULATION		
• Passing	—Chest pass	—Shovel pass
	—Overhead pass	—Push pass
	—Baseball pass	
• Shooting	—Lay-up shot	—Jump shot
	—Two-hand set shot	
• Bouncing	—Stationary dribbling	—Bounce pass
	—Moving dribbling	
• Catching	—Pass above the waist	—Rebounding
	—Pass below the waist	—Pass to the side
		—Jump ball reception
• Volleying	—Tipping	
	—Center jump	
LOCOMOTION		
• Running	—In different directions while dribbling	
	—In different directions without ball	
• Sliding	—Guarding while dribbling	
• Leaping	—Lay-up shot	
	—Pass interception	
• Jumping	—Center jump	—Rebounding
	—Tip-in	—Catching a high ball
STABILITY		
• Axialm ovements	—Pivoting	
	—Bending	
• Dynamic balance	—Compensation for rapid changes in direction, speed, and level of movement	
• Dodging	—Feinting with the ball	

CONCEPT 16.4

It is essential for the instructor to know the learner in order to make a difference in motor development and movement skill learning.

FOSTERING IMPROVEMENT

As instructors (i.e., parents, teachers, coaches, therapists) our primary purpose is to help learners improve in accordance with their developmental needs and potential. The operational goal of improvement helps us to see all learners (whether they are children, adolescents, or adults) at their actual developmental levels. By assessing current levels of motor behavior and providing meaningful and enjoyable learning experiences, developmental instructors will foster improvement.

The operational goal of improvement encompasses three other concepts that guide us. The first of these concepts is *movement control* in which we reflect our knowledge of the three categories of movement (stability, locomotion, and manipulation), the phases of motor development (reflexive, rudimentary, fundamental, and specialized), and the levels of movement skill learning (beginning/novice, intermediate/practice, and advanced/fine-tuning). By

TABLE 16.4 Contemporary Dance Skills

Fundamental Movements	Specialized Movement Skills
LOCOMOTION	
• Walking • Running • Leaping • Jumping • Hopping • Galloping • Sliding • Skipping	—Contemporary dance is a movement form that uses a movement vocabulary specific to the particular creative effort being expressed. The choreographer uses movement as a vehicle of expression. Therefore, fundamental locomotor and stability movements serve as the means for conveying concepts and ideas.
STABILITY	
• Axialm ovements	—Bending, stretching, twisting, turning, reaching, lifting, falling, curling, pushing, pulling
• Static and dynamic balance	—Numerous balance skills requiring synchronizing rhythm and proper sequencing of movement

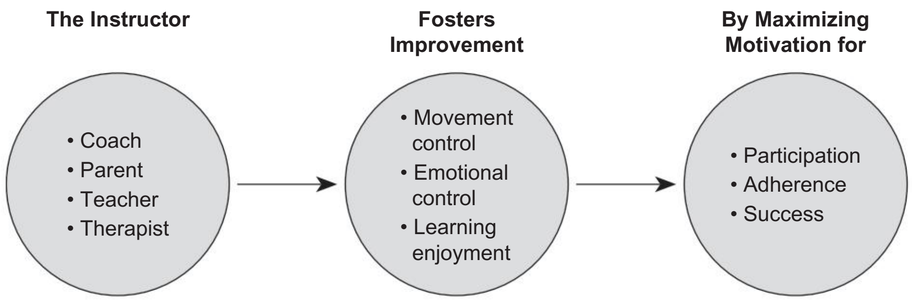

Figure1 6.2
Fostering improvement in sport maximizes athlete motivation.

condensing information into the concept of movement control, we form a basis for analyzing our effectiveness in improving the skills of learners.

The second concept under the goal of improvement is *emotional control*. Instructors are concerned with how learners understand themselves and others. We rely heavily on appropriate communication skills in ourselves and in others. These communication skills include self-discipline as well as experiences through which learners can develop responsibility, self-control, and positive interaction with their peers. The concept of emotional control provides a guide for evaluating past experiences and designing new experiences.

The third and final concept is *learning enjoyment*. This concept also gives instructors a guide for evaluating their programs with improvement in mind. The objective is to stimulate an eagerness to learn within each individual. Success-oriented experiences and opportunities to receive encouragement and recognition positively reinforce one's view of learning. By making the learning of new movement skills enjoyable and striving for perfection of these skills, we promote intrinsic motivation within the individual, with the goal of maximizing motivation for participation, adherence, and success (Figure 16.2).

TABLE 16.5 North American Football Skills

FundamentalM ovements	Specialized Movement Skills	
MANIPULATION		
• Throwing	—Forward pass —Centering	—Lateral
• Kicking	—Place kick —Punting	—Field-goal kicking
• Catching	—Pass above the waist —Pass below the waist —Pass at waist level	—Over the shoulder —Across the midline —Hand-off
• Carrying	—Fullback carry —One-arm carry	
LOCOMOTION		
• Running	—Ball carrying —Pursuit of ball carrier	
• Sliding	—Tackling	—Blocking
• Leapinga ndj umping	—Pass defense	—Pass reception
STABILITY		
• Axialm ovements	—Blocking —Tackling	
• Statica ndd ynamic Balance	—Blocking —Stances —Dodging a tackle	—Rolling —Pushing

The overall goal of improvement, with its three emphases of (1) movement control, (2) emotional control, and (3) learning enjoyment, provides us with a compact philosophical construct that can serve as an operational guide to teaching action. This construct can and should be modified. Its purpose is not to limit instructors but to empower them by providing operational guidelines to ensure that instruction is meaningful, relevant, and fun. Every instructor must rely on some sort of philosophical construct. The purpose of the suggested philosophical construct is to provide a basis for keeping instruction realistic, practical, and meaningful. We encourage you to reflect on this point and to either adopt our model as presented or adapt it to suit your unique philosophical approach to the teaching and learning of movement skills.

Knowing the Learner

It is vitally important for you as a parent, teacher, coach, or therapist to know your learners and to recognize that each comes to you with a different set of physical, mental, emotional, and social capabilities. You must accommodate an awesome number of individual differences when planning skill learning and practice sessions. Some of these individual differences are easy to detect; others are not. However, it is to your advantage to be aware of as many factors as possible. The following are important points to remember:

- Peoplel earna td ifferentr ates.
- Each person's potential for performance excellence is unique.
- Fundamentalm ovementa nd perceptual-motor skills should be mastered before the specialized skill is attempted.

TABLE 16.6 Softball/Baseball Skills

FundamentalM ovements	Specialized Movement Skills	
MANIPULATION		
• Throwing	—Overhand throw for accuracy —Overhand throw for distance —Underhand toss —Overhand pitch —Underhand pitch	
• Catching	—Above-waist ball —Below-waist ball —Flyb all	—Grounder —Across midline —Line drive
• Striking	—Batting —Bunting	
LOCOMOTION		
• Running	—Base running —Fielding	
• Sliding	—Fielding —Base sliding	
• Leaping	—Base running	—Fielding
• Jumping	—Fielding	
STABILITY		
• Axial movements	—Batting —Fielding —Pitching	
• Dynamicb alance	—Compensation for rapid changes in direction, speed, and level of movement	

- Responses to instructional approaches vary amongl earners.
- Responses to winning and losing vary among individuals.
- Responses to praise and criticism, reward and punishment, vary among individuals.
- Formere xperiencesv arya mongi ndividuals.
- Variations in home-life experiences influence peopled ifferently.
- Strengths in some areas can compensate for deficiencies in other areas.
- Attention spans and concentration abilities vary among individuals.
- The developmental levels of individuals vary, resulting in dissimilar potential for learning andp erformance.
- There is no uniformity in the physical potential of individuals (particularly during the preteen and early teenage years).
- Individuals display greater or lesser degrees of both gross and fine motor skills depending on a variety of environmental factors as well as inherited and biological factors.
- The ability to analyze, conceptualize, and solve problems varies among individuals.

Cues to Teaching a New Movement Skill

When teaching a new movement skill the instructor will find it beneficial to do the following:

- Identify the type of skill in terms of its context (i.e., open or closed; gross or fine; discrete,

TABLE 16.7 Soccer Football Skills

Fundamental Movements	Specialized Movement Skills	
MANIPULATION		
• Kicking	—Instep kick	—Inside of foot kick
	—Toe kick	—Outside of foot kick
	—Heel kick	—Dribbling
	—Corner kick	—Passing
	—Goal kick	—Goalie punt
• Striking	—Heading	
	—Juggling	
• Catching	—Goalie skills	
• Throwing	—Throw-in	
	—Goalie throw	
• Trapping (Collecting)	—Sole	
	—Double-knee	
	—Stomach	
	—Single-knee	
	—Chest	
LOCOMOTION		
• Running	—With ball	
	—Without ball	
• Jumping and leaping	—Heading	
• Sliding	—Marking	
STABILITY		
• Axial movements	—Goalie skills	
	—Field play skills	
• Dynamic balance	—Marking	
	—Dodging opponent	
	—Feinting with ball	

serial, or continuous; and stability, locomotor, or manipulative).

- Establish a practice environment consistent with the nature of the skill.
- Introduce externally paced activities under internally paced conditions first (i.e., control the environment and conditions of skill practice first).
- Introduce situations that require responses to sudden and unpredictable cues in externally paced activities as skill develops.
- Strive for greater consistency, duplication, and elimination of environmental influences for internally paced activities as skill develops.
- Encourage the learner to "think through" the activity in the early stages of learning.
- Encourage the learner to screen out unnecessary cues as skill develops.
- Know and respect the cognitive state of the learner as well as his or her learning goals.

LEVELS AND STAGES OF MOVEMENT SKILL LEARNING

The sequential progression in the learning of a new movement skill may be classified into general levels or stages. Fitts and Posner (1967) proposed a three-stage model for movement skill learning

TABLE 16.8 Track and Field Skills

FundamentalM ovements	Specialized Movement Skills	
MANIPULATION		
• Throwing	—Shot put	—Hammer
	—Discus	
	—Javelin	
LOCOMOTION		
• Running	—Dashes	—Pole-vault approach
	—Middle distances	—High-jump approach
	—Long distances	—Long-jump approach
• Leapingt akeoff	—Low hurdles	—Running long-jump
	—High hurdles	—Pole-vault takeoff
• Jumping	—High jump	
	—Long jump	
• Verticalj ump	—High jump	
STABILITY		
• Axialm ovements	—Pivoting and twisting (shot put, discus, javelin, and hammer)	
• Dynamic balance	—Compensation for rapid changes in speed, direction, and level of movement	

TABLE 16.9 Racquet Sport Skills

FundamentalM ovements	Specialized Movement Skills	
MANIPULATION		
• Striking	—Forehand shot	—Lob shot
	—Backhand shot	—Smash
	—Overhead shot	—Corner shot
	—Sweep	—Drop shot
LOCOMOTION		
• Running	—Netr ush	
	—Ballr etrieval	
• Sliding	—Lateral movement to ball	
STABILITY		
• Axialm ovements	—An aspect of all strokes (twisting, stretching, pivoting)	
• Dynamic balance	—Compensation for rapid changes in direction, level, and speed of movement	

TABLE 16.10 Volleyball Skills

FundamentalM ovements	Specialized Movement Skills	
MANIPULATION		
• Striking	—Overhand serve —Underhand serve	—Spike —Dink
• Volleying	—Set —Dig	
LOCOMOTION		
• Sliding	—Lateral movement	
• Running	—Forward —Backward —Diagonal	
• Verticalj ump	—Spike	
STABILITY		
• Axialm ovements	—Found in general play (stretching, twisting, turning, falling, reaching)	
• Dynamic balance	—Rapid changes in speed, level, and direction of movement	

TABLE 16.11 Gymnastic Skills

FundamentalM ovements	Specialized Movement Skills	
LOCOMOTION		
• Running	—Approach	
• Verticalj umping	—Back flip —Front flip	
• Skipping	—Skip-step	
• Leaping	—Various stunts	
STABILITY		
• Axialm ovements	—One or more found in numerous stunts and apparatus skills (bending, stretching, twisting, turning, falling, reaching, pivoting)	
• Static balance	—Integral part of all stationary tricks and landing on dismounts	
• Inverteds upports	—Tip-up —Tripod	—Headstand —Handstand
• Bodyr olling	—Forward roll —Backward roll	—Back walkover —Front walkover
• Dynamic balance	—Compensation for changes in direction, level, and speed of movement	

that centers on the cognitive state of the individual along the learning continuum. Gentile (1972) proposed a two-stage model based on the goals of the learner. Gallahue and colleagues' (1972, 1975) three levels model with accompanying substages incorporates elements from both Fitts and Posner and Gentile, but also proposes specific responsibilities for the instructor (i.e., parent, teacher, coach, therapist) along the learning continuum. The following paragraphs provide a brief look at each model.

CONCEPT 16.5

Movement skill learning is an age-independent process that follows a predictable sequence of stages that identify the cognitive state and the learning goals of the individual along the learning continuum.

Fitts and Posner's Three Stages of Skill Learning

Fitts and Posner (1967) were among the first to propose that learning a new movement skill occurs in stages. Their three-stage model still forms the basis for research today (Magill, 2010). Fitts and Posner viewed movement skill learning from the standpoint of the cognitive state of the learner and contended that the learner gradually progresses along a continuum of change from the *cognitive stage,* to the *associative stage,* and finally to the *autonomous stage.*

During the **cognitive stage,** the learner tries to form a conscious mental plan for performing the skill. For example, an individual learning how to snowboard down a mountain slope might ask the following questions: "How do I stand on the board without falling?"; "What do I do when my board starts to slide downhill?"; "Where is my balance point?"; "How do I change directions?"; and most importantly, "How do I stop?"

The second stage is called the **associative stage** because at this point the learner is able to make conscious use of environmental cues and associate them with the requirements of the movement task. Our snowboarder, for example, is now able to associate changes in the board's speed and direction with the slope of the hill, the conditions of the snow, and the angle of the board.

During the **autonomous stage** performance of the movement task becomes habitual with little or no conscious attention given to the elements of the task during performance. At this stage our snowboarder streaks down the mountain, deftly changing speeds and directions with slight changes in body posture and pressure on the snowboard and without consciously attending to the task.

Gentile's Two Stages of Skill Learning

In 1972 Gentile proposed an alternative two-stage model for learning a new movement skill and has since expanded it to view the process from the perspective of the goals of the learner (2000). Gentile's two stages are called the *getting the idea stage* and the *fixation/diversification stage.*

At the **getting the idea stage** the primary goal of the learner is to obtain a basic awareness of the essential requirements for successful performance of the skill. During this first stage in learning a new movement skill, the learner establishes the basic movement patterns for executing the task and begins to make crude discriminations in how it is performed. The learner at this stage learns how to complete the task under highly specific conditions. For example, the goal of our snowboarder in getting the idea of how to move downhill while balancing with both feet strapped to the snowboard is to be able to do so under specific conditions involving the slope of the hill and the surface conditions. Should the snow conditions change from powder to packed snow or to ice, or from a gentle slope to a steep one, the learner will not be able to regulate this new and radically different environment without once again "getting the idea" of how it is done under these new and different conditions.

During Gentile's second stage, the **fixation/diversification stage,** the goal of the learner is to achieve consistency of performance and the ability to adapt to changing conditions and to the task being an open or closed skill (see chapter 1). If it is a closed movement task, the learner works for consistency from trial to trial (i.e., "fixation") as in shooting free throws in basketball. If the movement is open, the learner strives for fluidity and adaptability (i.e., "diversification") under constantly changing environmental conditions, as in snowboarding.

Concept 16.6

The learning of a new movement skill can be viewed from the perspective of levels and stages that provide the instructor (i.e., parent, teacher, coach, therapist) with specific cues for maximizing learning.

Combining Levels and Stages of Skill Learning

In 1972 the senior author first proposed a model for movement skill learning based on elements of both the Fitts and Posner and the Gentile models (Gallahue, Werner, and Luedke, 1972, 1975), that has since been modified and expanded (Gallahue, 1982; Gallahue and Cleland-Donnelly, 2003). Gallahue's view of learning a new movement skill adapts elements from the previous two models in that it recognizes both the cognitive state of the learner and the goals of the learner. Additionally, it proposes appropriate actions on the part of the instructor in being a facilitator of learning at the *beginning/novice level, intermediate/ practice level,* and *advanced/fine-tuning level* of learning a new movement skill (see Table 16.12).

At the **beginning/novice level** of learning a new movement skill the learner tries to develop a conscious mental plan of the essential requirements of the task. Because of the conscious attention given by the learner to the task, performance is highly variable, generally erratic, and with lots of errors. Fatigue often sets in early because the learner tries to pay attention to all of the elements of the task and is unable to screen out relevant information from that which is unimportant. The beginning level of learning a new movement skill has three accompanying stages: the *awareness stage,* the *exploratory stage,* and the *discovery stage.*

At the **awareness stage** the cognitive state of the learner is one of being naïve and ignorant about the task, its basic requirements, and the appropriate terminology used to describe the task. The goal of the learner is to develop a basic conscious awareness of the general characteristics of the task. This is a "getting the idea" stage. For example, when learning how to do a forward roll the learner first develops an awareness of the essential requirements of the task (i.e., to tuck and move forward) and an understanding of how the terms "tuck your chin," "push off with your hands," and "stay in a small ball" are used in performing the task.

At the **exploratory stage** the learner has a conscious awareness of the basic requirements of the task and now experiments with performing the task in a variety of ways. The cognitive state of the learner is typified by knowing what the body is supposed to do, but being unable to do so with consistency. The goal of the learner is to experiment with the varied possibilities of how the task may be performed. This is viewed as a "precontrol" stage in which there is great variability and gross errors in performance. For example, when learning to do a forward roll, our learner may explore the many rolling possibilities by experimenting with the movement concepts of rolling with different amounts of *effort,* occupying various amounts of *space,* and rolling in *relationship* to different objects and people (Gallahue & Cleland-Donnelly, 2003). At this stage our forward roller explores the movement concepts of how the body *can*m ove.

At the **discovery stage** of learning a new movement skill the cognitive state of the learner is one of consciously forming a mental plan of how the task should be performed. The goal of the learner is to find more efficient ways of performing the task. This is a "coordinating and controlling" stage in which the learner begins to gain greater motor control and "discovers" how to perform the task. At this stage our forward roller begins to internalize the skill concepts of how the body *should* move.

For individuals at the beginning/novice level of learning a new movement skill, the instructor needs to be aware of the conscious cognitive requirements of this stage. The intent, at this level, is

TABLE 16.12 Gallahue's Levels and Stages of Learning a New Movement Skill, with Attention to the Learner's Cognitive State and Goals, and the Role of the Instructor

Levelsa ndS tages of Learning a New Movement Skill	CognitiveS tate of the Learner	Goals of the Learner	Role of the Instructor
BEGINNING/NOVICE LEVEL	Learner tries to form a conscious mental plan of the movement task:	Learner tries to gain basic awareness of the requirements of the movement task:	Instructor helps the learner with the general framework of the movement task:
• Awareness stage	—Wants to know how the body *should*m ove	—To get an idea of how the task is performed	—By helping the learner get the general idea of the task
• Exploratory stage	—Knows what to do, but unable to do it with consistency	—To experiment with how the body *can* move	—By helping the learner explore and self-discover how to perform the task
• Discoverys tage	—Forms ac onscious mental plan for performing the task	—To find more efficient ways of performing the task	—By helping the learner gain greater movement control and motor coordination
INTERMEDIATE/ PRACTICE LEVEL	Learner has a good general understanding of the movement task:	Learner tries to get the "feel" of the movement task:	Instructor helps the learner focus on combining and refining skills:
• Combinations tage	—Putss killst ogether with less conscious attention to their elements	—To integrate multiple skills into a fluid time/ space sequence	—By helping the learner integrate and use skill combinations
• Application stage	—Makes efforts to refine the skill	—To use the task in some form of activity	—By helping the learner refine and apply the task
ADVANCED/FINE-TUNING LEVEL	Learner has a complete understanding of the movement task:	Learner tries to perform the task with unconscious effort (i.e., "zone"):	Instructor focuses on skill maintenance and refinement:
• Performance stage	—Givesl ittleo rn o conscious attention to the elements of the task	—To perform with increased accuracy, control, and movement efficiency	—By helping the learner achieve increased precision of movement
• Individualized stage	—Fine-tunesp erformance based on personal attributes and limitations	—To modify performance to maximize success	—By helping the learner personalize the movement task

to provide the learner with the gross general framework of the task. To do so the instructor needs to:

- Provide for visual demonstrations of the skill to promote cognitive awareness.
- Introduce the major aspects of the skill only (beb rief).
- Permit the learner to try out the skill early.
- Provide plenty of opportunity for exploration of the skill and self-discovery of its general elements.
- Recognize that this is primarily a cognitive stage and that the learner needs only to get the general idea of the skill.
- Compare the new skill, when possible, to similar skills with which the learner may be familiar.
- Provide immediate, precise, and positive feedback concerning general aspects of the skill.
- Avoid situations that place emphasis on the product of one's performance; focus instead ont hep rocess.

The **intermediate/practice level** is the second level of learning a new movement skill. At this level the learner has a general understanding and appreciation for the requirements of the task and is able to perform in a manner approximating the requirement of the final skill. Additionally, the learner now has a better understanding of the requirements of the skill and a mental plan for performing it under both static and dynamic conditions. There is less conscious attention to the elements of the task at this level, but greater attention to the goal of the task. The poorly coordinated movements of the beginning level disappear, and the learner now begins to get the "feel" for the skill as kinesthetic sensitivity becomes more highly attuned. At this level the learner relies more on muscle sense and less on the verbal and visual cues of the beginning level. The intermediate/practice level of learning a new movement skill has two accompanying stages: the *combination stage* and the *application stage*.

At the **combination stage** the learner begins to put movement skills together in different combinations, first in pairs, then in increasingly complex forms. The cognitive state of the learner is one of trying to combine skills with decreasing conscious attention to the elements of the task. The goal of the learner is to integrate multiple skills into a fluid sequence of events in both time and space. Our forward roller now practices doing a roll from a squat to a squat position, then from progressively more complex forms—from a stand, from a walk, and finally over an object. This is a stage of "integrating" and "using" movement skills in combination with one another.

At the application stage more attention is given to refining the task and applying it as a specialized movement skill to some form of daily living, recreational, or introductory sport-related activity. The cognitive state of the learner is one of refining the skill, and the goal of the learner is to use the skill or combination of skills in some form of activity. Attention is given to smoothing out the task and using it in an applied sense. For example, our forward roller now adapted her rolling skills to introductory forms of various martial arts and gymnastics activities. This is a "refining" and "applying" stage.

The instructor working with learners at the intermediate/practice level of learning a new movement skill needs to focus on greater skill development. Practice conditions should promote skill refinement and maximize feedback. To accomplish this the instructor needs to:

- Providen umerouso pportunities for practice.
- Provide opportunities for skill refinement in a supportive, nonthreatening environment.
- Devise practice situations that progressively focus on greater skill refinement.
- Provide short, fast-paced practice sessions with frequent breaks before implementing longer sessions with fewer breaks.
- Help the learner self-analyze the task and then provide constructive feedback to the learner.
- Structure quality practice sessions that focus on quality performance (i.e., "perfect practice makesp erfect").
- Accommodate for individual differences in the rate of skill learning.

- Focusa ttentiono nt hew holes killw henever possible.
- Setu pp ractices essionst hats imulatet he intensity and demands of the real-life daily living, recreational, or competitive situation.

The **advanced/fine-tuning level** is the third and final level in learning a new movement skill. The cognitive state of the learner at this stage is one of having a complete understanding of the skill. The mental plan for the skill is highly developed, and little or no conscious attention is given to the cognitive elements of the task. The individual is able to screen out irrelevant information and is not bothered by distractions. There is excellent timing and anticipation of movements and the action appears almost automatic. The learner at this level is frequently said to be "in the groove" or in a "zone" when performing the task. At the advanced/fine-tuning level there are two stages, the *performance stage* and the *individualized stage.*

At the **performance stage** of learning a new movement skill the learner is further involved in refining and applying the elements of the movement task but with emphasis on using it in specific performance situations. The cognitive state of the learner is one in which little or no conscious attention is given to the task, and the goal of the learner is to perform with increased accuracy, control, and efficiency. This is a "precision" stage. Using our rolling example, the performer in the sport of gymnastics now performs a floor exercise routine using a variety of rolling movements. The attempt at this stage is to do so with considerable precision by pointing the toes, positioning the arms just so, and tucking the body in a manner that exudes power and grace.

The **individualized stage** is the final stage in learning a new movement skill. At this stage the cognitive state of the learner is one of making fine-tuning adjustments in skill performance based on unique strengths or weaknesses and attributes or limitations. The goal of the learner is to modify performance to maximize success based on such things as body size, physical conditioning, emotional control, and the cognitive requirements of the task. This is a "personalizing" stage. Our gymnast, for example, when incorporating rolling moves into her floor exercise routine will take her height, weight, strength, endurance, and injury status into consideration when performing her routine. In short, to be successful she will have to personalize her routine.

Instructors of individuals at the advanced/ fine-tuning level of movement skill learning must focus on additional refining, maintenance of the skill, and

INTERNATIONAL PERSPECTIVES

Olympic Gold: Is Bigger Always Better?

The Summer and Winter Olympics occur every four years. They are the world stage upon which each country places their very best athletes. Large countries and small compete on a level playing field that permits all an opportunity to "go for the gold." At the Summer Olympics, Australia, a country of just 22 million, consistently ranks among the top four or five countries in terms of medal count. So too, tiny Slovenia (population 1.9 million) and isolated Cuba (population 10 million) succeed at a far greater rate per capita than do many of the larger countries, including the United States, China, and Russia.

Australia, Cuba, and Slovenia defy the logic that more populous countries should experience greater success in terms of the total medal count than less populous countries. How can this be so? The answers are many, varied, and complex, but in all cases it basically comes down to putting athletes at the center of the sport development process and providing them with the coaching, training resources, and consistent support required to help them reach their maximum potential in sport *and* life. In terms of Olympic medal success, bigger is not always better.

Source:www .nytimes.com/interactive/2008/08/04/sports/olympics/20080804_MEDALCOUNT_MAP.html providing selected feedback. Instructors should not require the learner to consciously attend to the skill as a whole. Therefore, instructors should:

- Structure practice sessions that promote intensity and enthusiasm.
- Be available to provide encouragement, motivation, and positive support.
- Offer suggestions and tips on strategy.
- Structure practice sessions that duplicate real-lifes ituations.
- Help the learner anticipate her or his actions in gamelikes ituations.
- Know the learner as an individual and be able to adjust methods to meet individual needs.
- Provide feedback that focuses on specific aspects of the skill.
- Avoid asking the learner to think about performance of the skill, which might result in "analysisp aralysis."

Open Motor Skills and Improving "Thinking Time"

Open motor skills are those that are performed in an unpredictable, dynamic, and constantly changing environment. They require quick responses to external stimuli, therefore making one's reaction time to the stimuli an important key to success. Reaction time has two components: premotor time and motor time. Premotor time is the "thinking time" between presentation of the stimulus and initiation of a response. Motor time is the time it takes from initiating the response to its completion. Premotor time or thinking time can be improved with training. Motor time, however, is less susceptible to change through training.

The majority of sport and active games require fluidity and flexibility of performance because they incorporate a variety of open motor skills. Virtually all team sports (basketball, soccer/football, rugby, baseball, cricket, field hockey, etc.) require making quick decisions in a constantly changing environment. So do most dual sports (tennis, wrestling, martial arts, fencing, etc.) and several individual sports (equestrian, skiing, snowboarding, dance, etc.). Open motor skills are generally fast paced, involve one or more aggressive defenders, occur in a limited play space, and require high levels of conditioning for sustained participation. It therefore becomes exceedingly important to train developing athletes in a manner that quickens their decision-making skills. To do so it is important to (1) help the learner focus on the relevant stimuli by tuning out unneeded information ("noise") in the immediate environment; and (2) help the learner know what response options are available in advance of committing to a particular response by understanding and internalizing the myriad of response possibilities available in a situation.

Valuable techniques for improving thinking time include both rapid movement skill training and high-intensity training. Rapid movement skill training involves learning to complete a movement task in minimal time, with minimal energy and with maximum consistency. High-intensity training focuses on the intensity of training, not its duration, simulating competitive-like situations, modifying equipment and the size of the play area, and practicing against higher level opponents.

It is critically important for the coach to use a variety of techniques that help the learner become comfortable in situations that require rapid decision making in a dynamic environment. Too often well-meaning but uninformed coaches make the common mistakes of continuing to train at a slow speed rather than simulating game conditions, failing to emphasize the importance of reaction time during practice sessions and training continually under noncompetitive conditions. By doing so they fail to prepare developing athletes with the thinking tools necessary for success (Wang, 2010).

Changing a Well-Learned Technique

When an individual displays a well-learned but improper technique in performing a skill, you are faced with the dilemma of determining whether to attempt to change the habit or to leave it alone. The individual may be experiencing success with the technique, but you know that proper execution would be more efficient and successful. A well-learned technique is difficult and time-consuming to change because any new learning requires taking an unconscious advanced skill and returning it to a conscious cognitive level. Under stress and in conditions where rapid decisions are required, the individual is likely to revert to the incorrect technique. Only after considerable practice will the incorrect response be consistently replaced by the correct action. In deciding whether to change an individual's technique, the instructor needs to consider the following issues:

- Determine if there is sufficient time to make the change (in weeks and months, not hours andd ays).
- Determine if the individual wants to make the change.
- Be certain that the individual understands why the change is being made.
- Be certain that the individual realizes that performance will regress prior to improvement.
- Provide as upportive,e ncouraging environment.
- Structure practice sessions that will gradually bring the learner back to and beyond where sheo rh ew asp rior toi ntervention.

SUMMARY

The refinement of specialized movement skills occurs in three stages. In the transitional stage, it is crucial that a smooth shift be made from mature fundamental movement patterns to corresponding specialized movement skills. This transition will be hampered if the individual has not developed proficient patterns necessary for performance. Instructors must be alert to the proficiency with which the individual knows the specialized skill and not give in to the temptation of ignoring incorrect form as long as the outcome is satisfactory. Too often the focus is on the product rather than on the process. There is no legitimate reason for failing to use the proficient, mechanically correct pattern in the performance of a specialized movement skill. Use of a mature pattern of movement will, in the long run, enhance movement performance. However, once proficiency has been achieved, has become relatively automatic, and has been applied to numerous situations, it is entirely appropriate to encourage unique variations.

At the application stage, attention is focused on greater degrees of precision, accuracy, and control. Performance scores generally improve at a rapid rate, and the individual is keenly aware of the specific advantages and limitations of his or her body. The individual at this level is also influenced by a variety of social, cultural, and psychological factors in selecting specific activities for regular involvement.

The lifelong utilization stage is a continuation and further refinement of the previous stage. It is the pinnacle of the phases and stages of motor development. This stage encompasses lifetime sport and recreational activities. Failure to develop and refine the fundamental and specialized skills of the previous stages will restrict any person's ability to reach this stage.

The learning of a new movement skill occurs in levels or stages. The models proposed by Fitts and Posner (1967) and Gentile (1972, 2000) can be adapted and expanded into a three-level model with accompanying stages. Paying attention to where the learner is in this skill-learning hierarchy provides the instructor with important clues to successful teaching.

The goal of the instructor concerned with the motor development and movement education of youth is to foster improvement in such a way that there is an orderly and developmentally sound progression through the fundamental movement and specialized skill phases. Improvement in movement control, emotional control, and learning enjoyment serves as a practical philosophical construct around which to plan and implement meaningful learning experiences.

QUESTIONS FOR REFLECTION

1. What is a "proficiency barrier" and why is it an important consideration in the development of specialized, or complex, movement skills?
2. Can specialized movement skills be developed prior to obtaining proficient performance in fundamental movement skills?

3. If youth sport is so popular among children, why is the drop-out rate so high?
4. In what ways does the role of the instructor change as the learner moves from the beginning to the practice and finally to the elite level of learning a new movement skill?
5. What is the role of the coach in helping developing athletes improve their reaction time in dynamic sport skill situations?

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Web Resources

http://www.asep.com/

The homepage of the American Sport Education Program. Site includes homepages for coaches, officials, sport administrators, sport parents, and instructors. Also includes information on ASEP's curricula and courses.

http://ed-web3.educ.msu.edu/ysi/

The homepage of The Institute for the Study of Youth Sports run by Michigan State University's Department of Kinesiology. The site includes information on PACE Coaches' Education Program, publications, coaching handbooks, a Bill of Rights for young athletes, and youth sports links.

http://acsm.org/health+fitness/pdf/fitsociety/fitsc203.pdf

The homepage for *Youth Sport and Health.*T his site includes timely tips for maximizing the youth sport experience and promoting healthful living among children and adolescents.

www.nays.org/

The National Alliance for Youth Sports homepage. NAYS is a nonprofit organization dedicated to improving youth sports. The site includes information for parents, coaches, and administrators.

http://www.aahperd.org/naspe

The National Association for Sport and Physical Education (NASPE) homepage. The site provides various resources for professionals in physical and sport education areas. Site includes various youth sport skill development resources.

http://coaching.usolympicteam.com/coaching/kpub.nsf

The homepage for *Olympic Coach.*T his e-magazine includes timely articles and tips for coaches of elite athletes at all age levels.

http://www.asep.com/about.cfm

"ASEP is committed to improving amateur sport by encouraging coaches, officials, administrators, parents, and athletes to embrace the 'athletes first, winning second' philosophy and by providing the education to put the philosophy to work."–*Rainer Martens, PhD, ASEP founder*

CHAPTER 17

Fitness Changes During Adolescence

KEY TERMS

Conveniences amples
Fieldt est
Interraterr eliability
Intrarater reliability
Stratified random sample
Hydrostaticw eighing
Aird isplacementp lethysmography
Bioelectricali mpedancea nalysis
Skinfoldc alipers
Bodym assi ndex(BMI)
Obesogenic

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Describe adolescent gender differences and similarities in health-related fitness
- Discuss changes in movement dimensions such as balance, timing, or force production/control
- Demonstrate knowledge of major changes in body composition and physiological functioning in adolescent males and females
- List and describe age-related aspects of health-related fitness during adolescence
- List and describe age-related aspects of performance-related fitness during adolescence

KEY CONCEPT

Although differences exist between genders as well as within genders on measures of health-related and performance-related fitness, adolescent males and females have the potential to make significant improvements through regular participation in physical activity.

Health-related fitness and performance-related fitness change rapidly during adolescence. Both males and females are capable of making significant increments in all measures of fitness. This chapter examines these changes. The first section is devoted to the components of health-related fitness. Results of the National Children and Youth Fitness Study (NCYFS, 1985) are the primary source of data because of the validity of the sample and the reliability of the data. Although the data presented here are several years old, they are relevant today for several reasons. First, the sampling techniques used assured a stratified random sampling of participants from throughout the United States. Second, this sampling technique is viewed by researchers as the most likely to yield a representative sample of what the population as a whole looks like. Third, the data set is highly reliable because only trained examiners were used to gather data. Fourth, the trained examiners collected scores at multiple sites, thereby further reducing the chance of error between examiners. The figures presented in this section are based on the mean sample scores for each health-related fitness item tested. There is considerable variability in performance scores on all items at all age levels.

HEALTH-RELATED FITNESS

In adolescents, physical activity levels are associated with sex, socioeconomic status, and the activity levels of significant others (Raudsepp & Viira, 2000). There is, however, a distinct lack of reliable data that permit us to make accurate comparisons across generations or across cultures. The problem exists primarily in sampling and data collection techniques. Prior to the publication of the National Children and Youth Fitness Study (1985, 1987), large-scale, population-based field studies used **convenience samples**. Although thousands of children and youth were tested on a variety of fitness items, little attention was given to sampling procedures. As a result the data tend to be suspect and are not suitable for generalizations across ages and the population as a whole. For example, it is possible that participants in some locations were more highly motivated by the testing than others. As a result, performance scores could be biased in favor of more highly motivated participants. Furthermore, in convenience samples little attention is given to geographical representation, rural versus urban settings, and private versus public school populations, all of which may have dramatic effects.

CONCEPT 17.1

Field assessments of physical fitness are frequently unsuitable for the formulation of generalizations about youth fitness because of questionable underlying assumptions, sampling procedures, and data collection techniques.

Another inherent difficulty with nationally normed **field test** fitness data published prior to the NCYFS is in the test administration. Different examiners, usually trained physical education professionals, collected data at each site. Also, all students in the convenience sample method were receiving physical education, a factor that may have skewed the data upward. It is difficult, if not impossible, to ensure consistency among testers. Therefore, **interrater reliability** (objectivity) and **intrarater reliability** (consistency) tend to be poor.

A third problem in comparing generational scores rests in the test items. Comparison can be made only among items performed and administered in exactly the same manner. Changing the protocol, even slightly, for an assessment item may result in drastically inflated or deflated scores.

With these concerns in mind we have chosen to use the NCYFS data as a basis for our discussion about the health-related fitness of adolescents. To date, the NCYFS data are the most valid and reliable. The NCYFS is based on a **stratified random sample** of 5,140 males and 5,135 females from twenty-five randomly selected counties in the United States. Over 88% (4,539) of the randomly selected males completed the test battery, and exactly 83% (4,261) of females completed the testing (Errecart et al., 1985). The high participation rate and the definitive manner in which the sample was obtained contributed greatly to the validity and generalizability of the results. Reliability of the NCYFS was ensured by a highly trained field staff of ten individuals who "directly" supervised administration of the assessment measures given by trained teachers (Ross et al., 1987).

Each of the sections that follow discusses the various health-related components of fitness in respect to the NCYFS data. Comparisons, where appropriate, are made with norms from the AAHPERD Health-Related Physical Fitness Test (HRPFT, 1980). In general, HRPFT scores are better than NCYFS scores. This may be due to the sampling and test administration issues discussed earlier. When comparing the two tests (HRPFT and NCYFS), carefully observe the slope of the two curves. In most cases, the slopes are remarkably similar, thereby strengthening the validity of the data for both tests in changes over time. Note where age differences in the slopes of the two lines exist. These differences may reflect variations in activity patterns between the two studies due to sociocultural shifts in activity levels over time. Table 17.1 provides a synthesis of findings from theNCY FS.

Aerobic Endurance

Aerobic endurance is related to the functioning of the heart, lungs, and vascular system. One's aerobic capacity may be evaluated in the laboratory through a variety of stress tests that require the subject to exert an all-out effort to go into oxygen debt. These "max" tests, as they are known, are usually performed on a treadmill or bicycle ergometer. The VO_2 max score is obtained as the result of exhaustive exercise (Rowland, 2005). Rowland (2005) reports that "between the ages of 6 and 12 years, the VO_2 max of a boy more than doubles" (p. 90). Girls improve at about the same rate as their male counterparts but, on the average, have slightly lower VO_2 max values (Armstrong & Welsman, 2000). When VO_2 max is expressed relative to body weight, little positive change is seen in boys or girls prior to puberty. In fact, girls exhibit a progressive decline in VO_2 max from age 8 onward. Moreover, "the 15-year-old girl has a VO_2 max that is 20% lower than her male counterpart" (Rowland, 2005, p. 90). Although measuring VO_2 max is the preferred method of determining aerobic capacity, large longitudinal population studies using treadmill and ergometer tests are nonexistent.

Instead, research has focused on *population samples* across ages using field test estimates of aerobic endurance. As a result, the one-mile jog has emerged as the most popular and valid field test item with adolescents (Hunt et al., 2000). In a ten-year retrospective study of various fitness components, Updyke (1992) found that aerobic fitness declined annually among a large cross-sectional convenience sample of children and youth.

CONCEPT 17.2

Field-based population studies of health-related fitness yield more valid and reliable data than convenience samples, thus giving a more accurate picture of the fitness of youth.

Based on the National Children and Youth Fitness Study (NCYFS) as depicted in Figure 17.1, males on the average continue to improve in aerobic endurance until age 16, whereupon they regress

TABLE 17.1 Common Field Measures of Adolescent Health-Related Fitness and a Synthesis of Findings

Health-Related Fitness Component	Common Field Measures	Synthesis of Findings
Aerobice ndurance	1-milew alk/run	—Males and females both improve at a near parallel rate until mid-childhood —Males are faster than females at all ages —Males continue to improve until late adolescence —Females regress and plateau from later childhood onward —Males show rapid yearly increments until late adolescence
Muscularst rength/ endurance	Modified situps Abdominal crunch	—Females improve at a less rapid rate than males —Females tend to plateau in performance during midadolescence —Males outperform females at all ages
	Pull-ups	—Females average less than one pull-up throughout adolescence —Males demonstrate slow gains prior to puberty followed by rapid gains throughout adolescence —Males significantly outperform females at all ages
Jointfl exibility	Sit-and-reach	—Females outperform males at all ages —Females make yearly incremental improvements until late adolescence —Males regress during early adolescence followed by rapid improvement
Bodyc omposition	Percentageb odyf at using skinfold calipers (calculated from triceps and calf skinfold measurements) Body mass index (calculated from height and weight)	—Females have a higher percentage body fat than males at all ages —Female body fat percentages increase rapidly during early and midadolescence followed by a plateau in late adolescence —Males increase in percentage body fat during late childhood and the preadolescent period —Males decrease in percentage body fat during early adolescence and maintain low fat levels throughout adolescence

slightly through age 18. These results are similar to mean mile walk/run times on the AAHPERD Health-Related Physical Fitness Test (HRPFT). However, the males tested in the HRPFT regressed slightly between ages 10 and 11, followed by steady improvement through age 14. This in turn was followed by a general plateauing of scores through age 17. It is difficult to explain the discrepancy in the slope of the two curves (Figure 17.2) at age 11, but this may be a function of the sampling techniques employed. (The HRPFT used a convenience sampling technique, whereas the NCYFS used a stratified random sampling technique.) Nevertheless, the similar slope of the two curves demonstrates that males improve in their mile walk/run times with age. That the boys in the NCYFS continued to improve until age 16 may be reflective of differences in aerobic activity patterns among boys between those sampled in the HRPFT and those in the NCYFS. Note, however, that for

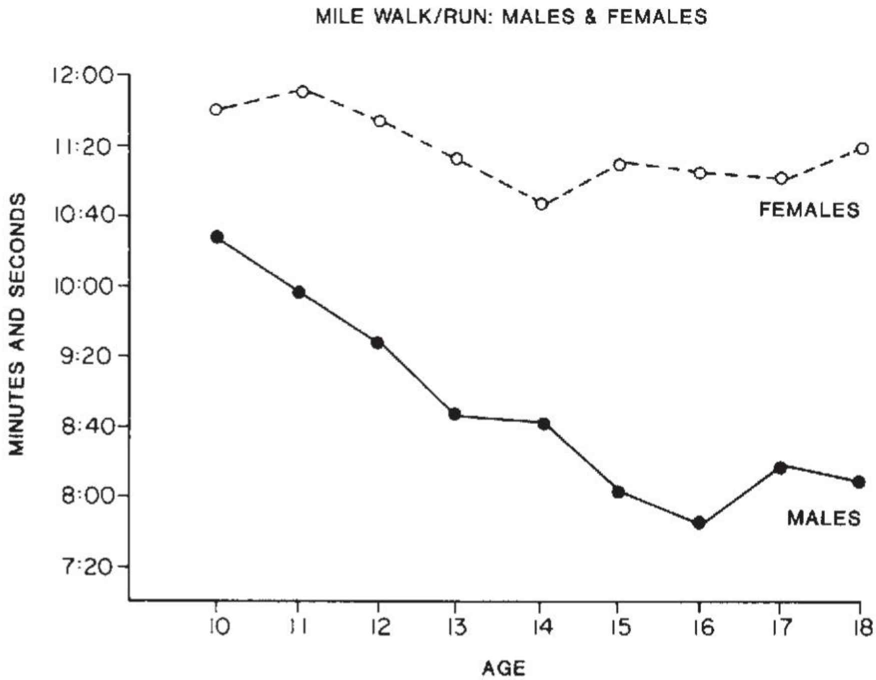

Figure 17.1

One-mile walk/run: mean scores for males and females 10–18 years, in minutes and seconds.

Source: Data from J. G. Ross et al., "The National Children and Youth Fitness Study: New Standards for Fitness Measurement" in *Journal of Physical Education, Recreation and Dance* (1985).

both tests, males, with age, tend to plateau after age 16 in their performance on the mile walk/run test. This should be viewed with concern in that it reflects a tendency toward more sedentary activity patterns in the older adolescent. The dropoff in scores coincides with the age at which most males are eligible to drive and work.

With regard to the performance of females on the mile walk/run test of aerobic endurance, the results are of similar concern. Although we might expect the male to outperform his female counterpart due to a variety of anatomical and physiological variables, we would hope to see a descending slope (i.e., lower times) over a longer period. Based on the results of the NCYFS, the female is closest to her male counterpart on the mile walk/run at age 10, and the gap between males and females remains roughly parallel until age 14. It widens, however, at a dramatic rate from then on (Figure 17.1). Although females performing on both the NCYFS and the HRPFT tended to improve with age until around 13 or 14 years, there was a decided tendency to regress and plateau in performance. The 18-year-old female is at almost the same level as her 12-year-old counterpart.

Data from the HRPFT tend to support those published in the NCYFS. However, females in the HRPFT peaked at an earlier age and regressed at a more rapid rate than those tested in the NCYFS (Figure 17.3). In studies where body size has been controlled for, laboratory tests of maximal aerobic power indicate that males increase through childhood and adolescence until about age 17 or 18. Females' maximal aerobic power continues to increase through childhood and puberty but levels off by age 14 (Bar-Or & Rowland, 2004). Sex

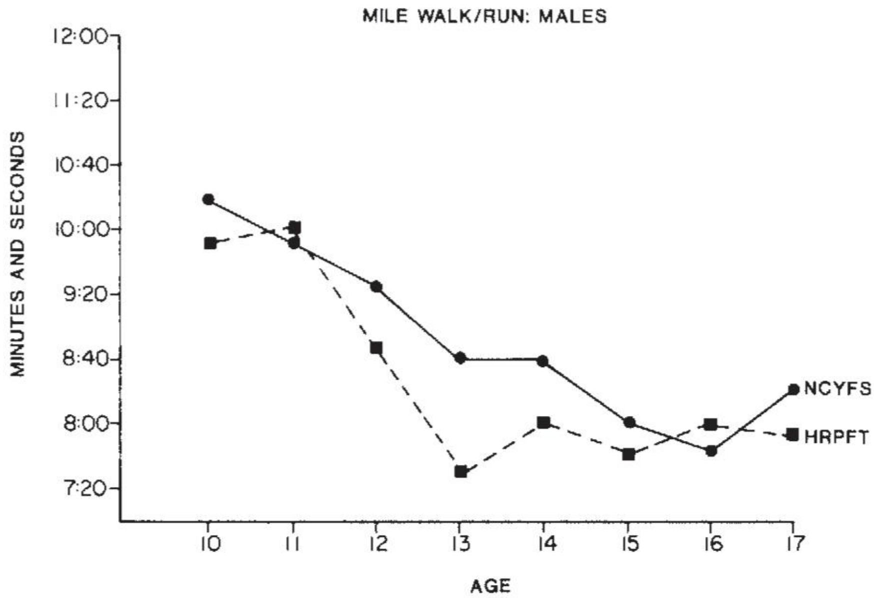

Figure 17.2
Comparison of one-mile walk/run scores between NCYFS and HRPFT: mean scores for males 10–17 years, in minutes and seconds.

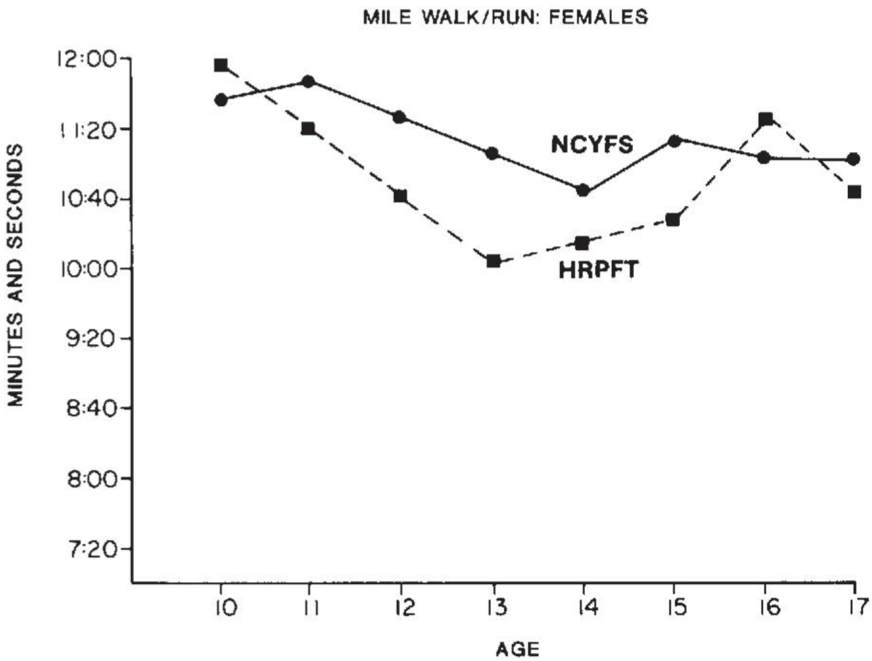

Figure 17.3
Comparison of one-mile walk/run scores between NCYFS and HRPFT: mean scores for females 10–17 years, in minutes and seconds.

differences become more pronounced, in favor of males, from later childhood through adolescence.

Muscular Strength and Endurance

Modified sit-ups and chin-ups are frequently used as field measures of *abdominal isotonic strength/endurance*. They are isotonic in that the muscles go through a full range of motion while in a contracted state. They are related to strength because a significant force is overcome, and they are related to endurance because a maximum number of repetitions is recorded. From 6 to 9 years of age both boys and girls are similar in their performance scores on the bent-knee sit-up test. However, from age 10 onward males improve at a much more rapid rate than their female counterparts. Figure 17.4 depicts males improving at a near linear rate from ages 11 to 16 with a tendency to level off and slightly regress from ages 16 to 18. However, for both males and females peak gains in strength typically occur within one year after peak height and peak weight velocities (Faigenbaum, 2000), although there is greater individual variation among females.

Figure 17.5's presentation of scores for chin-ups, a measure of upper-trunk strength and endurance, provides support for the contention that strength increases at a near linear rate for boys from about age 12 (the approximate age of onset of male puberty) through about age 18. Comparing mean scores from published norms on bent-knee sit-ups in the HRPFT reveals similar conclusions, although the boys tested on the HRPFT outperformed their age-mates on the NCYFS (Figure17. 6).

In female *upper-body strength/endurance* the data are somewhat different. Females appear to be weak in this area throughout childhood and adolescence. There appears to be no peaking followed by a plateau and gradual decline as previously thought. Rather, there is a consistently flat curve indicating low levels of upper-body strength/endurance at all ages. Females, however, seem to fare somewhat better on measures of abdominal endurance as measured by the NCYFS. Mean score values for the bent-knee sit-up test improve slightly with age. In terms of abdominal strength/endurance, older adolescents tend to score slightly higher than their younger counterparts. Mean score values for bent-knee sit-ups on the HRPFT revealed similar results, although females tended to perform at a higher level at all ages on the HRPFT (Figure 17.7).

DEVELOPMENTAL DILEMMA

What's Happening in Our Schools?

It is common knowledge that physical activity is extremely important for the health and well-being of children and adolescents. The medical community promotes physical activity as a disease prevention measure. Government agencies recognize it as a means to lower health care costs. Educational institutions realize its value in the overall development of all students. Then why is it that youth in the United States lead primarily sedentary lives? They sit in classrooms much of the day during the week, and when at home watch television or play video games. According to the *2010 Shape of the Nation Report* only five states require physical education in every grade in K–12, and only one state aligns with the nationally recommended 225 minutes of physical education per week in middle and high schools. In addition, over 60% of all states permit waivers and/or exemptions for students from taking physical education. To counter these discrepancies the National Association for Sport and Physical Education recommends that schools across the United States "make physical education the cornerstone of a comprehensive school physical activity program that also includes health education, elementary school recess, after-school physical activity clubs and intramurals, high school interscholastic athletics, walk/bike-to-school programs, and staff wellness programs" (NASPE, 2010).

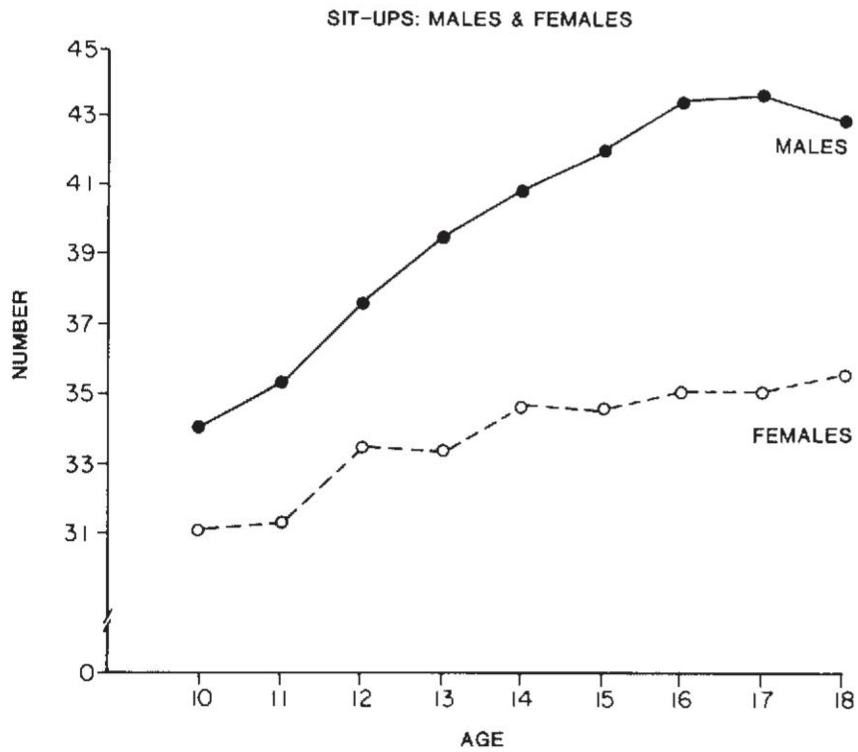

Figure 17.4

Bent-knee sit-ups: mean scores for males and females 10–18 years, number in 60 seconds.

Source: Data from J. G. Ross et al., "The National Children and Youth Fitness Study: New Standards for Fitness Measurement" in *Journal of Physical Education, Recreation and Dance* (1985).

> **CONCEPT 17.3**
>
> Females are comparable to males in abdominal strength and endurance prior to puberty, but males make significantly more rapid gains throughout adolescence.

Beunen and Thomis (2000) indicated that strength increases follow a general type of growth curve typically found for most external body dimensions, including height. Furthermore, in males there is a distinct spurt in strength that occurs within three months to one year of peak height velocity. For females there is a less dramatic increase in strength. The sudden upsurge by boys may be explained by their increased muscularity brought about by high levels of testosterone. Furthermore, the tendency on the part of males at all ages to "go all out" on measures of fitness may account for the vast discrepancy between males and females. Females do not improve at such a rapid rate perhaps because of greater amounts of fatty tissue in proportion to lean muscle mass. The tendency on the part of females to level off during mid- and later adolescence could also be a matter of motivation and lack of all-out enthusiasm rather than of purely physiological factors (Kraemer & Fleck, 2005). These are important points to consider. One must be careful to avoid the implication that no matter how hard females try to improve their performances on measures of strength and endurance they will fail. The data using motivated females suggest the opposite (Bar-Or & Rowland, 2004).

In fact, although in terms of absolute strength men are usually stronger than women because of

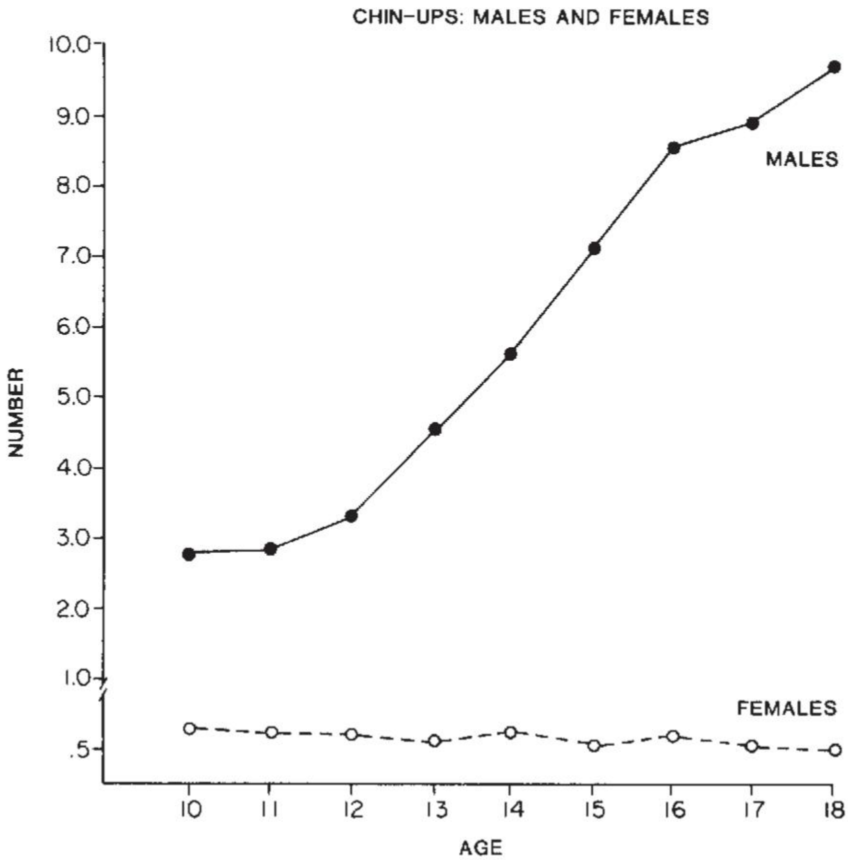

Figure 17.5

Chin-ups: mean scores for males and females 10–18 years, number completed.

Source: Data from J. G. Ross et al., "The National Children and Youth Fitness Study: New Standards for Fitness Measurement" in *Journal of Physical Education, Recreation and Dance* (1985).

their higher quantity of muscle, when compared to relative strength (i.e., muscle cross-sectional area) no significant differences in strength exist between the sexes (Faigenbaum, 2000).

The often dramatic differences exhibited between males and females and the span of years in which improved performances can be expected on measures of muscular strength and endurance should be examined carefully. Although males on the average can be expected to outperform females in measures of strength and endurance due to anatomical, physiological, and biomechanical advantages, there is not an adequate biological explanation of differences in the span of years over which relative improvements may be seen. A reasonable explanation may be based on social, cultural, and childrearing differences between males and females (Raudsepp & Viira, 2000).

CONCEPT 17.4

Males tend to make rapid gains in muscular strength and endurance throughout adolescence, whereas females tend to peak at the onset of puberty and regress slightly by the end of this period.

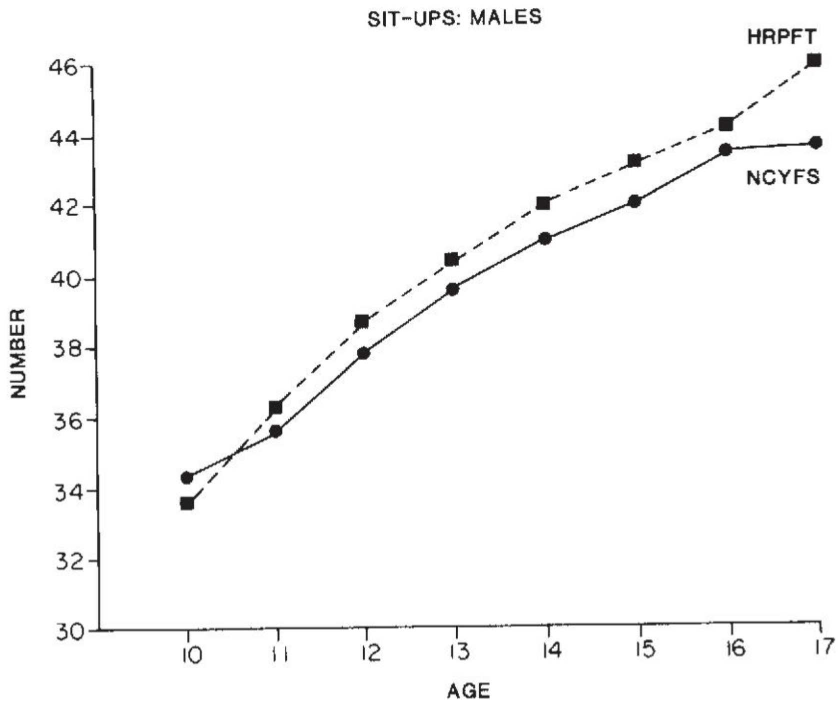

Figure 17.6
Comparison of bent-knee sit-up scores between NCYFS and HRPFT: mean scores for males 10–17 years, number in 60 seconds.

Flexibility

The sit-and-reach test has become the standard field measurement of *joint flexibility*. Data clearly indicate that on the average females make near linear improvements in sit-and-reach scores from ages 10 to 16, followed by a slight decline. Females at all ages outperform their male counterparts on this measure (Figure 17.8). Reasons for this discrepancy have not been adequately explained but may center around anatomical differences as well as sociocultural variances in activity patterns favoring joint flexibility in females (Malina, Bouchard, & Bar-Or, 2004).

There is a slight dropoff in sit-and-reach scores for males around age 12. This may be associated with the prepubescent growth spurt during which the long bones are growing faster than the muscles and tendons. As a result, performance of the sit-and-reach regresses until the muscles and tendons catch up. Also, both males and females begin to plateau and regress slightly in their flexibility scores around age 17. Decreases in joint flexibility during this period are clearly associated with a general decrease in the activity levels of the older adolescent and with aging. A high level of joint flexibility may be maintained well into adulthood and beyond if appropriate activities are maintained. In other words, the phrase "use it or lose it" applies. Loss of flexibility begins around age 17.

CONCEPT 17.5

As a population, females display greater joint flexibility throughout adolescence than their male counterparts, but both tend to regress over time due to reduced activity patterns rather than age.

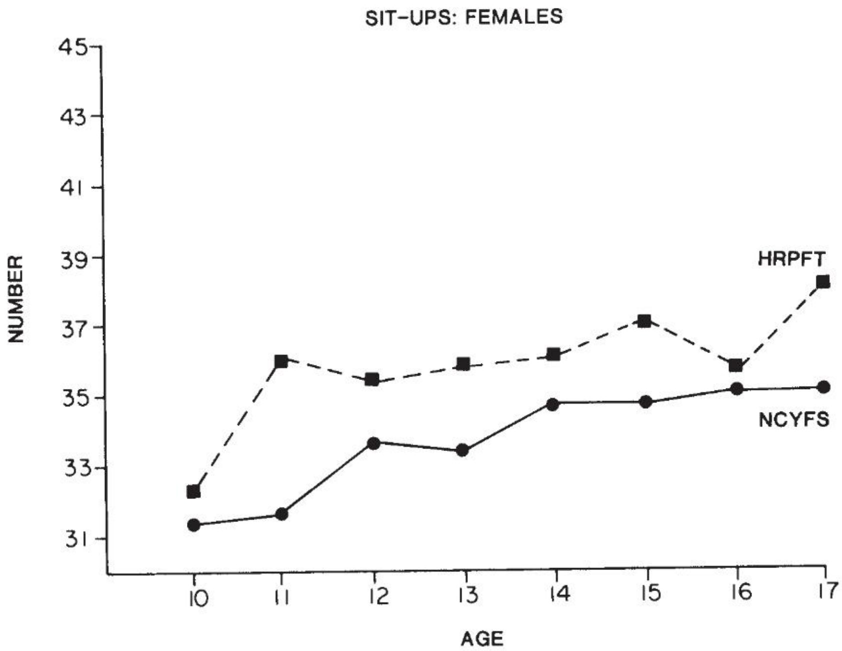

Figure1 7.7
Comparison of bent-knee sit-up scores between NCYFS and HRPFT: mean scores for females 10–17 years, number in 60 seconds.

Body Composition

The term *body composition* refers to the percentages of fat, bone, and muscle in the human body. It represents a major marker of health-related fitness. To accurately assess one's body composition, the percentage of body fatness needs to be separated from the other components of one's total body weight.

Hydrostatic weighing is an accurate, although inconvenient, method of determining percentage body fat. It involves submerging an individual under water and calculating his or her underwater weight from which an accurate estimate of percentage body fat can be calculated. Accurate hydrostatic weighing is not a practical measure for field-based assessments of body composition. Somewhat similar to hydrostatic weighing is the process of **air displacement plethysmography** (ADP). ADP incorporates air displacement in a chamber rather than water displacement in a tank. ADP tends to be more comfortable for the subject since he or she is not required to get wet. ADP accuracy tends to be high, but ADP chambers are relatively expensive.

Bioelectrical impedance analysis (BIA) has become a popular method of determining body composition due to its portability of equipment and ease of use. BIA measures the opposition to the flow of an electric current through the body fluids contained mainly in the lean and fat tissue. Impedance is low in lean tissue, but high in fat tissue. Computerized calculations provide an estimate of body fat percentage.

Despite their limitations, **skinfold calipers** and calculating one's **body mass index (BMI)** remain the preferred methods of estimating percentage body fat in the field. The reliability of the caliper technique has been frequently challenged, but when administered by trained personnel, it may yield fairly accurate results. Figures 17.9a and b depict body mass index for boys and girls from age 2 to 20, respectively (CDC, 2000). Although highly similar prior to puberty, there are increasing differences between the sexes throughout adolescence.

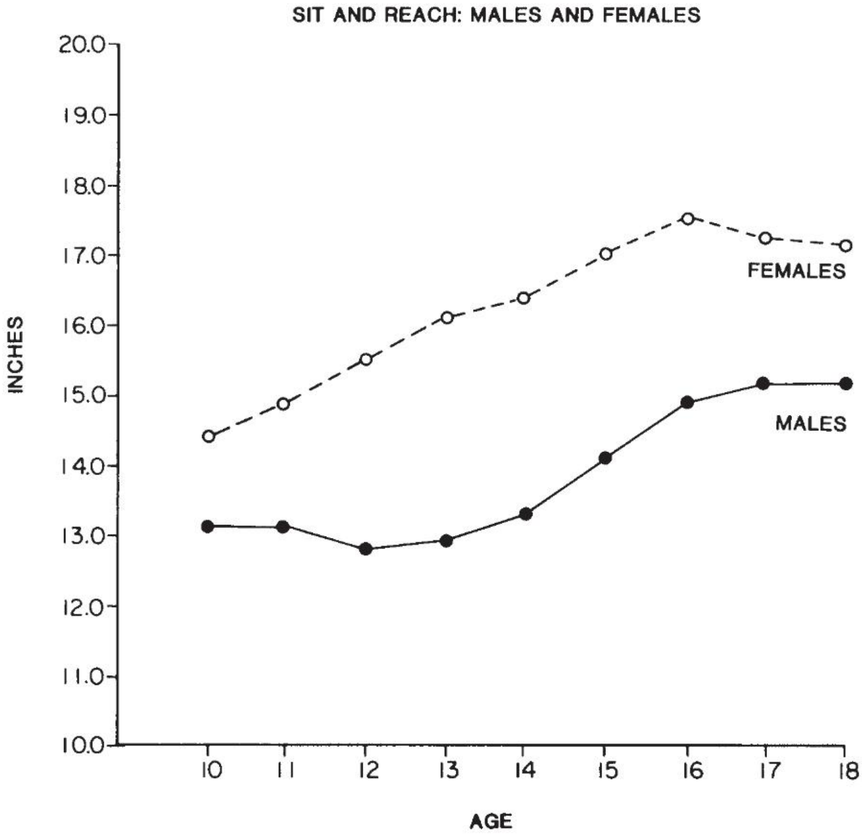

Figure 17.8

Sit-and-reach: mean scores for males and females 10–18 years, in inches.

Source: Data from J. G. Ross et al., "The National Children and Youth Fitness Study: New Standards for Fitness Measurement" in *Journal of Physical Education, Recreation and Dance* (1985).

CONCEPT 17.6

As a population, females steadily gain in percentage body fat measurements from preadolescence through adolescence.

CONCEPT 17.7

Male body fat percentages increase during the preadolescent period, decline sharply at puberty, and level off throughout adolescence.

When determining BMI status of children and adolescents the reference points of 85th and 95th percentile are considered the standard. For children aged 2–19 years, BMI of greater than or equal to the 85th percentile but less than the 95th percentile are classified as "at risk for overweight" while those at or above the 95th percentile are classified as "overweight." Some studies use the term *obese* for the 95th percentile while others classify obesity at the 97th percentile (Popkin & Udry, 1998; Swallen et al., 2005; Wang & Beydoun, 2007). When comparing BMI scores across recent decades, studies have indicated that on the average, the current generation of adolescents (12–19 years) are significantly fatter than their counterparts of previous

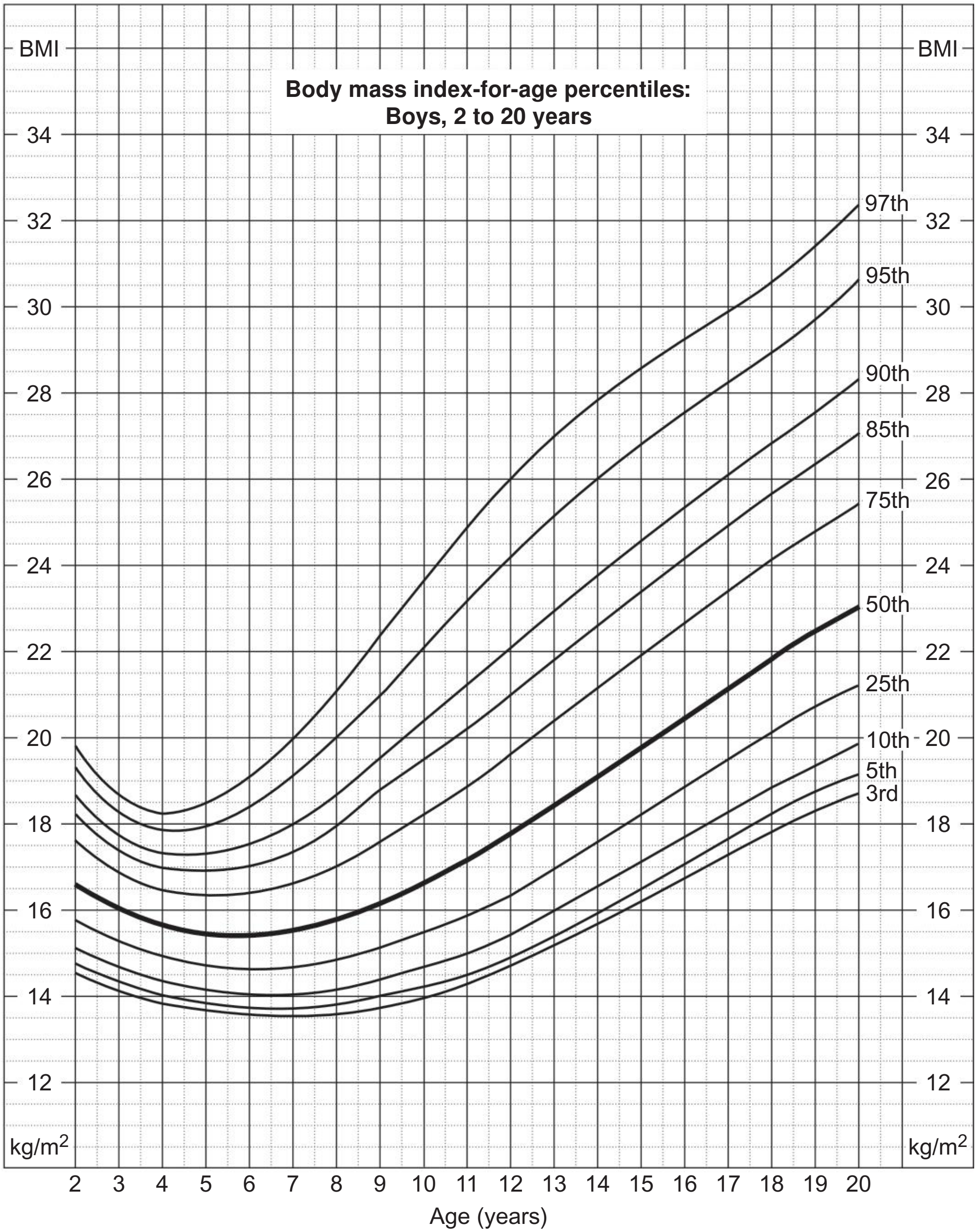

Figure 17.9a

Body mass index-for-age percentiles, boys, 2 to 20 years, CDC growth charts: United States.

Source: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).

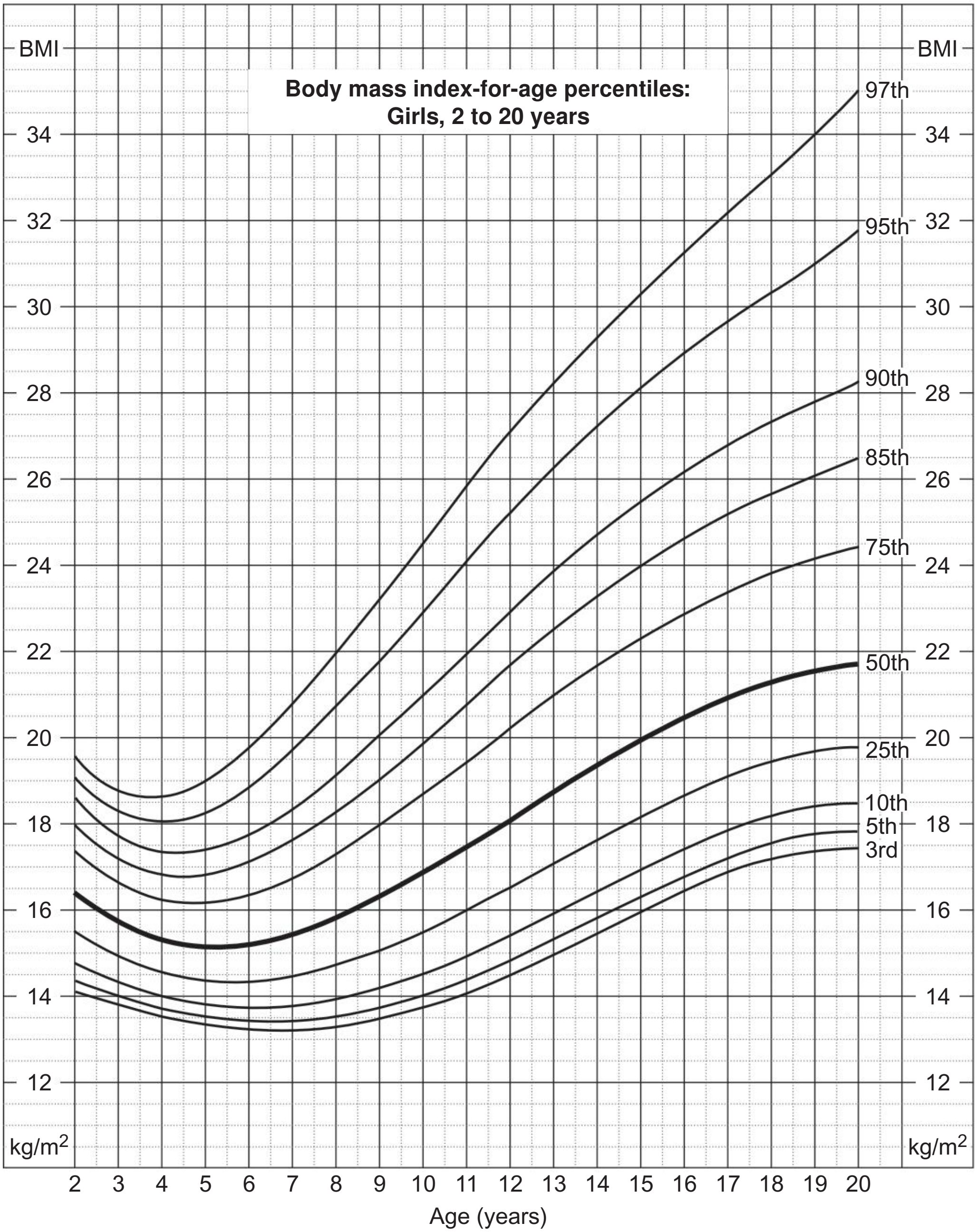

Figure 17.9b

Body mass index-for-age percentiles, girls, 2 to 20 years, CDC growth charts: United States.

Source: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).

TABLE 17.2 Current (2003–2004) Prevalence (%) of At Risk for Overweight + Overweight U.S. Adolescents (12–19 Years) by Racial/Ethnic Group

Gender	All	Non-Hispanic White	Non-Hispanic Black	Mexican American
Boys	36.8	38.7	31.4	37.3
Girls	31.7	30.4	42.1	31.1

generations (Wang & Beydoun, 2007). Data from the National Health and Nutrition Examination Surveys (NHANES) and the National Longitudinal Study of Adolescent Health (NLSAH) indicate that during 2003–2004 34% of adolescents between the ages of 12–19 years were classified as "at risk of overweight" or "overweight" (BMI $\geq$ 85th percentile). In that same group 17.4% were classified as "overweight" (BMI $\geq$ 95th percentile) (Wang & Beydoun, 2007). There is a trend toward increased fatness among different generations of American youth and across different racial/ethnic groups (Table 17.2). The findings from one study indicated that "Asian-American and Hispanic adolescents born in the U.S. are more than twice as likely to be obese as are the first-generation residents of the 50 states" (Popkin & Udry, 1998). Moreover, *The United States Youth Risk Behavior Survey* (CDC, 2003) revealed that over 59% of high school females were attempting to lose weight, while slightly more than 29% of their male peers were also attempting weight loss. The same survey also revealed a steady drop in vigorous physical activity by high school students, both female and male, from grades 9 through 12. To add to this concern, some studies estimate that between one half to 75% of obese adolescents were significantly more likely to maintain their obesity into adulthood (The et al., 2010; Wang & Beydoun, 2007). It has been suggested that the United States is an **obesogenic** culture due to its promotion of high energy intake and low energy expenditure.

Regular vigorous physical activity can alter body composition. Exercise coupled with caloric regulation will result in an increase in lean body mass and a decrease in percentage body fat in children, adolescents, and adults. The extent to which body composition can be altered depends on the degree and length of training. Alterations in body composition are not necessarily permanent. As activity levels decrease, body fat percentages increase. Parizkova (1982) demonstrated a significant relationship between physical activity levels and lean body mass percentages. Also, several researchers (Bandini et al., 1990; Bar-Or, 1983; Moore et al., 1991; Pate et al., 1999; Romanella et al., 1991) have noted that intensity of activity is significantly lower in obese children, adolescents, and adults. Lloyd and colleagues (2000) conducted a longitudinal study in which they looked at the cumulative long-term sport histories of eighty-one females with regard to bone mineral density. The results of their study showed that the amount of physical activity that distinguishes sedentary teenage females from those who are active on a nearly daily basis is related to a significant increase in bone mineral density favoring the active teenagers. Clearly, increased levels of physical activity coupled with moderation in caloric intake are keys to increasing bone mineral density in females, and to reducing the trend toward increased fatness in both males and females. The reader is referred to the policy statement of the American Academy of Pediatrics (2000) on *Medical Concerns in the Female Athlete,* including disordered eating, menstrual dysfunction, and decreased bone mineral density.

CONCEPT 17.8

Differences between males and females on measures of health-related and performance-related fitness are just that, differences, explainable by a variety of anatomical, physiological, and sociocultural factors.

> **INTERNATIONAL PERSPECTIVES**
>
> **Obesity Around the World**
>
> While undernourishment is a major concern for many nations around the world, it is also true that obesity has reached epidemic proportions globally. The International Obesity Taskforce (IOTF) of the International Association for the Study of Obesity (IASO) was established to serve as a research-based think tank whose multinational membership includes obesity experts whose responsibilities include obesity prevention and policy from a global perspective. The IASO/IOTF estimates that worldwide as many as 200 million school-aged children are overweight with 40–50 million classified as obese. Some countries are recording obesity levels that doubled in recent years. Obesity levels are becoming more prevalent in developing countries, as well. Recently the IOTF recognized the country of Brazil as a world leader in establishing policies to prevent obesity. These included actions such as regulating food marketing, monitoring obesity trends, and managing obesity. To see obesity data for countries around the world check out the IOTF's interactive map at http://www.iaso.org/iotf/obesity/.

PERFORMANCE-RELATED FITNESS

The *motor fitness* components of speed, power, agility, balance, and coordination are generally considered to be the performance- or skill-related components of fitness. These differ considerably from the health-related components of fitness in that they are genetically dependent, resistant to major environmental (experiential) modifications, and relatively stable. Also, these traits are closely related to skillful performance in a variety of sports.

Quantitative changes in a variety of gross motor skills have been studied by several investigators over the past several decades. As a result we have a wealth of information on the performance capabilities of males and females from childhood to adulthood. It is even possible to compare performance scores between generations and arrive at some tentative conclusions concerning secular trends in motor performance on selected skills. Haubenstricker and Seefeldt (1986) presented data summaries for four motor performance items assessed by a variety of investigators prior to 1960 and since 1960. Three of these—running for speed, jumping for distance, and throwing for distance using the post-1960 data—are summarized in the following sections and presented in Table 17.3.

Running Speed

Running speed may be assessed across studies that use different distances by converting dash times, usually 30- to 60-yard (27.4–54.8 m) dashes, to units of yards covered per second. To further standardize measurements, Haubenstricker and Seefeldt (1986) reported that only those studies that used a stationary start were included. The results of these comparisons led them to conclude that:

> There is systematic improvement in the running speed of children during the middle and late childhood years. This improvement in running speed continues during the teenage years for males. The running speed of post-1960 females increases until age 15, after which time it appears to plateau. (pp. 67–69)

Figure 17.10 graphically depicts changes in running speed with age from childhood through adolescence. Running speed is similar in boys and girls, only slightly favoring the boys, throughout childhood. However, beginning at about age 12, males begin to make more rapid improvements while their female age-mates begin to plateau. Reasons for the early plateauing on the part of adolescent females may be explained, in part, by early maturation and lower levels of personal motivation as compared with their late-maturing and often more highly motivated male age-mates. Figure 17.11 illustrates comparable results in actual age changes in running the 100-yard (91.4 m) sprint run.

TABLE 17.3 Common Field Measures of Adolescent Motor Fitness and a Synthesis of Findings

MotorF itness Component	CommonF ield Measures	Synthesis of Findings
Speed	30-t o6 0-yardd ash	—Boys and girls are similar throughout childhood —Boys outperform girls at all ages —Males make more rapid improvement after puberty than females —Males make significant annual gains throughout childhood and adolescence —Females tend to plateau in midadolescence
Muscularp ower (Lower trunk)	Jump for distance Jump for height	—Boys and girls are similar throughout childhood —Boys slightly outperform girls during childhood, but the gap widens significantly at male puberty
Muscularp ower (Upper trunk)	Throwf ord istance	—Males make significant annual increments throughout adolescence —Females begin to plateau during early adolescence and regress by midadolescence
Balance		
Staticb alance	Stabilometer Stick balance 1-foot balance	—Males and females make significant qualitative, as well as quantitative, improvements with age
Dynamicb alance	Beamw alk	—Males make rapid improvement at all ages but especially after puberty —Females and males improve with age throughout childhood and adolescence —Females tend to outperform males during childhood on both static and dynamic measures —Males and females are similar on both static and dynamic measures throughout adolescence with no clear advantage for either

CONCEPT 17.9

The gap between males and females widens considerably in favor of males from puberty onward on measures of speed and power.

Jumping for Distance

Jumping for distance, a purported measure of muscular power, has been assessed in a large number of studies. In summarizing performance scores of children and adolescents 5 to 17 years of age, Haubenstricker and Seefeldt (1986) found that males only slightly outperform females, and that there is steady improvement for both from ages 5 to 14 (Figure 17.12). After that females begin to level off and may even decline. Males, however, continue to improve at a linear rate to about age 17 (Figure 17.13). The discrepancy between males and females on the standing long jump that begins to appear after age 12 and the widening gap may be explained in a variety of ways.

First, jumping for distance incorporates an element of strength. Males from puberty onward demonstrate dramatic strength gains, whereas their female counterparts, because of low levels of circulating androgens, tend to level off in their strength. Therefore, a widening of the gap at this time is to be expected. The tendency of females to regress may also be explained by lack of motivation or increasingly sedentary lifestyles. Changes in body proportions

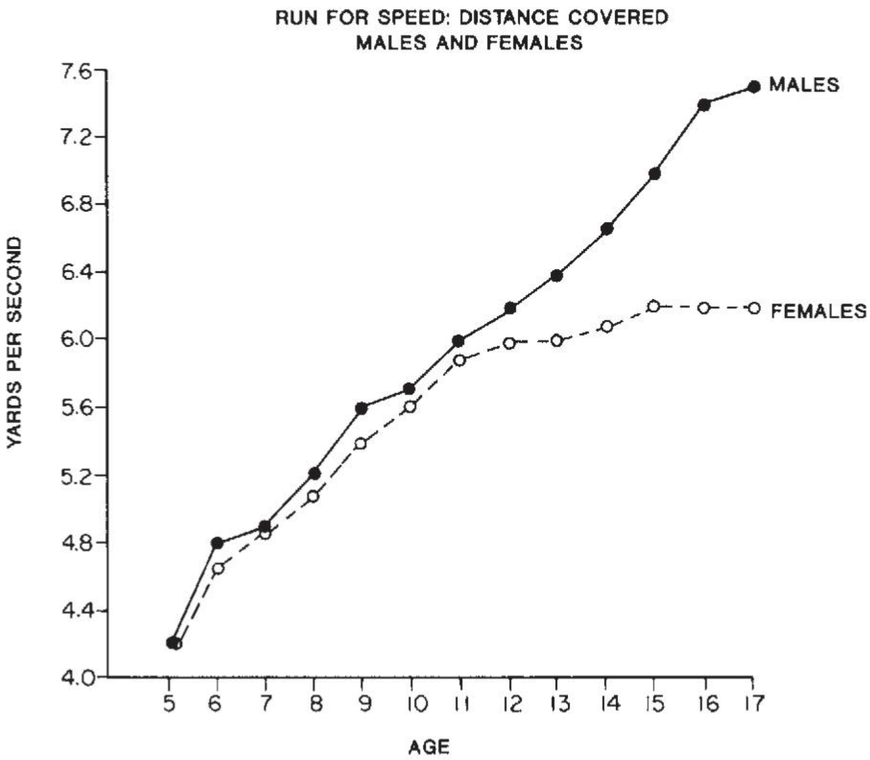

Figure 17.10

Age changes in running speed: mean scores for males and females 5–17 years, from post-1960 studies.

Source: Data from J. Haubenstricker and V. Seefeldt, "Acquisition of Motor Skills During Childhood" in V. Seefeldt (Ed.), *Physical Activity and Well-Being,* 1986 (Reston, VA: AAHPERD).

and lower centers of gravity may also contribute to these changes (Malina, Bouchard, & Bar-Or, 2004).

Throwing for Distance

Throwing for distance is a frequently used measure of muscular power in the upper extremities. As with running for speed and jumping for distance, skill enters into the equation and it may be biased against individuals, both male and female, who have not had sufficient throwing experiences. Those who run, jump, or throw at the mature stage are likely to score well on performance measures that incorporate these skills. The contribution of a mature pattern is no more evident than in throwing for distance. Immature throwers are at a distinct disadvantage. Therefore, significantly lower mean performance scores for females throughout childhood and adolescence may be due to lower skill levels rather than weakness in the upper arm and shoulder girdle area (Malina, Bouchard, & Bar-Or, 2004). Figure 17.14 clearly shows significant differences between males and females at all ages, and the gap only widens with age. Males experience a significant upsurge in performance scores around age 13 corresponding roughly with the onset of puberty. Females, however, demonstrate a much more gradual increase to age 15 followed by a tendency to regress slightly. Reuschlein and Haubenstricker (1985) offered the best explanation for these dramatic differences between genders. In their study of the throwing patterns of fourth, seventh, and tenth graders, 51, 61, and 70% of the males, respectively, threw with "good form" at what may be considered the mature

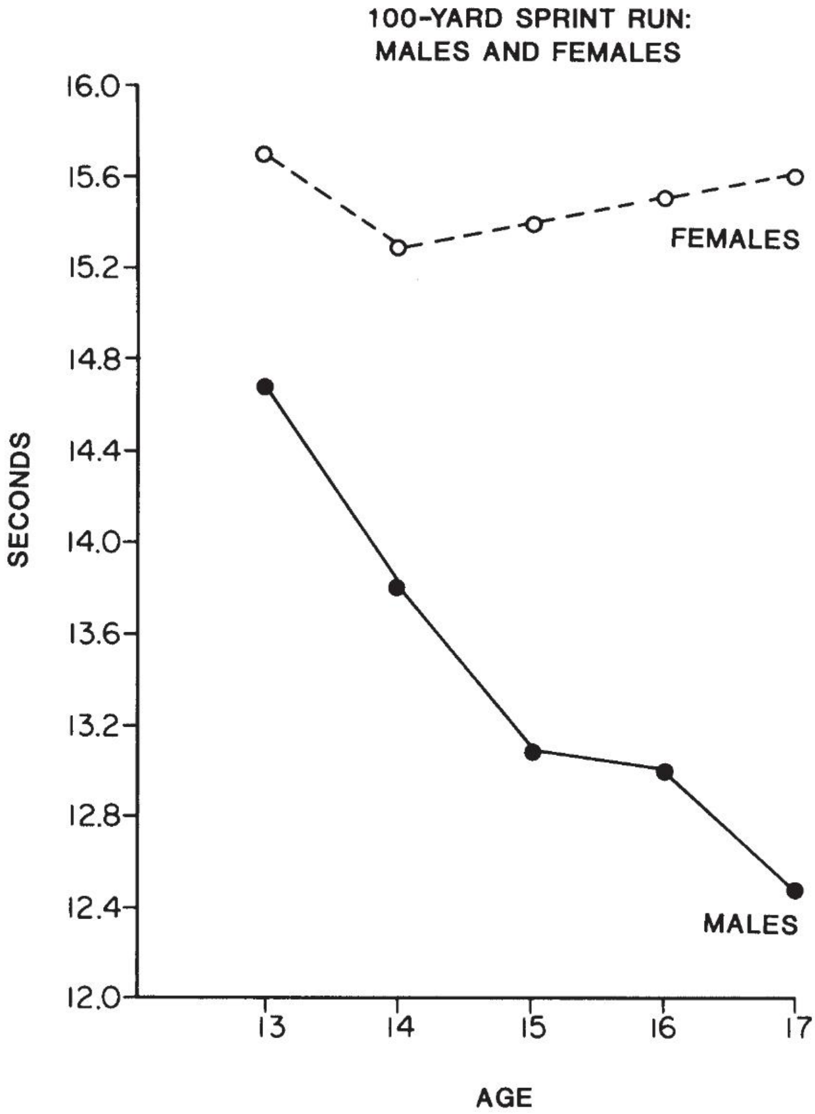

Figure 17.11
100-yard sprint run mean scores for males and females 13–17 years, in seconds.
Source: Data from J. G. Ross et al., "The National Children and Youth Fitness Study: New Standards for Fitness Measurement" in *Journal of Physical Education, Recreation and Dance* (1985).

stage, but only 15, 19, and 23% of the females, respectively, threw at the mature stage.

Balance

Williams (1983) found in her review of age and gender differences in balance performance that, in general, balance improves from ages 3 to 18. Difficulty, however, exists in directly comparing the abundant information that exists on balance. A wide variety of measures have been used over the years to assess both *static balance* and *dynamic balance,* and, as a result, comparisons between studies are not possible. It is possible, however, to conclude

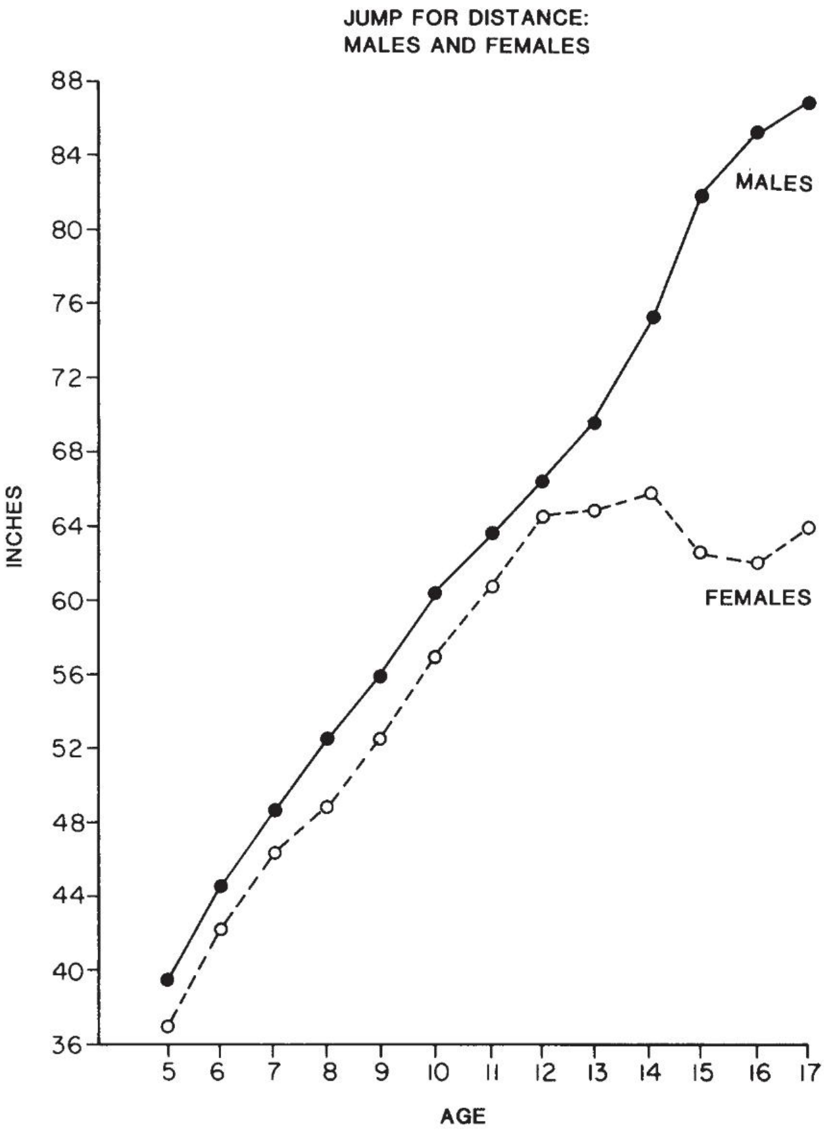

Figure1 7.12

Age changes in standing long jump: mean scores for males and females 5–17 years, from post-1960 studies.

Source: Data from J. Haubenstricker and V. Seefeldt, "Acquisition of Motor Skills During Childhood" in V. Seefeldt (Ed.), *Physical Activity and Well-Being,* 1986 (Reston, VA: AAHPERD).

that balance tends to improve with age through childhood and adolescence. Furthermore, females tend to outperform males on measures of both static and dynamic balance during childhood, but females appear to have no clear advantage during adolescence (Malina, Bouchard, & Bar-Or, 2004).

CONCEPT 17.10

Although females tend to outperform males on measures of balance during childhood, no clear pattern appears to exist during adolescence.

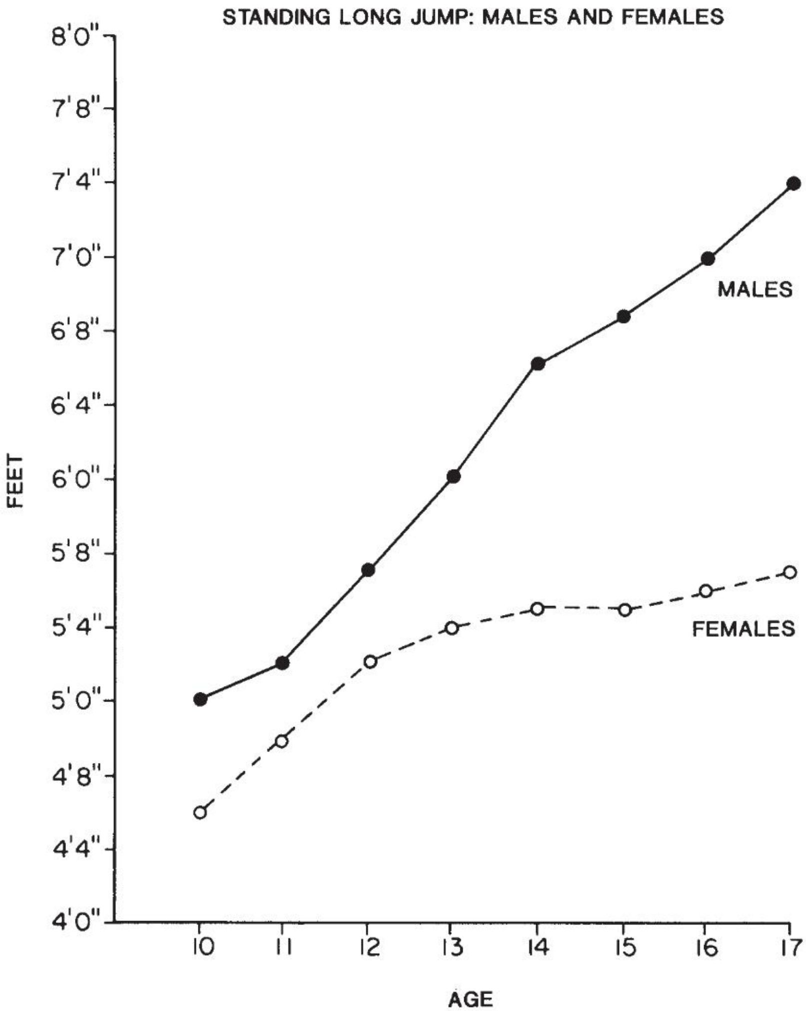

Figure 17.13

Standing long jump mean scores, for males and females 10–17 years, in feet.

Source: Data from J.G. Ross et al., "The National Children and Youth Fitness Study: New Standards for Fitness Measurement" in *Journal of Physical Education, Recreation and Dance* (1985).

SUMMARY

The health-related and performance-related fitness of the adolescent undergoes dramatic changes from the beginning of the adolescent period to later adolescence. In general, boys and girls are similar throughout childhood on most measures of fitness. The onset of the preadolescent growth spurt marks the beginning of a rapid acceleration in fitness scores for males. This may be associated with a variety of physical as well as social and cultural factors. Females on the other hand do not display the same rapid improvements as do their male counterparts. There is a decided tendency for adolescent females to improve at a lower rate to about age 15 where they frequently begin to plateau and sometimes regress in their performance.

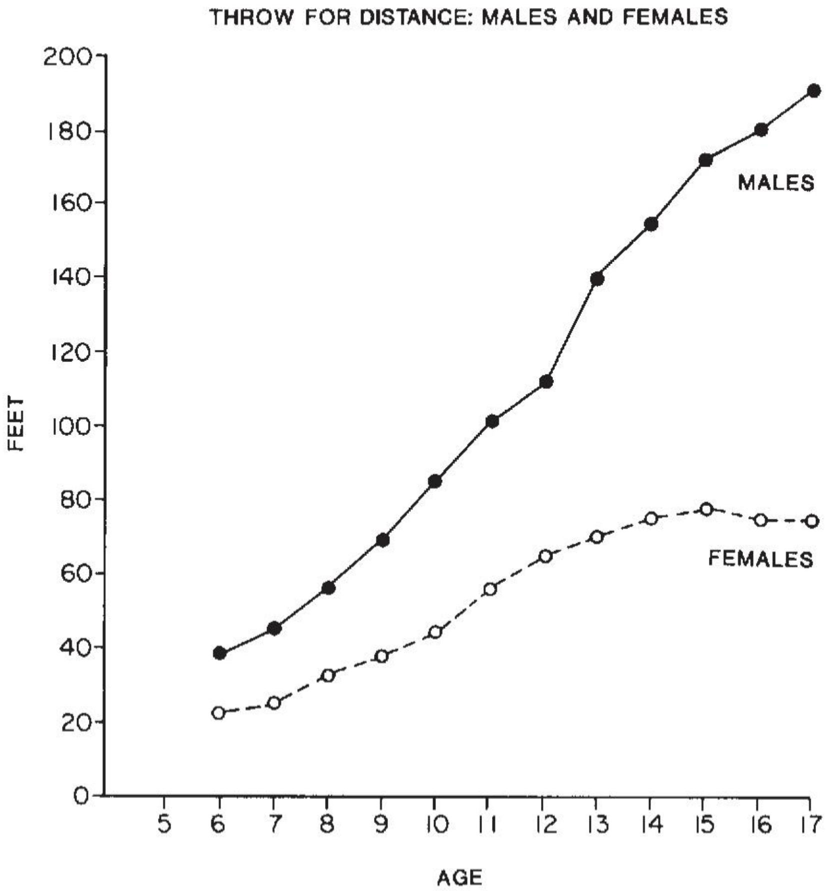

Figure 17.14

Age changes in throwing for distance: mean scores for males and females 6–17 years, from post-1960 studies.

Source: Data from J. Haubenstricker and V. Seefeldt, "Acquisition of Motor Skills During Childhood" in V. Seefeldt (Ed.), *Physical Activity and Well-Being,* 1986 (Reston, VA: AAHPERD)

Although males, on the average, can be expected to outperform females in measures of strength and endurance due to anatomical, physiological, and biomechanical advantages, there is not an adequate biological explanation of differences in the span of years over which relative improvement may be seen. A reasonable explanation may be encountered in social and cultural differences and childrearing differences between males and females.

Health-related fitness measures are susceptible to considerable improvement in both males and females. As activity patterns change—we hope for the better—we can anticipate changes in the slope of the performance curves for both males and females.

The success of programs designed to promote a positive state of adolescent health through increased physical activity depends on a multidisciplinary approach. Such an approach actively strives to provide youth with new and relevant information about the how and why of increased physical activity and proper nutrition. This must be done in a manner that promotes learning enjoyment as well as personal responsibility and decision making.

An International Consensus Conference on Physical Activity Guidelines for Adolescents developed two general guidelines believed to improve several health outcomes for all adolescents, while at the same time to minimize known risks. "All adolescents should be physically active daily, or nearly every day, as part of play, games, sports, work, transportation, recreation, physical education, or planned exercise, in the context of family, school, and community activities" (Sallis & Patrick, 1994, p. 307). Furthermore, "Adolescents should engage in three or more sessions per week of activities that last 20 min. or more at a time and that require moderate to vigorous levels of exertion" (Sallis & Patrick, p. 308).

On the average, today's adolescents are in poorer physical condition than their parents were at the same age. Regular, vigorous physical activity must be recognized as a cost-effective means for promoting normal growth and development during adolescence. Failure to do so will only contribute to the decline in the health status of North American youth.

Questions for Reflection

1. Why is it important for K–12 educational institutions to enhance their commitment to physical education?
2. Why is childhood and adolescent obesity considered an epidemic?
3. What are some of reasons why we see developmental differences in the health-related and performance-related fitness components between boys and girls?

Critical Readings

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Web Resources

http://www.aahperd.org/naspe/publications/Shapeofthenation.cfm

The *2010 Shape of the Nation Report: Status of Physical Education in the USA* provides a current picture of physical education (PE) in the American education system.

http://healthyamericans.org/reports/obesity2010/

F as in Fat: How Obesity Threatens America's Future 2010 is a report from the Trust for America's Health and the Robert Wood Johnson Foundation. In addition to the report the website provides an interactive map with state-by-state data related to overweight/obesity rankings.

http://aappolicy.aappublications.org/cgi/content/full/pediatrics;107/6/1470

This web page contains the American Academy of Pediatrics' policy statement related to strength training with children and adolescents. Developmental guidelines and recommendations are provided.

http://www.cdc.gov/HealthyYouth/physicalactivity/index.htm

The National Center for Chronic Disease Prevention and Health Promotion at the Centers for Disease Control and Prevention provides information on health and physical activity for healthy youth.

http://www.nhlbisupport.com/bmi/bmicalc.htm

The National Institutes of Health's National Heart, Lung, and Blood Institute provides an online calculator for determining your body mass index.

http://www.nsca-lift.org/

The National Strength and Conditioning Association homepage. The NSCA is a nonprofit organization dedicated to providing the most advanced information on strength training, conditioning, and injury prevention through researcha ndp rofessional networking.

UNIT V

Adulthood

Age does not depend upon years,
but upon temperament and health.
Some men are born old,
and some never grow so.

—*Tyron Edwards*

CHAPTER

18

PHYSIOLOGICAL AND PSYCHOSOCIAL DEVELOPMENT IN ADULTS

KEY TERMS

Tasks pecificity
Interindividualv ariability
Intraindividualv ariability
Gerontology
Senescence
Geneticsw itchingt heory
Geneticm utationt heory
Freer adicalt heory
Homeostasis
Antioxidants
Osteoporosis
Osteopenia
Sarcopenia
Brainp lasticity
Agem arkers
Hypoxia
Arteriosclerosis
Atherosclerosis
Senilem iosis
Presbycusis
Activityt heory
Disengagementt heory
Retirement
Ageism
Successfula ging

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Discuss the limitations of generalizing about declines during the adult years
- Describe how the interaction among characteristics of the individual, the nature of the task, and the environmental conditions affects the motor performance of adults
- Discuss how the concepts of task specificity, interindividual variability, and intraindividual variability influence the success levels of adult motor performance
- Describe the theories of aging related to cellular changes, the human immune system, and homeostasis
- Identify age-related changes in the musculoskeletal system
- Identify age-related changes in the central nervous system
- Identify age-related changes in the circulatory and respiratory systems
- Identify age-related changes in body composition
- Identify age-related changes in the sensory systems
- Discuss the relationship between the motor and psychosocial domains
- Discuss the effects of exercise on select psychological factors of middle-aged and old-aged adults
- Discuss the importance of a physically active lifestyle as it relates to activity theory and disengagement theory
- Describe how remaining physically active can enhance the retirement process
- Define ageism and recognize its various forms
- Describe the importance of health and physical activity as important predictors of longevity and successful aging

KEY CONCEPT

Throughout adulthood, changes in the body's physiological systems may influence motor performance and may represent a mechanism of the aging process.

Decade after decade the average lifespan of human beings has reflected a steady increase. In fact, a person born in 1900 had an average life expectancy of about 47 years, whereas a person born today has a projected average life expectancy of more than 77 years. Continual improvements in health care, disease reduction, and lifestyle changes have resulted in steady increases in the average number of years both men and women live. As a result, more older adults are represented in the general population. Likewise, with increased medical interventions and improved lifestyle behaviors many more adults are living and will live into their eighties and nineties (Figure 18.1) (U.S. Census Bureau, 2008).

As we enter adulthood, we experience a number of physical and physiological changes that affect our behavior. Likewise, as we continue through the life span, changes in our affective and cognitive abilities alter how we respond to our environment. As discussed in earlier chapters, these domains are not mutually exclusive but are intricately interrelated. These relationships are evident when an older individual compensates for an age-related slowing of reaction time by using different cognitive strategies to accomplish a task. We also see the association between the different domains when older individuals experience declines in self-competency and self-esteem as age-related changes in muscular strength begin to limit their abilities to perform functional daily living skills.

CONCEPT 18.1

As we advance through adulthood, aspects from our motor, cognitive, and affective domains interact to affect motor behavior.

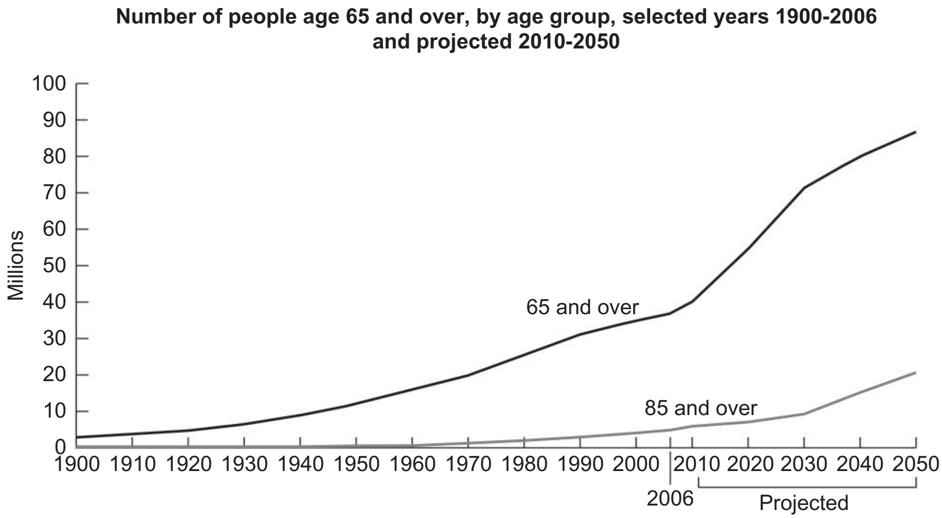


Figure1 8.1

Total number of persons age 65 or older, by age group, 1900 to 2050, in millions.

Note: Data for the years 2010 to 2050 are middle-series projections of the population. Reference population: These data refer to the resident population.

Source: Federal Interagency Forum on Aging-Related Statistics. *Older Americans 2010: Key Indicators of Well-Being.* Federal Interagency Forum on Aging-Related Statistics. Washington, DC: U.S. Government Printing Office. July 2010.

When we generalize about behavior and performance across the life span, we usually make the observation that individuals experience continual improvement from infancy through adolescence, a leveling off during young adulthood, a slow decline during middle adulthood, and a much greater decline during older adulthood. A major problem emerges, however, when we describe a complex event like human development in such simplistic terms. This oversimplified perception of the aging process can place unrealistic expectations on young children and unnecessary limitations on older adults. In adulthood some functions follow the general pattern, but other characteristics show no signs of deterioration, and some show the capacity for continual improvement. Spirduso and MacRae (1990) point out that variability in the motor performance of adults increases with each decade of life. "The descriptions of 'average' behavior for specific age groups grow less and less accurate for an individual's performance as the age of the group increases" (p. 183).

The motor behavior exhibited by an individual depends on the interaction of a number of variables categorized by: (1) the nature of the task; (2) the environmental conditions; and (3) the cognitive, affective, and psychomotor characteristics of the individual. The nature of a task involves such elements as degree of difficulty, duration, and the need for speed or accuracy. An older adult whose vision has weakened may not be able to perform a specific task successfully if it involves speed. If, however, there are no time requirements, the individual may complete the task with a high degree of success.

CONCEPT 18.2

Although many age-related changes reflect general trends, individual characteristics play a major role in determining whether a person follows those trends.

Examples of the environmental conditions that may influence motor behavior include room temperature, lighting, floor surface texture, and degree of familiarity of surroundings. An older individual with an age-related slowing of the circulatory

INTERNATIONAL PERSPECTIVE

How Long Will I Live?

Life expectancy refers to the average number of years that a newborn in a specific population is expected to live if the mortality rates that exist today continue to apply. According to the statistics reported by the World Health Organization the "average" citizen of the United States can expect to live around 78 years. Other countries with an average life expectancy in the seventies include the United Kingdom, Mexico, Brazil, and China. Those countries whose life expectancies reach the low eighties include Australia, Canada, and Switzerland. In stark contrast are the countries of Afghanistan and Sierra Leone, both with an average life expectancy in the forties. A multitude of factors play a role in a particular country's life expectancy. Some significant factors include the country's malnutrition levels, disease prevalence, and infant mortality rates. Genetic and hereditary characteristics play an important role, as well. In most cases the economic status of a country is highly influential. For example, Zimbabwe, whose life expectancy is the lowest listed at 42 years, holds a World Economic Forum ranking of 132 out of 133 measured countries for global economic competitiveness. Japan, on the other hand, has the highest average life expectancy, 83 years. Economically Japan ranks second in the world in gross domestic product. By incorporating a more global perspective in their research, gerontologists are exposed to a wealth of information as they examine the aging process for all humans.

system will likely feel uncomfortable in a cool room. Discomfort and stiffness could limit the person's ability to complete required tasks.

The third category related to motor behavior pertains to the state of the individual. In reference to the cognitive domain, the ability to understand skill instructions is vital to the successful completion of a motor task. An inability to follow verbal instructions may be the result of an age-related loss in hearing, which could prevent or restrict pertinent information from reaching otherwise healthy processing centers of the brain. On the other hand, an older person who appears to have trouble understanding verbal instructions may have Alzheimer's disease (a disease that greatly affects cerebral functioning). Affective domain characteristics that may influence motor behavior include motivation, peer relationships, and self-confidence. An older adult who has recently lost a spouse or a close friend may lack the motivation to be physically active or to try hard in the performance of a motor task he or she regards as unimportant. Finally, in the motor domain, physiological changes play a crucial role in the performance of a motor task. Older adults usually experience declines in muscular strength, vision, and other systems. These age-related changes are discussed in greater detail later in this chapter.

CONCEPT 18.3

Individual characteristics, demands of the task, and environmental circumstances are major factors in determining the level of success experienced by the adult in performance of a motor task.

In reviewing various aspects of motor performance in the adulthood years, three key principles emerge. The first of these is that the maturity or success of the performance of a motor task is **task specificity**. The generalization that the motor performance of an individual will deteriorate with age may be true for some tasks but certainly not for all. The degree of performance success depends on the specific demands of the task. Does the task require speed of movement, accuracy, or both? Does the task require a specific amount of joint flexibility or cardiovascular endurance? Does the task require a great deal of memorization? As we mentioned earlier in this chapter, certain physiological systems will experience age-related functional decline through adulthood, whereas other physiological systems may remain relatively unchanged. If the demands of a particular task require an individual to use a physiological system in decline, performance may be less than ideal. If, however, the motor task demands require the use of healthy physiological systems, no physiological limitations should prevent the individual from performing the task successfully. Other limiting factors (i.e., constraints) may impair task performance, but these also follow the concept of task specificity. A high degree of room illumination may be necessary for the completion of one task, whereas it may have little or no bearing on whether another task is completed successfully.

CONCEPT 18.4

The aging of different physiological systems varies among adults and within individual adults.

A second principle that emerges from this review is that there is a tremendous amount of **interindividual variability** in how people age. Both genetics and lifestyle play vital roles in determining the life spans of individuals. A person who has a lineage of nonagenarians (persons 90 years of age or older, but less than 100) probably has in her genetic blueprint the makings of a long life. Her lifestyle choices will affect whether her longevity will reach its genetic potential. Level of physical activity, smoking, stress, drug abuse, and diet are important lifestyle variables that impact the number of years we live. Similarly, in the area of motor performance in adults, a certain physiological system may deteriorate more slowly in one individual than in another because of genetic differences. If a motor task requires a high degree of muscular strength, for example, the person who genetically loses muscular strength at a slower rate may have an easier time completing the task than a person whose ancestors tended to experience strength loss more rapidly. An individual's lifestyle choices may affect various physiological systems and, in turn, may influence the performance of a motor task dependent on the healthy functioning of those physiological systems. A number of additional variables affect the outcomes of motor tasks. We cannot isolate a single variable and predict the likelihood of success. We can, however, realize that genetic blueprints and lifestyles vary widely and consequently affect the motor performances of specific tasks in different ways, depending on requirements of the tasks.

This leads to the next principle of **intraindividual variability**. Individual physiological systems do not necessarily experience age-related declines at the same rate. Certain physiological characteristics will begin to decline in early adulthood, and others wait until later. Still other characteristics will not experience declines at all. Generalizing about an individual's overall developmental rate without considering variations among her or his personal characteristics may limit the individual's movement potential.

Combining the three principles of task specificity, interindividual variability, and intraindividual variability with the knowledge that motor performance can vary in accordance with the requirement of the task, the environment, and the biology of the individual provides us with the foundation to evaluate the motor performance of adults from an individual basis rather than a generalistic approach. A percentage of the adult-aged population will face limitations and stereotyping when their performances are evaluated with a generalistic approach. As with children and adolescents, the motor performance of adults should be assessed using individual characteristics following their individual developmental rates.

Why Do We Age?

The scientific endeavor that seeks to understand the aging process is referred to as **gerontology**. Gerontologists represent such disciplines as biology, psychology, and sociology. These professionals study the various aspects of aging in an attempt to identify the mechanisms that cause people to age and how aging affects the daily lives of individuals. Normal biological aging occurs as a result of a gradual, time-related process that takes place as degenerative physiological events overtake regenerative physiological events. This process is referred to as **senescence**. If a person lives long enough he or she will experience senescence. Diseases, on the other hand, that affect individuals in middle and later adulthood are not representative of senescence as they are contracted by some individuals and not others. Studying 54,000 adults between the ages of 30 and 70 years Sehl and Yates (2001) estimated the rates of senescence for thirteen different biological functions and organ systems to range from 0 to 3% each year.

A number of theories seek to provide the answer to the age-old question "Why do we age?" Many early theorists suggested that the human body simply wears out through the wear and tear of daily living. They compared the human body to a machine that breaks down and wears out parts with continual use (and sometimes abuse). The performance of the machine deteriorates, and it eventually ceases to operate. This analogy suggests that deterioration is a continual process. Although this may be the case with some human characteristics, it is not representative of the total aging process. To the contrary, numerous investigations have demonstrated that the use of the human body (i.e., through exercise and physical activity) can slow, stop, or in some cases reverse aspects of age-related deterioration. Chodzko-Zajko (1999a) points out "it is well established that significant physiological, psychological, social, and societal benefits accrue from participation in physical activity and that the benefits of a physically active lifestyle extend throughout the lifespan" (p. 213). Another major problem associated with a wear-and-tear theory of aging is that it is difficult if not impossible to determine whether changes in a specific body system cause aging or are the outcome of a basic genetic, cellular, or molecular process (Hoyer & Roodin, 2009).

CONCEPT 18.5

Changes at the cellular level, at the immune system level, and/or in the interaction of the physiological systems may represent the underlying causes of aging.

A number of other theories have been presented to address the question of why we age. The level at which these theories approach the aging question range from the cellular to the whole organism.

At the cellular level we are interested in what happens to the integrity of the cells of the human body during aging. Every part of the body is structured of cells. Each cell has a specific function and possesses the genetic material to accomplish that function. Cells divide and increase in number for growth, maturation, and/or maintenance of a particular organ or tissue. What has been demonstrated is that the number of times a cell can divide is limited. Hayflick (1980) observed that connective tissue cells divided approximately fifty times. It is possible that the cells are programmed genetically to shut down after a certain number of replications. This is referred to as **genetic switching theory**. Another possibility is that the genetic material that dictates cell function may change or mutate as time passes. As these mutated cells increase, either through ongoing cell mutation and/or replication during cell division, they may cause deterioration in the tissue or organ. This is referred to as the **genetic mutation theory**. Depending on the function of the affected organ or tissue, deficits may appear in motor performance, overall health, or both. The likelihood of such deficits increases when these cellular changes occur in more than one organ or tissue. A third possibility at the cellular level pertains to the **free radical theory**. Certain molecules within a cell react violently when they come in contact with oxygen. These molecules break away from the cell and become unstable fragments. These highly reactive molecular components are referred to as free radicals. Free radicals attempt to bind with other molecules within healthy cells, negatively influencing the normal cell function and possibly causing DNA damage. Aging may be a manifestation of this process (Hoyer & Roodin, 2009).

A second approach to understanding why we age involves the function of the human immune system, which consists of the lymph nodes, spleen, thymus, and lymphoid tissue in the tonsils and intestine. The purpose of the immune system is to protect us from various organisms that enter the body. With age, the human immune system gradually decreases in effectiveness. This increases the vulnerability of older adults to illnesses and extends their recovery times. In addition, the immune system of an older individual may begin to target healthy organ and tissue cells for destruction, as if they were "bad" cells. These immune system malfunctions may represent the process by which we age.

A third possible explanation as to why we age involves the concept of **homeostasis**. Homeostasis refers to the maintenance of stability in the physiological systems and their interrelationships, but can also be influenced by psychosocial factors. Homeostasis is the state in which various systems of the body (i.e., sensory, digestive, and cardiovascular) work in harmony to keep the body in a normal, healthy condition. The human body is an incredibly complex network of systems that carry out their functions both independently and in combination. Guyton (1991) stated that the cells of the organs and tissues within the interrelated systems benefit from a homeostatic state and contribute to its maintenance. This harmonious state is maintained until a particular system or group of systems malfunctions or cannot contribute to the maintenance of homeostasis. The degree to which negative consequences are manifested depends on the ability of the other systems to adapt and the degree to which the dysfunctional system is unable to contribute to the homeostatic network. A moderate level of dysfunction in a particular system may impair health and the ability to carry out functional daily living skills. A high level of disruption leads to death.

There appears to be a reciprocal relationship between aging and the maintenance of a homeostatic state. With age, the balance among the systems involved in homeostasis is less stable and more vulnerable to disruption. Individual systems appear to experience age-related decreases in their ability to contribute to the homeostatic equilibrium. Subsequently, age-related characteristics begin to emerge. Greater susceptibility to illnesses, longer recovery times from illnesses, and greater limitations in motor performance become more prevalent.

CONCEPT 18.6

Current and potential interventions may result in extending the lifespan by slowing the aging process.

As mentioned earlier, life expectancy of both males and females increases consistently, and thus the population of older adults in the United States continues to expand. Much of these increases in life expectancy can be attributed to lifestyle. Well-known behaviors such as not smoking, reducing the intake of high-cholesterol foods, and minimizing psychological stress contribute to longer life spans. Certainly a physically active lifestyle can add years to one's life expectancy. For the most part, these factors contribute to the average life span by reducing the potential for contracting life-shortening diseases.

Two interventions that have had a positive life extending influence in laboratory animals relate to the intake of **antioxidants** and dietary restriction. The theory behind antioxidants involves the reduction of the influence of free radicals. Antioxidants (agents that prevent or inhibit oxidation) such as vitamins C and E may prolong life and delay the aging process by binding with free radicals before they have the opportunity to harm healthy body cells.

Research beginning in the 1930s, and replicated many times, has demonstrated an increase in the life span of laboratory rats as a result of moderate to severe dietary restriction. By reducing the animals' caloric intake by 25 to 40% but maintaining the proper levels of vitamins and nutrients the rats lived significantly longer than their counterparts who were allowed to eat freely (Hoyer & Roodin, 2009). One possible explanation for the increased longevity with caloric restriction is that it may delay or prevent age-related pathologies in the cardiovascular, renal, and central nervous systems (Lee et al., 2001). Although certain successes with these intervention strategies have been experienced with laboratory animals, their potential with humans has yet to be determined.

PHYSIOLOGICAL CHANGES IN THE ADULT MUSCULOSKELETAL SYSTEM

The human skeleton is multifaceted in its function. It protects internal organs, gives form to the body, acts as levers from which muscles attach, provides a reserve site for calcium, and develops blood cells in the bone marrow. Skeletal muscles excited by the central nervous system move most of the bones of the body. In addition, the muscles, tendons, and ligaments provide stability to the articulating joints throughout the body.

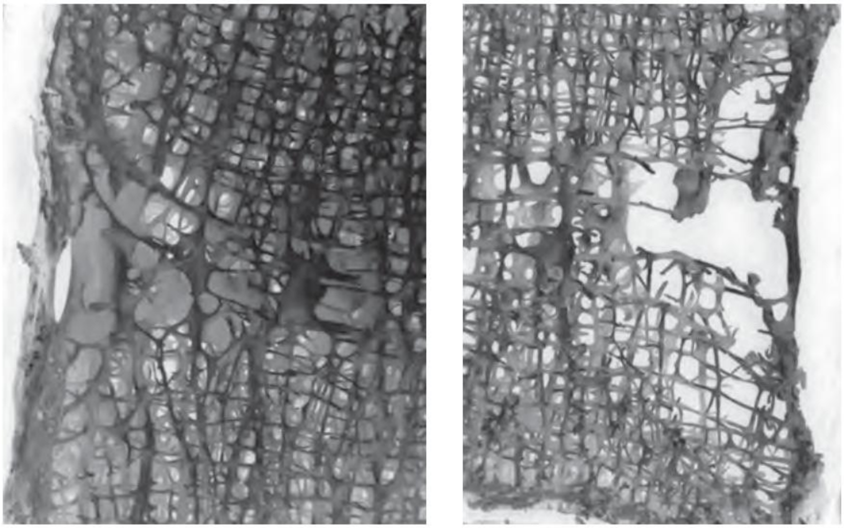
Skeleton

Various changes within the skeletal structure appear as a person ages. Many individuals experience a shortening in stature. It is estimated that women may lose as much as two inches between the ages of 25 and 75 years, whereas men may decrease in height by about one half inch between the ages of 30 and 50 years followed by another one inch between the ages of 50 and 70 years (Hoyer & Roodin, 2009). This "shrinkage" may be attributed to one or more causes. As we age, the disks that separate the vertebrae of the spinal column undergo various changes. In a healthy state, intervertebral disks possess jellylike nuclei. The vertebral disks of older adults often lose a portion of the water content important for shock absorption, and the disks become more fibrous. This, along with changes in bone mineral density in the vertebrae, results in compression of the disks. Disk compression reduces the length of the vertebral column and causes the subsequent loss of overall height. Other contributors to age-related height loss include spinal misalignment and poor posture. Curving of the spine may result from a reduction of the shock-absorption capacity of the vertebral disks. Postural problems may reflect weakening in the muscles that support the spine and thorax (rib cage). Although these conditions appear in many older adults, they are not inevitable. A certain amount of vertebral water content loss may occur, but the muscles supporting the spine and thorax can maintain strength through physical activity and proper exercises. In addition, the loss of bone mineral content may be prevented or slowed through proper treatment.

CONCEPT 18.7

Osteoporosis represents a potentially debilitating disease that requires the attention of individuals at all stages of adulthood.

The disease **osteoporosis** may contribute to height reduction in older adults, but its other consequences can be much more devastating. Osteoporosis is characterized by a reduction of *bone mineral density* severe enough to increase vulnerability to fractures of the bone (Figure 18.2). In healthy bone, the ongoing process of bone mineral production and absorption maintains a balance in calcium metabolism regulated by the endocrine system. In other words, old cells die and are removed, making way for new cell production. With age, that balance between absorption and production becomes less stable, and more bone mineral content is absorbed than is produced. Although this imbalance normally leads to a slight age-related loss in bone density, osteoporosis accelerates the process. As the bone mineral content is reduced, the bones become increasingly porous and fragile. Fractures can occur within a bone, causing that bone to compress. These compression fractures are often seen in the spinal column of older adults with osteoporosis. Normal weight-bearing stress on the spinal column causes tiny fractures in the individual vertebrae. As more fractures occur, the vertebrae become more compressed and the



Magnified healthy bone   Magnified osteoporotic bone

Figure 18.2
Comparison of normal lumbar vertebra on the left, to lumbar vertebra with osteoporosis on the right.

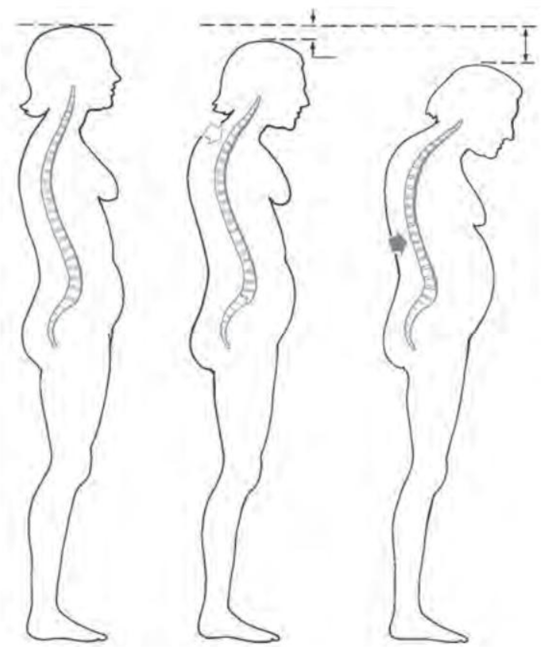


Figure 18.3

Skeletal changes with osteoporosis.

Source: © LifeART/Fotosearch.

position of the thorax is altered. This positional change can adversely affect the functions of the lungs and other internal organs directly below the thorax region. In addition, postural deviations and spinal deformities are common with osteoporosis (Figure 18.3).

Individuals with osteoporosis are more vulnerable to fractures *within* a bone, but fractures *of* the bone also represent a major concern. As the bone mineral content declines and bones become more porous, the individual with osteoporosis is at great risk of bone breakage as a result of minimal trauma. We often hear reports of older adults falling and breaking their hips. Even the force experienced from a fairly mild fall may be sufficient to break a brittle femur ravaged by osteoporosis. Of additional concern is that osteoporotic bones heal at a much slower rate than healthy bones.

Osteoporosis can occur in both men and women, but it is present in a much higher rate in females. In fact, of the 10 million U.S. citizens estimated to have osteoporosis, 80% are women (National Osteoporosis Foundation, 2011). Women lose bone at a much faster rate than men due to more drastic hormonal changes with age and because they begin with less bone mass (Spirduso, Francis, & MacRae, 2005). Hormonal changes experienced by women following menopause may disrupt bone mineral formation. Other factors that play a role in maintaining bone density are calcium intake and weight-bearing physical activity. Calcium plays an important role in regulating bone metabolism, and weight-bearing stress aids in building and maintaining bone density. Hormonal changes, the reduction of calcium intake, and restrictions in weight-bearing exercises place an individual at risk for significant bone mineral loss.

It has been demonstrated that astronauts in space suffered substantial bone mineral loss after only a few weeks in a weightless environment.

Upon arriving back to Earth's gravitational pull and performing various exercises, they recovered most but not all of their preflight bone density. This phenomenon confounds the situation for the older adult recovering from a hip fracture. The weight-bearing restrictions placed on the broken hip for healing purposes can further increase bone mineral loss.

Drinkwater has called osteoporosis the "silent thief of the golden years" (1992). Outward signs of the disease are usually not evident until the vertebrae experience compression fractures, posture deviations become apparent, or the individual begins to experience back pain from spinal misalignment. However, since the late 1970s diagnostic technology has been able to safely and accurately identify an individual's bone density. Because osteoporosis is preventable, using such technology to monitor bone density is essential and should begin in early adulthood. Comparing an individual's bone density with a bone density standard for healthy young adults will tell a physician if that person is subject to an accelerated bone loss rate. Treatment can minimize future bone loss. To receive treatment, however, a diagnosis must be made. Siris et al. (2001) found that in a longitudinal study of over 200,000 postmenopausal women there was an unexpectedly large number of individuals who had osteoporosis but had not been diagnosed. In addition, the investigators found that an unexpectedly large number of women had mild losses of bone mineral density, a condition known as **osteopenia**. It was determined that 7% of the population studied had osteoporosis with another 40% having osteopenia.

Although osteoporosis is preventable, it is not yet reversible. However, diagnosis and treatment can restrict further bone loss, even in those individuals whose bone mineral stores are depleted.

Treatment for osteoporosis involves hormonal replacement for postmenopausal women; increasing calcium intake; and, of particular interest to the movement specialist, increasing weight-bearing exercises. Several recent studies have indicated a significant relationship between resistance training and increased bone mineral density (Ballard et al., 2003; Hawkins, Wiswell, & Schroeder, 2002). Additional factors that play a detrimental role in a person's bone density include smoking, alcohol abuse, and high consumption of caffeine (see Table 18.1). Drinkwater points out a principle of specificity that applies to weight-bearing activities. Weight-bearing stress must be directed to a specific bone area for that bone to be affected. This is valuable information for movement professionals planning physical activities for individuals with osteoporosis. Also, recognize that exercise should be seen as an adjunct to the primary treatment of hormonal replacement (Drinkwater, 1994).

Muscles and Joints

Muscular strength is essential for the performance of motor skills, whether they are related to high-level athletic performance or daily functional living. With age the structure and function of skeletal muscle change. Structurally, individuals experience **sarcopenia**, or skeletal muscle mass atrophy. Muscle mass decreases as the number and size of muscle fibers decline through the late middle and older adulthood years. Functionally, a decrease in muscular strength seems to parallel this loss in muscle tissue. The general adulthood pattern for muscle strength is represented by a peak in strength at about 25 to 30 years, a plateau until approximately 50 years, and a gradual decline until about 70 years, followed by a much sharper strength decline in the succeeding years (Figure 18.4). Cross-sectional data indicate an approximate 20% loss in strength for males after 55 years of age and a more drastic 35% strength decline in women who are 55 years or older (Samson et al., 2000). Longitudinal data appear to support the loss of strength in the older adult years but indicate that significant strength declines are not manifested until the early older adulthood years rather than the late middle adulthood years.

TABLE 18.1 Risk Factors Associated with Osteoporosis

Age	Occurs at a much higher rate in older adults
Sex	Occurs at a much higher rate in females
Familyh istory	Heredity and genetics play a major role
Lowb odyw eight/being small and thin	Women and men with small bones are more likely than larger people to have osteoporosis
Race andet hnicity	Occurs at a higher rate in Caucasian, Asian, and Latino populations compared to those of African heritage
Historyo fb rokenb ones	Greater risk if bones were broken during adult years
Menopause	Bone loss increases due to drop in estrogen levels
Estrogenl evels	Can occur from menopause, removal of ovaries, or amenorrhea
Amenorrhea	Absence of menstrual periods could result in lower estrogen levels
Calciumd eficiency	A mineral that represents a building block for bone
VitaminD d eficiency	Helps the body use calcium
Caffeine	May decrease calcium absorption
Inactivel ifestyle	Limits weight-bearing activity
Smoking	Chemicals in cigarettes have a negative influence on bone cells
Alcohola buse	Can reduce bone formation
Eatingd isorders	Can result in estrogen level decreases and amenorrhea

Source: National Osteoporosis Foundation, 2010.

DEVELOPMENTAL DILEMMA

Here Comes the Sun

As we grow older we sometimes face predicaments in which there are no clear answers, or we are told to do two separate things and those two things contradict each other. This can happen often with health issues of older adults. Sometimes you have two of your body's physiological systems competing against each other. Take, for example, the integumentary system and the skeletal system. The integumentary system includes the skin while the skeletal system, of course, includes the bones. With age, the epidermis or outer layer of skin thins as a result of declining cell activity. Its ability to shield against UV radiation declines over time. Older adults often avoid sun exposure for this reason. Contrast this with the skeletal system's requirement for vitamin D. The body uses vitamin D to absorb calcium, an important factor for healthy bones. How does the body acquire vitamin D? Two ways: through the skin's direct exposure to sunlight and through our dietary intake. If older adults limit their sun exposure, they must make a concentrated effort to eat foods that supply them with the necessary levels of vitamin D.

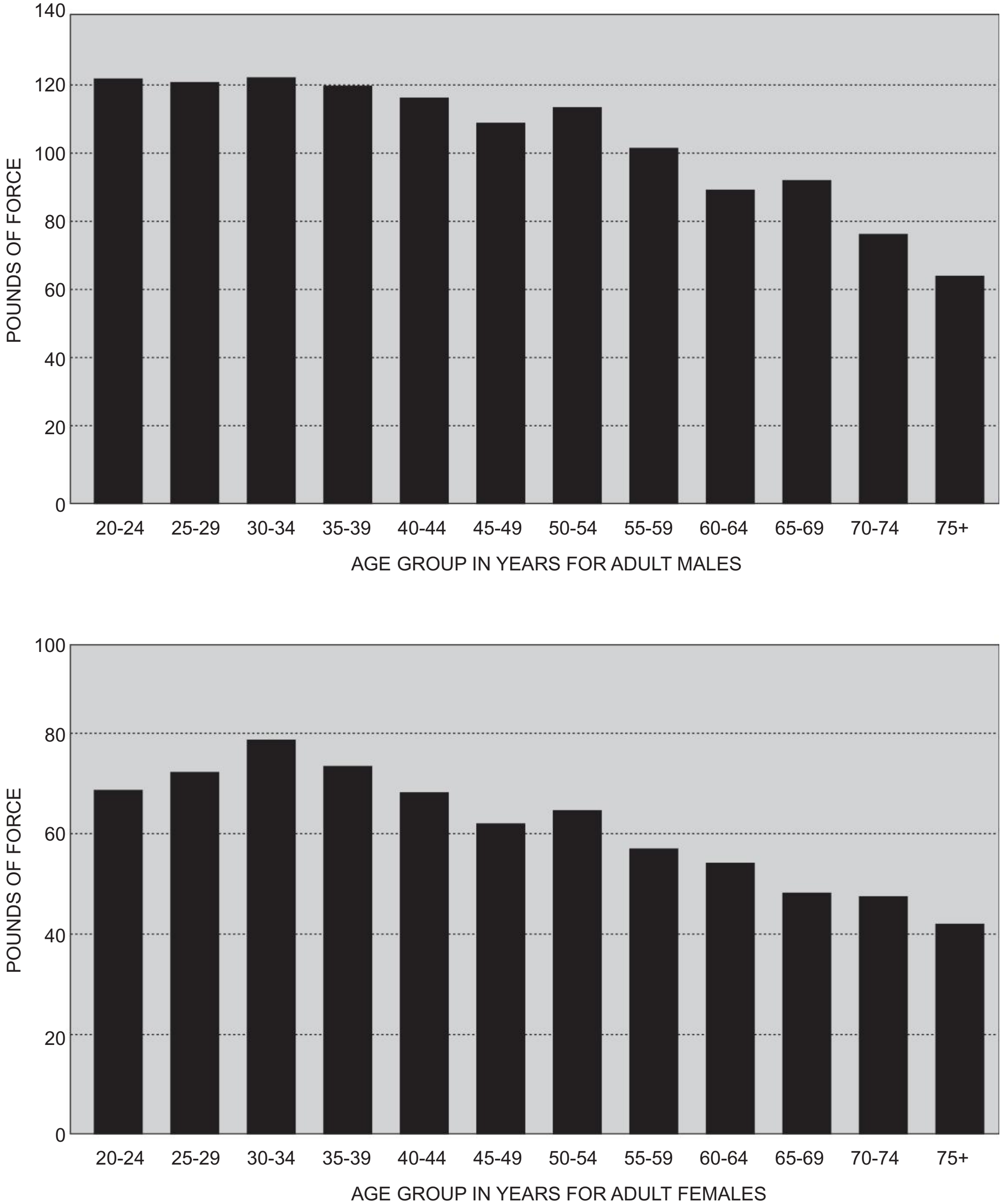


Figure 18.4

Muscular strength across adulthood (adult male and female mean right grip strength measures).

Source: Data graphed from Mathiowetz et al. (1985).

The previous paragraph outlined a general viewpoint regarding age-related muscle performance, but several specific variables should be considered concerning the performance of an individual. Although sarcopenia appears to occur with age, muscle atrophy also occurs as a result of inactivity. Inactivity-induced atrophy can occur at any age and is not only a function of growing old. There is substantial evidence that adults who maintain physically active lifestyles experience much smaller declines in muscular strength than their nonactive peers (Lemmer et al., 2000; O'Neill et al., 2000). In individuals 90 years or older, it has been demonstrated that a strength-training program improves muscular strength and increases muscle mass (Fiatarone et al., 1990). Additional evidence indicates that even frail older adults can gain increases in strength following a low-intensity training program (Westhoff, Stemmerik, & Boshuizen, 2000). In addition to enhancing muscular strength and muscle mass, it has been suggested that strength training in older adults may reduce the severity of chronic conditions such as hypertension, obesity, arthritis, and diabetes, as well as increasing mobility, joint range of motion, and weight reduction (Holland et al., 2002; Lamoureux et al., 2003; Schwartz & Evans, 1995). Clearly, an individual's lifestyle represents a key variable in determining whether his or her muscular strength capacity will follow or deviate from the general curve.

Another important consideration about strength involves the requirements of a particular task. Although *muscular strength* is often used to describe the muscle functions of a particular movement task, most skills require some combination of muscular strength and *muscular endurance.* It has been demonstrated that muscular endurance is less affected by aging than is muscular strength. Dummer, Vaccaro, and Clarke (1985) found no significant differences between the muscular endurance of young adult swimmers and older adult swimmers. Their findings indicate that it may be possible to offset age-related declines in muscular endurance by engaging in physically active lifestyles. It likewise makes us aware that an older adult may be more likely to complete muscular endurance–related motor tasks than muscular strength–related tasks.

A general trend in age-related changes in muscle function is apparent, but tremendous interindividual variability exists. The loss of muscle mass often seen with increasing years is also affected by the adult's levels of physical activity and muscle use. In addition, the muscle function demands of various tasks influence task performance outcome.

Joints and connective tissues appear to undergo age-related changes. Joints become less flexible. In general terms, joint flexibility peaks for young adults in their twenties and gradually declines thereafter. Much of the reduction of flexibility can be attributed to water loss in the connective tissue resulting in greater stiffness of ligaments and tendons. There is also an age-related loss in the water content of the cartilage tissue. A loss of flexibility, and in some cases a loss of joint stability, can be of significant consequence to the older adult in carrying out everyday functional living tasks. Physically active lifestyles and stretching exercises appear to retard age-related loss in joint flexibility (Holland et al., 2002).

At the extreme end, age-related joint diseases such as osteoarthritis not only place limitations on certain movements but can totally restrict them as well. Osteoarthritis is the most prevalent form of arthritis in people 50 years of age or older, and at least half of the population over 60 years of age show some symptoms of the disease. Treatment involves therapy to maintain joint activity and flexibility; increasing strength in muscles associated with affected joints; reducing body fat to reduce strain on weight-bearing areas; relieving pain with analgesics; and in extreme cases, total joint replacements urgery.

Central Nervous System

The components of the central nervous system (CNS) are the brain and spinal cord, with the neuron representing the basic unit by which signals are transmitted. The human brain has approximately 100 billion neurons, requiring an incredibly complex network of neuronal connections. The three primary elements of the neuron are the cell body, axon, and dendrite (Figure 18.5).

Dendrites carry signals to the cell body, while *axons* carry signals away. Signal transmissions throughout the CNS are both electrical and chemical. Electrical signals travel along dendritic branches to the cell body and then along the axon. The transmission of the signal from one neuron to another involves altering the electrical signal to a chemical signal and then back to an electrical signal. This occurs at the junction between two neurons. The chemical substances released during this event are called *neurotransmitters.*

CONCEPT 18.8

Age-related structural changes in the central nervous system may result in decrements of various functions.

A number of age-related changes occur in the CNS. Structurally, the brain experiences a continual loss of neurons that are not replaced. We are born with all of our nerve cells, and when they die they are not replaced. We lose thousands of brain cells each day without generating replacements. Consequently, the brain of the older adult is smaller and weighs less than the brain of a younger adult. In addition, the size of the ventricles or brain cavities increase, particularly during older adulthood.

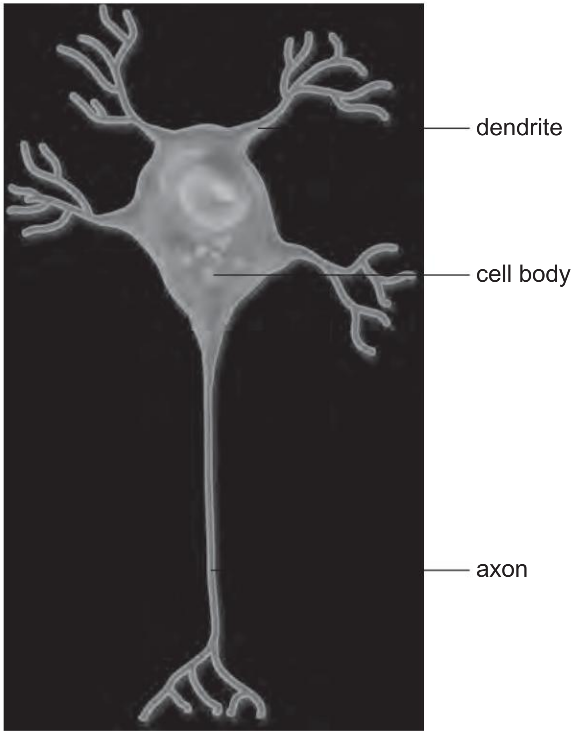


Figure 18.5
Structure of the neuron.

Although this age-related neuronal loss is sufficient to decrease brain size and weight, some sections of the brain are less susceptible to neuron decreases than others. The cerebral cortex experiences a 10 to 20% loss of mass between the ages of 20 to 90, whereas other sections of the brain may undergo as much as a 50% loss in mass. Therefore, any functional changes that may occur as a result of neuronal loss should be considered specific to certain regions. Some researchers even question the impact of age-related neuronal death by demonstrating that large numbers of neurons may shrink or atrophy, but not die, with increasing age (Albert, 1993).

Although it should follow that the loss of millions of neurons through adulthood would affect behavior, this assumption ignores the adaptable nature of the brain or what is called **brain plasticity**. Neurons are continually dying, but there is evidence that living neurons develop compensatory dendritic branches to help maintain connections that may otherwise deteriorate. Although the pathway connections may be maintained, the strength of the signal may be reduced or distorted when fewer neurons are involved in the signal transmission. In addition, signals that deviate slightly from their designated courses may not be corrected. The ultimate changes in behavior due to neuron loss remain unclear. While compensation mechanisms may maintain signal pathways, the quality of those signals may be compromised. Some intriguing research in the area of brain plasticity has been conducted recently by William Greenough and his colleagues at the University of Illinois. They have been able to demonstrate structural changes in the brains of laboratory animals who have engaged in complex movement tasks (Ivanco & Greenough, 2000; Jones & Greenough, 1996; Jones, Klintsova, Kilman, Sirevaag, & Greenough, 1997; Kleim, Pipitone, Czerlanis, & Greenough, 1998). While there is a significant leap from laboratory rats to human beings, this line of investigation is worth monitoring.

Other manifestations that appear to be age-related are abnormal formations including *neurofibrillary tangles, senile plaques,* and an accumulation of *lipofuscin.* These formations are often referred to as **age markers** because they appear in the older brain and increase in number as the brain continues to age. Neurofibrillary tangles occur when long, thin fibers that transport chemical substances to all parts of the neuron become twisted and entangled. It is thought that these neurofibrillary tangles may contribute to a slowing of CNS responsiveness and may play a role in the eventual death of the neuron in which they are housed. Senile plaques are spherical formations composed of substances remaining from degenerated neurons. The plaques are located outside of the neuron and may interfere with normal neuronal transmission by disrupting the synaptic juncture. Experts suggest that senile plaques may play a role in memory loss. Neurofibrillary tangles and senile plaques are also present in large quantities in the brains of individuals with Alzheimer's disease. Lipofuscin is a brownish or yellowish pigment that appears in neurons as the brain ages. The effects of lipofuscin on neuronal function have not been confirmed, but there is a greater concentration of the pigment around less active neurons. Therefore, the presence of lipofuscin may retard or inhibit cell activity.

As mentioned earlier, neurotransmitters are instrumental in the sending and receiving of neuronal signals. They are chemical substances that regulate the passage of signals across the synaptic junction. As the brain ages, this biochemical activity is often affected. The amount of neurotransmitter available as the signal reaches the synapse may be reduced, and the signal may decrease in strength. Extreme deficiencies of the neurotransmitter dopamine is characteristic of Parkinson's disease.

Finally, the aging brain is susceptible to **hypoxia**, a condition in which the brain receives an inadequate amount of oxygen. Nerve cells of the brain are particularly vulnerable to oxygen deficits, which affects their function and longevity. With age, the circulation of oxygen-carrying blood gradually declines due to structural changes in the circulatory system and decreases in physical activity. The movement specialist must remember that increasing the level of physical activity in the older adult can enhance the blood flow to the brain and, in turn, increase the amount of oxygen reaching the nerve cells.

Circulatory and Respiratory Systems

The circulatory system involves the heart, blood vessels, and blood delivering nutrients to and removing wastes from the organs and tissues of the body (Figure 18.6). The nose, mouth, pharynx, larynx, trachea, bronchi, and lungs comprising the respiratory system serve the body's organs and tissues by providing oxygen and eliminating carbon dioxide (Figure 18.7). Both systems must function properly to keep the body healthy, and they play important roles in the performance of many tasks. Sufficient oxygen and nutrient delivery and waste transport are necessary for muscle fibers, neurons, and all cells of the body to carry out their appointed functions.

Concept 18.9

Declines in an adult's circulatory and respiratory functions may be the result of age, disease, lifestyle, or combinations of the three.

Although a number of changes take place in the main organs and tissues of the circulatory and respiratory systems as adults age, determining the underlying cause or causes of these changes is extremely difficult. Lifestyle choices, disease, aging, or some combination thereof contribute to changes that occur in these two systems. Separating these variables and delineating their individual effects on the systemic changes represent an arduous and sometimes impossible endeavor, but certain factors are more easily identified as age-related, lifestyle-associated, or disease-initiated. When possible, the origins of these changes will be addressed in the following discussion.

As the adult human body ages, the heart and blood vessels tend to undergo changes that affect their functions. Arteries serve as the primary pathways by which oxygenated blood is pumped to the various organs and tissues throughout the body. The arterial walls contract to keep the blood moving. During the adult years the arterial walls become less elastic and more rigid, representing a condition known as **arteriosclerosis**. An increase in calcification and a buildup of collagen connective tissue in the arteries cause arteriosclerosis, which occurs as a result of aging rather than disease. A second condition, **atherosclerosis**, is also seen in adults as they become older, but it represents a cardiovascular disease rather than the normal aging process. Atherosclerosis occurs when fatty deposits begin to collect within arteries. If the deposits do not completely close off the arterial openings, they create sites on the arterial walls on which blood clots can form. Both arteriosclerosis and atherosclerosis affect the performance of the circulatory system. With both conditions blood pressure increases and the amounts of oxygen and nutrients reaching the cells of the body decrease. This may impair the performance efficiency of the organs and tissues.

Other circulatory changes seen in adults as they age include changes in the valves of the heart and vessels. Valves within the circulatory system become thicker and less elastic. As a result, they work less efficiently.

A number of age-related changes are observed in the organs involved in respiration. The function of the lungs tends to increase through adolescence, plateau in the third decade, and gradually decline thereafter. This decline follows an age-related pattern, but the reduction during the fourth and fifth decades tends to be linked to factors such as an increase in body weight rather than to changes in the tissues. Other age-related variables that influence lung function include reduced levels of muscular strength in the muscle groups that aid in respiration. Postural problems often experienced by older adults may anatomically restrict the expansion capabilities of the lungs. Curvatures of the spine can compress the thorax and push the lungs against other internal

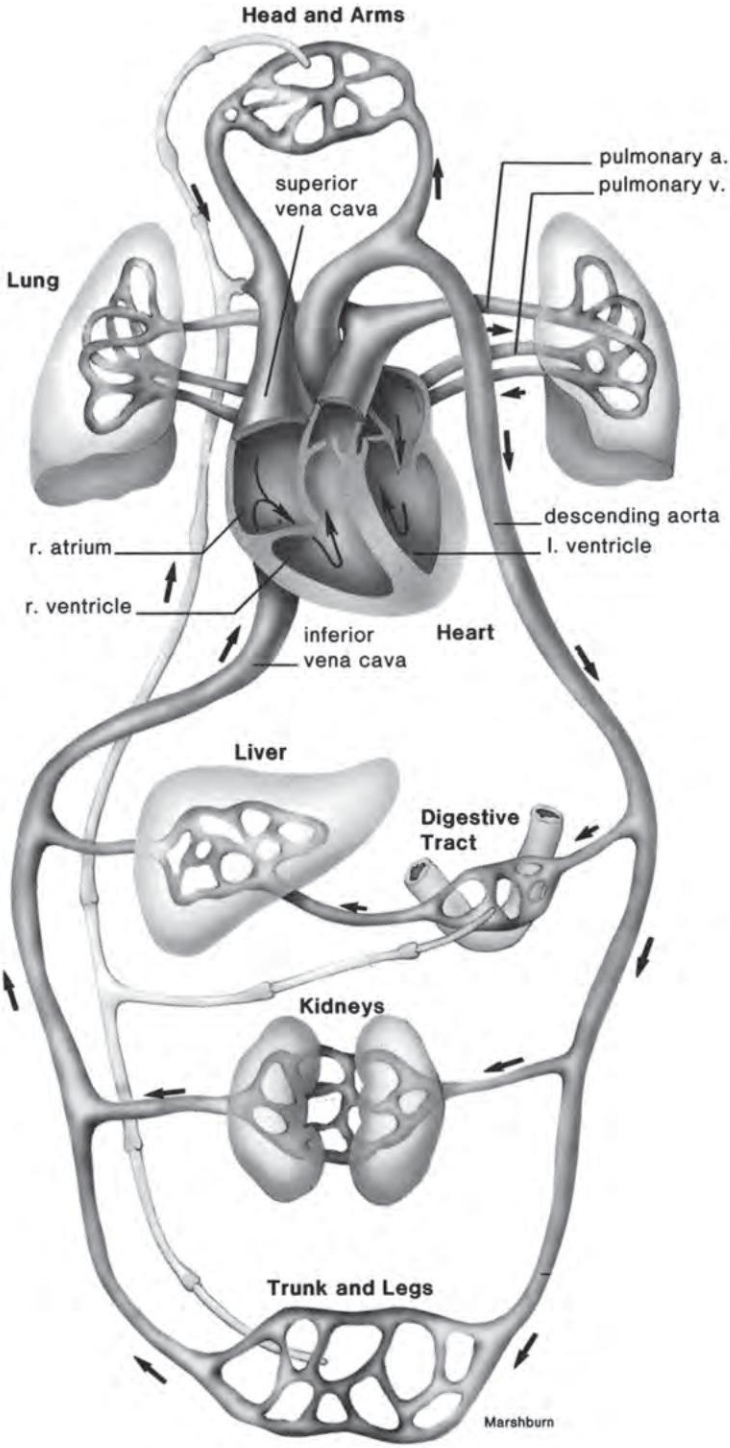


Figure1 8.6

Characteristics of the circulatory system.

From Sylvia S. Mader, *Understanding Human Anatomy and Physiology* (Dubuque, IA: Wm. C. Brown, 1991). Reprinted by permission of The McGraw-Hill Companies.

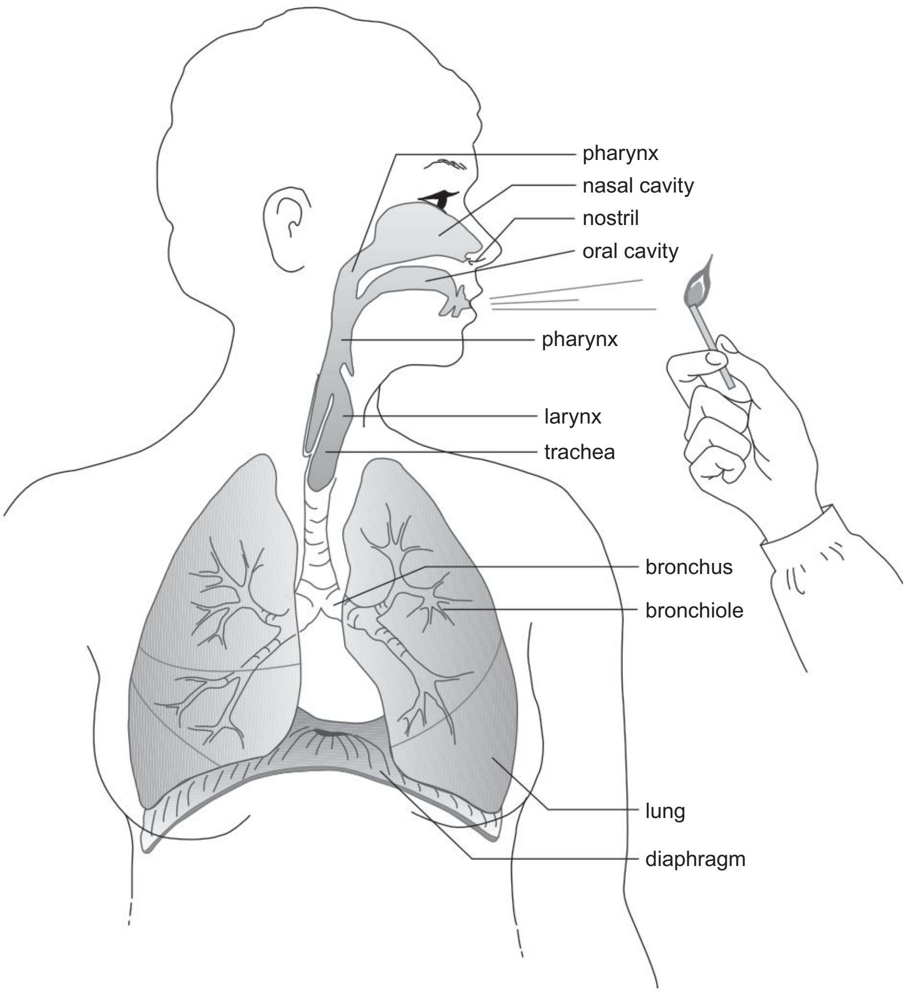


Figure 18.7
Characteristics of the respiratory system.

organs, impairing the work of the lungs and the other crowded organs.

Maximal oxygen uptake (VO_2 max) represents the best physiological measure of total body endurance. It serves to evaluate the greatest amount of oxygen that reaches the tissues during a maximum exercise effort by an individual. The general age-related trend in maximal oxygen uptake levels begins with a continual increase during childhood and adolescence. A plateauing during the twenties is followed by a gradual decline of approximately 1% for each subsequent year. Much of this continuous loss during middle adulthood can be attributed to other age-associated conditions such as a decline in the amount of blood pumped by the heart to the tissues and a loss of muscle mass. Many of the previously mentioned declines can be significantly minimized when older adults participate in aerobic-oriented activities. It has been estimated that one-third of the loss of VO_2 max from middle age to old age is the direct result of aging, while two-thirds can be attributed to physical inactivity (Kasch et al., 1990). Boileau et al. (1999) points out that for older adults aerobic exercise training has a positive impact on a multitude of factors including mortality, several chronic diseases including coronary heart disease, noninsulin-dependent diabetes, selected cancers, hypertension, body composition, bone mineral density, immune function, and depression. Other investigators have demonstrated that the cognitive functioning of older adults shows improvement when aerobic exercise is part of their lifestyle (Kramer, 2000; Kramer, Hahn, & McAuley, 2000).

Body Composition

In the United States and other developed countries there tends to be a general increase in body weight and body mass index in adults until they reach approximately 60 years of age. After the age of sixty body weight and body mass index in older adults tend to decline (Elia, 2001). Correspondingly, the intra-abdominal fat, which is related to such conditions as diabetes and obesity, increases steadily with age. Weight gain in adulthood can be attributed to a number of factors, but two primary characteristics stand out. Initially, the lifestyle factor of decreased physical activity plays a key role in weight gain. Energy expenditure is critical for weight management in the older adult. Unfortunately, the older adult tends to be less active due to various physical, psychological, and social causes. Secondly, adults as they age experience a decrease in their basal metabolic rate (Elia, 2001). The basal metabolic rate reflects the efficiency with which calories are burned. When older adults gain weight beyond that which is considered healthy they decrease their mobility, physical functioning, and independence. The potential for the need of support services is increased, and the ability to accomplish activities of daily living declines.

Weight management strategies throughout adulthood should include the development and maintenance of proper nutritional habits and the adoption of a physically active lifestyle. Physical exercise does not only result in weight loss but can also result in a reduction of overweight/obesity-associated conditions such as hypertension, arthritis, diabetes, and decreased mobility (Evans, 1995).

Sensory Systems

We gain information about the environment through various sensory systems. Different sensory receptors send to the central nervous system information about taste, smell, vision, touch, pain, sound, and other sensations. Some sensory systems—in particular visual, auditory, and proprioception—play crucial roles in motor performance.

Concept 18.10

Age-related changes in the eyes and ears can result in insufficient or distorted visual, auditory, and proprioceptive transmissions to the brain.

Visual System

For many if not most movement skills, vision represents the dominant sensory system. Vision occurs when the eye receives light rays reflected by objects in the visual field. As the light rays reach the eye, they are refracted as they pass through the cornea, aqueous humor, pupil, lens, and vitreous humor before the image reaches the retina. Refraction involves a process of bending the light rays. The degree to which the rays are bent depends on the transparency of the eye structures and the angles of light rays as they enter the eye. The cornea is the fibrous, transparent covering of the eyeball. The aqueous humor is a watery solution located in a chamber just behind the cornea and in front of the pupil and lens. Muscles attached to the iris contract or relax to determine pupil size. The size of the pupil regulates the amount of light that passes through the crystalline lens and into the vitreous body. The vitreous body holds a jellylike fluid called the vitreous humor. After the light rays have been refracted through the various transparent media, they form an image on the retina, the inner membrane of the eyeball. The retina transfers the image by way of the optic nerve to the cortex of the brain.

With age, the eye tends to undergo a number of structural and functional changes that affect the quality of vision. Visual quality is generally maintained during the early adulthood years, but anatomical changes that begin to occur during middle adulthood have a gradual but detrimental effect on visual abilities. However, such declines during these middle adulthood years rarely limit the ability to carry out everyday tasks. During the older adulthood years, the visual decrements experienced in middle adulthood become more pronounced and have a greater impact on functional and adaptive abilities. Approximately 14% of older adults 65–74 years of age report some difficulties with their vision with the number increasing significantly for those 75 years and older (Figure 18.8).

As the eye ages, the cornea begins to flatten somewhat, increases in thickness, and develops surface waviness and irregularities. These changes in the curvature of the outer eye alter the pathway of the light rays entering the eye and diminish the accuracy of the refractory process. The amount of light that eventually reaches the lens is reduced by the age-related changes in the constricting and dilating properties of the eye muscles regulating pupil size. The eyes of older adults do not respond to changes in light intensity as rapidly as those of young adults. When light is dim, the pupils of older adults do not open as widely as they did in previous years. This condition is known as **senile miosis**. The amount of light received by the lens of an older person with senile miosis can range from one-tenth to one-third that of younger adults. The lens undergoes a variety of changes, particularly in the older adult years. The clear, transparent lens characteristic of young adulthood gradually yellows in older adulthood. This

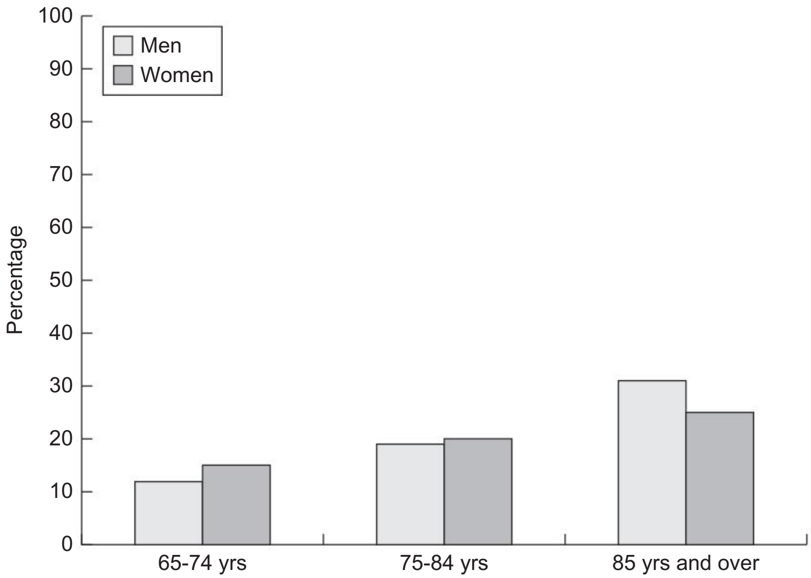


Figure1 8.8 Percentage of people age 65 and over who reported having any trouble seeing

Reference population: These data refer to the civilian noninstitutionalized population.

Source: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health Interview Survey.

decline in lens transparency results in a filtering effect and a reduction in the amount of light that ultimately reaches the retina. The lenses of the older adult also thicken and decrease in flexibility, which affects how light waves are projected on the retina.

Another problem that occurs with age is cataract formation. *Cataracts* result in a clouding of the lens and can result in complete lens opaqueness. Some cataract formation occurs in an estimated 95% of adults over the age of 70. Cataracts are treatable through a corrective or surgically implanted lens. Left untreated, cataracts will result in a reduction or elimination of light rays refracted to the retina.

With age, the clear gelatinous vitreous humor shows signs of becoming more liquid and may develop patches of cloudiness. In addition, the retina loses rods and cones. Rod receptor cells of the retina are particularly important for visually adapting to the dark. Thus, older adults often experience a gradual decline in light and dark adaptation. Cone receptor cells are essential for color vision, so the ability to discriminate colors is often diminished in the older adult. An accumulation of lipofuscin has also been noted in the retinas of older adults.

Structural changes of the eye that begin during middle adulthood and increase in later years often affect the visual function of the eyes. About the age of 40, the ability of an individual to focus at close distances tends to decline. This condition is called *presbyopia.* As an individual ages, this condition worsens. This onset of presbyopia during middle adulthood is generally attributed to age-related changes in the lens, which also cause increased glare sensitivity. In addition, the ability to track moving objects also becomes a problem, generally attributed to weaker eye muscle and focusing abilities. Figure 18.9 depicts various structures of the eye and their age-associated changes.

Auditory System

Although the auditory system does not serve as a primary sensory system for the completion of most motor tasks, auditory information can be extremely valuable in providing feedback in a number of movement situations. Hearing takes place when vibrating sound waves enter the ears and, through a complex process, are transformed into neuronal signals sent to the brain for processing. Audible sound waves travel from their source to the outer ears of a person. The outer ear consists of the pinna (the visible ear structure on both sides of the head) and the external auditory canal. The sound vibrations travel down the external auditory canal until they come in contact with the tympanic membrane (ear drum). The tympanic membrane begins vibrating in accordance with the vibration characteristics of the sound waves. These vibrations are transferred to three connected middle ear bones and subsequently transmitted to the fluid environment of the inner ear. The vibrations that reach the inner ear stimulate the sound-sensitive organ of Corti, which conveys the sensations down the cochlear nerve to the brain.

Approximately 32% of older adults 65–74 years of age report some difficulties with their hearing with the number increasing significantly for those 75 years and older (Figure 18.10). As adults grow older their ears undergo a number of structural changes that may impair the quality of their hearing. Various membranes and organs throughout the ear tend to become less flexible. This loss of flexibility can dampen the sound vibrations as they move from the external to the inner ear. Hearing loss associated with aging is referred to as **presbycusis**. In addition to membrane changes that may decrease the quality of hearing, presbycusis can result from a loss of cells in the auditory nerve or other organs instrumental in transmitting or interpreting sound waves. A decline in the amount of blood flow to various parts of the ear can contribute to hearing loss as well. In addition to presbycusis, older adults may experience *tinnitus,* a persistent ringing or buzzing noise in the ears. These age-related changes are somewhat permanent, but certain strategies can be explored to improve an older person's hearing. When age-related hearing loss becomes noticeable, a visit to a physician should be scheduled.

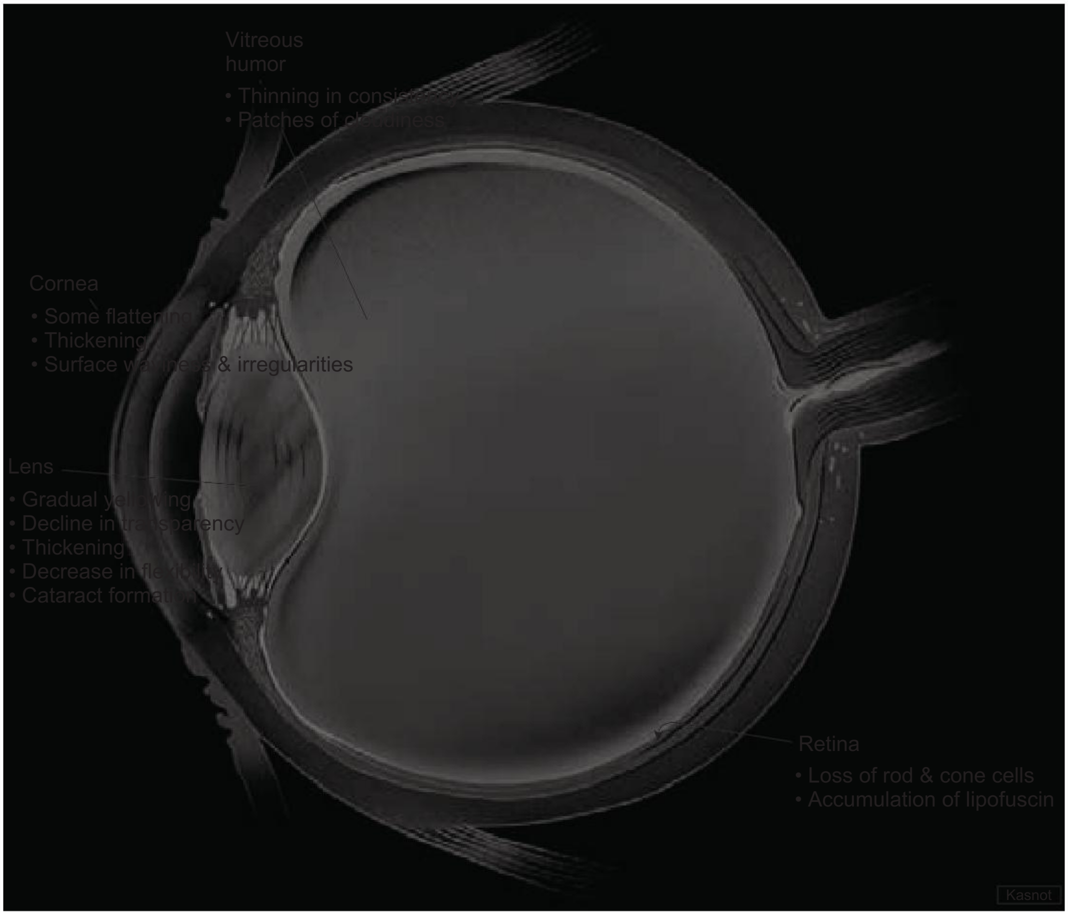


Figure1 8.9

Age-associated changes in the structures of the eye.

From John W. Hole, *Human Anatomy and Physiology* (Dubuque, IA: Wm. C. Brown, 1993). Reprinted by permission of The McGraw-Hill Companies.

The prevalence and consistency of *cerumen* (earwax) changes in older adults. Due to the drying and thinning of tissue in the external auditory canal, a greater amount of cerumen is likely to accumulate. Cerumen also becomes thicker. An accumulation of cerumen can block the external auditory canal, affecting the transmission of sound waves to the middle and inner ears. Such a condition can be treated by a physician, and hearing loss due to cerumen buildup can be restored.

Hearing assistance devices can be beneficial in many cases. It is important, however, to recognize that hearing aids amplify all sounds and may serve to confuse rather than help some individuals. Figure 18.11 depicts various structures of the ear and their age-associated changes.

Proprioception

Proprioception refers to a sense of body awareness and position. One of the primary methods of

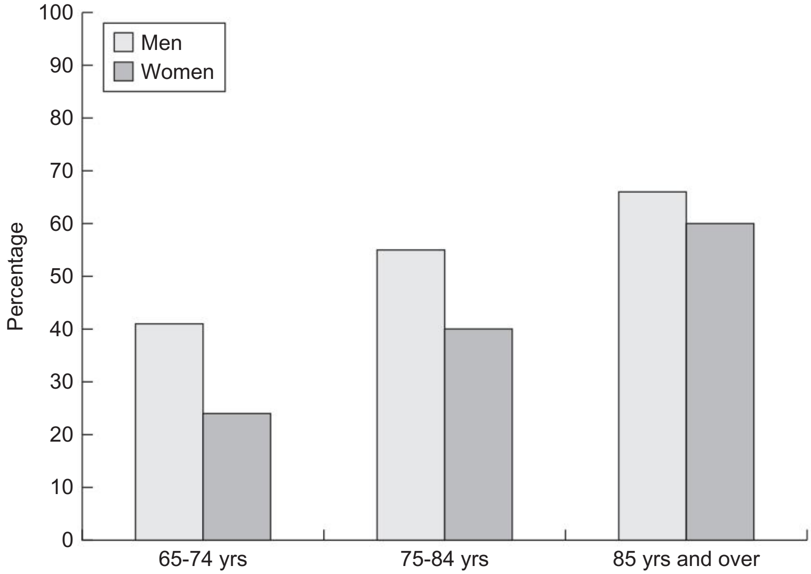


Figure 18.10 Percentage of people age 65 and over who reported having any trouble hearing
Reference population: These data refer to the civilian noninstitutionalized population.
Source: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health Interview Survey.

receiving proprioceptive information is through the vestibular system. The primary function of the vestibular system is to provide information concerning head movement and position. Various components of the vestibular system are located in each inner ear and include the semicircular canals, the utricle, and the saccule (Figure 18.12). These three structures are filled with a fluid called *endolymph.* When the head moves, the endolymph moves as well and stimulates sensory receptor hair cells located within the vestibular structures. The stimulation of these hair cells initiates the transmission of neural signals by way of the vestibular nerve to various parts of the brain and spinal cord.

In older adults, losses have been noted in the number of sensory cells located within the saccule, utricle, and semicircular canals. In addition, the nerves that transmit messages from the vestibular structures to the brain experience some age-associated degeneration. How these changes influence the motor behavior of an older individual remains subject to speculation. Older adults often experience vertigo and dizziness. Although these conditions may be attributed to age-related changes in the vestibular system, they may likewise occur as a result of certain medications, various diseases, or changes in posture.

Psychosocial Development

Various aspects of the motor domain influence the psychological state and the social characteristics of adults. Exercise, a physically active lifestyle, and the ability to carry out daily living skills are movement-oriented factors that can have a positive effect on how adults feel about themselves and how others view them. Progressive declines in motor performance, a decrease in muscular strength, and an inability to accomplish household tasks represent motor domain conditions that can negatively influence the psychological perspectives and social interactions of adults. In numerous situations the motor domain interacts with the psychosocial domain. When an

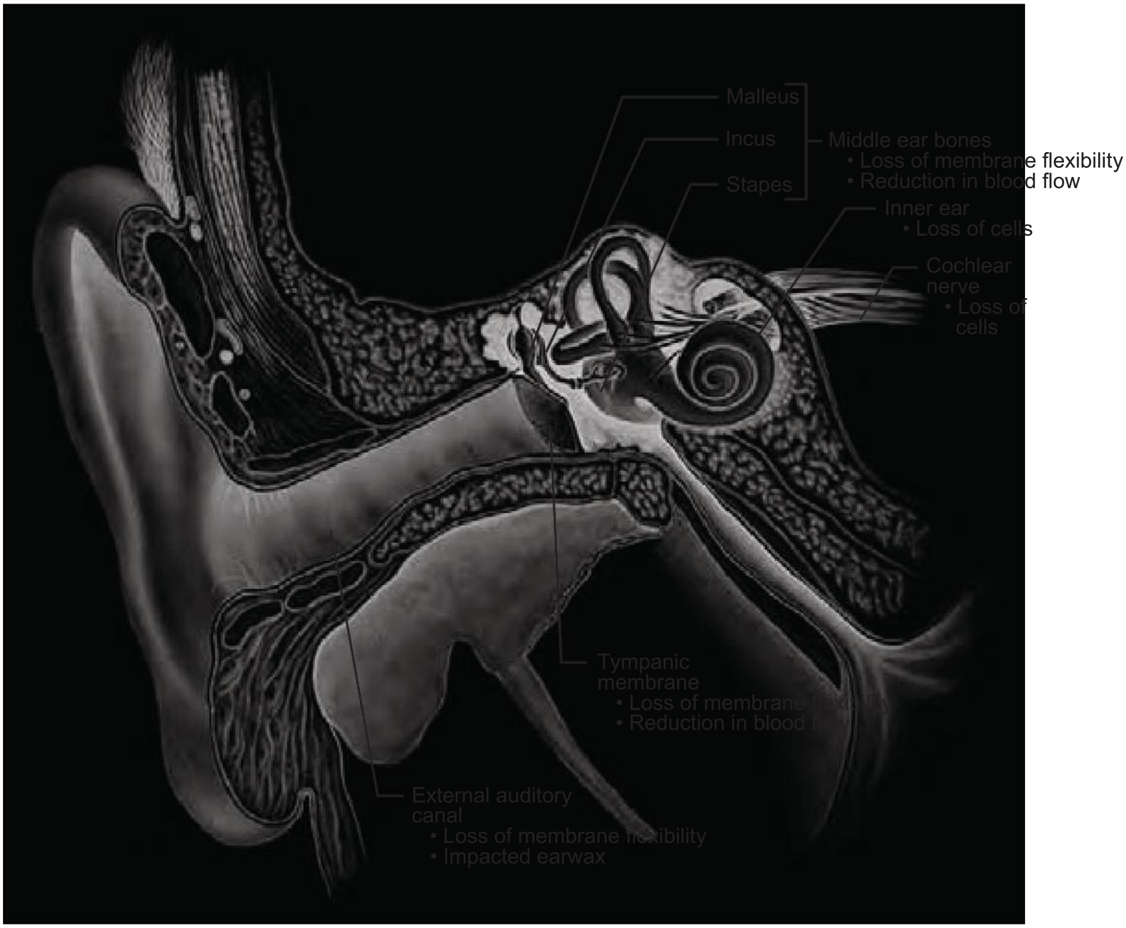


Figure1 8.11

Age-associated changes in the structures of the ear.

From John W. Hole, *Human Anatomy and Physiology* (Dubuque, IA: Wm. C. Brown, 1993). Reprinted by permission of The McGraw-Hill Companies.

individual elevates her or his self-esteem and body image following several months of weight training or when adults gather for early-morning exercise walks at a city mall, we see the positive influences of motor performance on psychosocial behavior. When individuals with impaired motor functions must be admitted to nursing care facilities and are depressed or insecure, we see the negative influences. Experiences encountered throughout adulthood have the potential to affect a number of psychosocial features.

Psychological Factors

The experiences in the motor domain interact in many ways with the psychological characteristics of adults. An often used method to explore this motor–psychology relationship is the examination of psychological factors following exercise or association with physical activity. Factors such as a sense of well-being, awareness of body image, perception of locus of control, and states of depression have been improved following participation in an exercise program. Individuals of

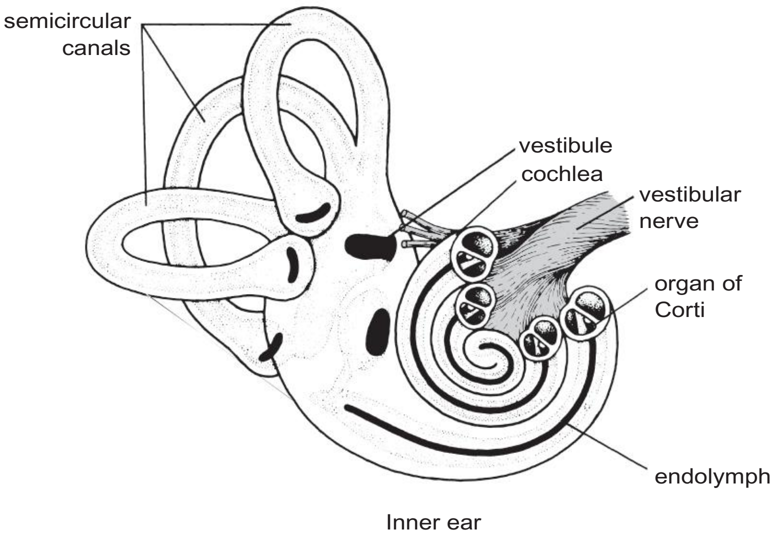


Figure 18.12

Components of the vestibular system.

From Sylvia S. Mader, *Understanding Human Anatomy and Physiology* (Dubuque, IA: Wm. C. Brown, 1991). Reprinted by permission of The McGraw-Hill Companies.

a middle and/or old adulthood-age group are often targeted as subjects for such interaction investigations.

CONCEPT 18.11

Exercise can have beneficial effects on a number of psychological variables associated with aging.

A *sense of well-being* serves as somewhat of a general term representing some type of positive change in a person's attitude (Hird & Williams, 1989). Perri and Templer (1985) noted significant improvements in the self-concepts of older adults following fourteen weeks of an aerobic program. In addition, men and women between the ages of 55 and 85 years have demonstrated heightened perceptions of self-concept at the conclusion of an eight-month dance/movement program (Berryman-Miller, 1988). Arent, Landers, and Etnier (2000) examined the results of over thirty studies and found that chronic exercise is associated with improved mood in older adults. Such mood improvements were observed for all types of exercise but were particularly evident with resistance training. McAuley et al. (2000) found that when older adults participate in physical activities such as walking or stretching/toning programs they experience an increase in multidimensional self-esteem. They did suggest that these self-esteem gains may erode once participation in physical activity is reduced or eliminated.

Body image is another psychological factor that has been shown to improve following involvement in an exercise program or higher levels of physical activity. Body image refers to the subjective pictures individuals have of themselves, created through their observations and the reactions of others (Thomas, 1989). Loomis and Thomas (1991) examined body attitudes of older women who lived at home and women who resided in nursing facilities. They found that the women living in nursing facilities reported greater dissatisfaction with their body images than did the individuals living at home. The investigators concluded that greater opportunities for participation in physical activity and exercise should be made available to the nursing facility residents.

Locus of control can be defined as a person's perception of her impact on events (Thomas, 1989). An individual with an internal locus of control perceives that she can influence events, whereas a person with an external locus of control believes that events are unaffected by her involvement and happen by chance. The investigation by Perri and Templer (1985) described earlier in this chapter resulted in an enhanced perceived internal locus of control by the adults who participated in the fourteen-week aerobic program.

Depression in adult populations may stem from numerous causes: a decrease in self-esteem due to the loss of employment, hormonal changes following menopause, or a reduction in the ability to carry out daily living skills due to failing health. Valliant and Asu (1985) examined men and women between the ages of 50 and 80 years who participated in different levels of exercise programming. Participants included structured exercisers, self-imposed exercisers, social exercisers, and nonexercisers. The investigators found that the structured group exhibited a reduction in depression following the twelve-week program. Another investigation examined the effects of exercise on the cognitive functioning of older adults diagnosed with clinical depression (Khatri et al., 2001). The investigators found that physical activity was beneficial to cognitive functioning such as memory for individuals suffering from depression. Contrarily, depression-related events such as interpersonal loss (death of a spouse or loved one) have a negative influence on exercise adherence in older women (Wilcox & King, 2004).

Physical activity can contribute to the mental health of older adults in a variety of ways. Engaging in a busy and active life, maintaining mental alertness, keeping a positive attitude toward life, and avoiding stress and isolation are characteristics that are demonstrated in older adults who participate in a physically active lifestyle (Stathi, Fox, & Mckenna,2002).

Socialization Factors

For many years social scientists have focused on two approaches, the **activity theory** and the **disengagement theory**, to help describe the optimal process of aging in regard to relationships with other people (Dacey, Travers, & Fiore 2009). Activity theory suggests that as adults grow older they require interaction with other people and continued physical activity to be happy and satisfied. Disengagement theory is the inverse of activity theory. Disengagement theory suggests that as people age they begin to lose relationships, gradually abandon past interests, and eventually withdraw from society. Disengagement theory argues that the curtailment in social interaction is necessary for older adults to accept society's disengagement from them. Acceptance of this society–individual separation allows older individuals to maintain a sense of integrity in their late adulthood years.

CONCEPT 18.12

Activity theory and disengagement theory provide opposing approaches to successful aging.

Maintaining a physically active lifestyle often requires interaction with individuals of different age groups in a variety of social environments. For example, it has been demonstrated that the amount of social interaction with a neighborhood influences the level of physical activity in older adults (Fisher et al., 2004). While these conditions run contrary to disengagement theory, they are consistent with activity theory. Remaining physically active in a social setting represents the activity theory's two primary conditions of sustaining or improving one's health status while preserving or developing relationships. Participation in physical activity encourages older adults to remain attached to society rather than to detach from it.

CONCEPT 18.13

Retirement represents a process rather than a single event.

The theories of activity and disengagement represent a general view of the aging process from a socialization standpoint. An event that represents more of a specific sociological milestone in an older adult's life is **retirement**. Retirement is an interesting phenomenon that some people savor, some tolerate, and some resent.

Some experts suggest that retirement reflects a lengthy series of adjustments similar to other life transitions (Hoyer & Roodin, 2009). Aspects of the motor domain can serve beneficial or detrimental roles at various times in the retirement process. Maintaining a physically active lifestyle may reduce the apprehension about the life changes manifested by retirement. The participation in lifelong sports or leisure pursuits such as golf, tennis, cycling, or hiking can make potentially difficult retirement-based transitions somewhat smoother by providing challenge and enjoyment to the retiree within a framework that can be regulated by realistic expectations. In addition, as described in several examples in previous chapters, remaining physically active as long as possible may help delay the onset of health impairment and dependency on others for the performance of daily living skills.

Of concern, however, is that while the vast majority of older adults are aware of the potential health benefits of physical activity, many fail to act upon such knowledge. Goggin and Morrow (2001) interviewed 403 adults over the age of 60 years and found that while 89% were aware that physical activity resulted in improved health, only about 30% were participating in sufficient exercise to realize such benefits. Recognizing this dilemma, Chodzko-Zajko (1999) recommends that a strong focus on programming should be emphasized in future aging–physical activity research.

CONCEPT 18.14

Ageism can be detrimental to an older adult's developmental process.

Another social phenomenon that adults often face as they advance in years is **ageism**, which involves stereotyping (negatively or positively) or discriminating against older adults on the basis of prejudice (Hoyer & Roodin, 2009). A perception that all old people have physical and cognitive deficits and should be treated like children is an example of ageism. It may also involve a dislike for older persons because they are perceived to be of minimal value to society or to represent a drain on societal resources. Ageism is often observed with the prejudicial perceptions of adolescents and adults but can be present in childhood. Behlendorf, MacRae, and Vos Strache (1999) found that even children possess ageist views of older people as less competent than younger adults in physical activities.

Without exploring the underlying bases of such perceptions, suffice it to say that they represent serious misconceptions. Table 18.2 provides several common misperceptions about older populations, many of them related to health status and physical capabilities. Ageism represents, at best, a level of ignorance about the individual value of each person of advanced age, and, at worst, a destructive tool that can damage the opportunities ande venl iveso fo lder adults.

SUCCESSFUL AGING

It has been proposed that the concept of **successful aging** is multidimensional, encompassing the sustained engagement in social and productive activities, the maintenance of high physical and cognitive function, and the avoidance of disease and disability (Rowe & Kahn, 1997) (Figure 18.13). In an attempt to determine specific items that may serve as predictors of successful aging, two longitudinal aging studies were initiated at Duke University. The first began in 1955 and observed 276 men and women (aged 60 to 90 years) every two to four years until 1976. The second investigation began in 1968 with 502 men and women (aged 45 to 70 years) and was also completed in 1976 (Shock, 1985). Palmore (1979, 1982) examined the data from the first Duke longitudinal study of aging and identified several

TABLE 18.2 Common Misperceptions about Older Adults

EXAMPLES OF MISPERCEPTIONS BASED ON NEGATIVE STEREOTYPES

1. Most older persons are poor.
2. Most older persons are unable to keep up with inflation.
3. Mosto lder peoplea rei ll-housed.
4. Most older people are frail and in poor health.
5. The aged are impotent as a political force and require advocacy.
6. Most older people are inadequate employees; they are less productive, efficient, motivated, innovative, and creative than younger workers. Most older workers are accident-prone.
7. Older people are mentally slower and more forgetful; they are less able to learn new things.
8. Older persons tend to be intellectually rigid and dogmatic. Most old people are set in their ways and unable toc hange.
9. A majority of older people are socially isolated and lonely. Most are disengaging or disengaged from society.
10. Most olderp ersons are confined to long-term care institutions.

EXAMPLES OF MISPERCEPTIONS BASED ON POSITIVE STEREOTYPES

1. The aged are relatively well off; they are not poor, but in good economic shape. Their benefits are generously provided by working members of society.
2. The aged are a potential political force that votes and participates in unity and in great numbers.
3. Older people make friends very easily. They are kind and smiling.
4. Most older persons are mature, experienced, wise, and interesting.
5. Most older persons are very good listeners and are especially patient with children.
6. A majority of older persons are very kind and generous to their children and grandchildren.

Source: From S. Lubomudrov, "Congressional Perceptions of the Elderly: The Use of Stereotypes in the Legislative Process," *Journal of Gerontology,* 27:77–81, 1987.

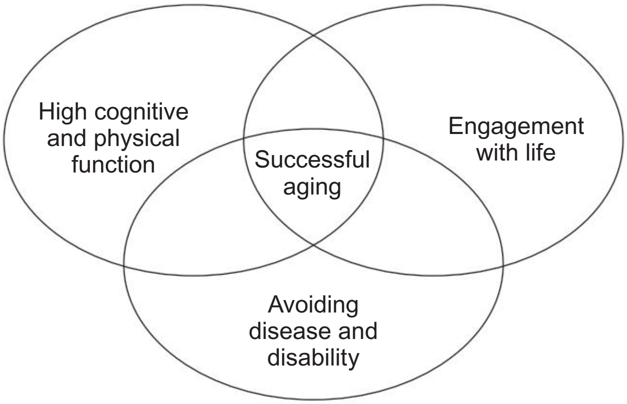


Figure1 8.13 Interaction of factors leading to successful aging
Source: Adapted from Rowe, J. W., and Kahn, R. L. (1997). Successful aging. *The Gerontologist, 37,* 433–440.

significant factors that could be classified as predictors of longevity and of successful aging.

Significant predictors of successful aging for both men and women included the motor domain characteristics of physical functioning and number of physical activities. In regard to the more specific factor of longevity, several components from the motor domain represented significant predicting factors. For both men and women, the physical functioning rating (representing the level of physical function ability in everyday tasks) was a significant predictor. A second significant predictor for men and women was each participant's self-rating of his or her health. For women, a significant longevity predictor was the number of activities involved that required physical mobility.

CONCEPT 18.15

Lifestyle characteristics can represent important determinants of longevity and successful aging.

One implication that arises from the results of these investigations is that a physically active lifestyle is a key element in the pursuit of successful aging.

Chodzko-Zajko (1999) further states that

> In order to age successfully, older adults need to be not only physically active but also socially, intellectually, culturally, and (for many seniors) spiritually active. . . . One of the challenges for our profession in the new millennium will be to learn how to integrate physical activity into the wider social, cultural, and economic context of active aging as a whole. (p. 214)

In an attempt to engage older adults in physical activity, it is important to know those factors that motivate them to exercise and those that serve as barriers to exercise. Cohen-Mansfield, Marx, and Guralnik (2003) found that older adults found motivation to exercise when they felt in good health, participated in an organized exercise program, and had someone with whom to exercise.

Roadblocks to exercising included health problems and/or pain, lack of time, and a state of laziness or lack of motivation. A summary of both motivators and barriers are noted in Figures 18.14 and 18.15. Fitness and health specialists working with older adults can reinforce motivating factors and counter barriers when attempting to engage theirc lientsi np hysicala ctivity.

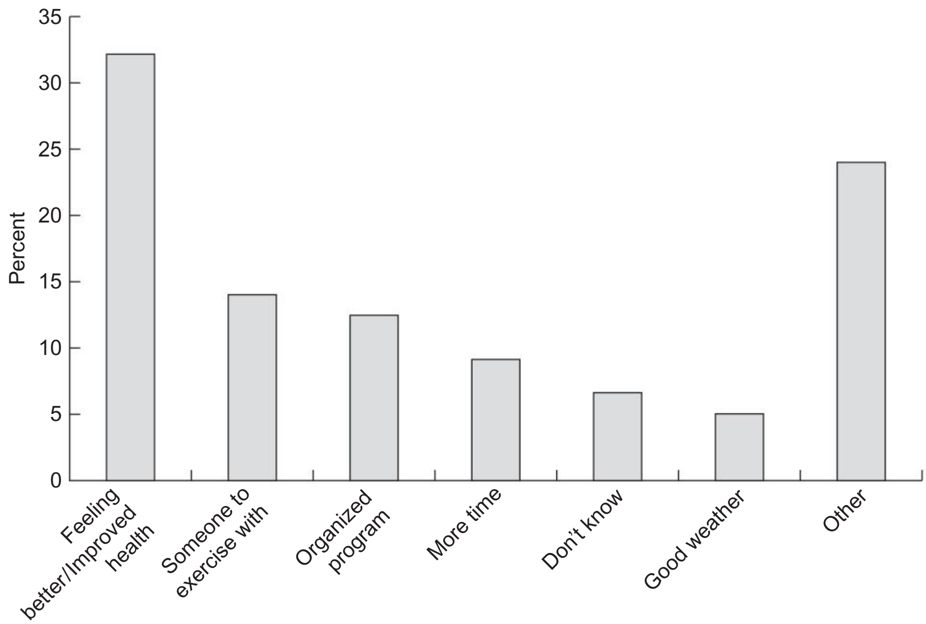


Figure1 8.14 Motivators to exercising with older adults

Source: Data from Cohen-Mansfield, J., Marx, M. S., & Guralnik, J. M. (2003). Motivators and barriers to exercise in an older community-dwelling population. *Journal of Aging and Physical Activity, 11,* 242–253.

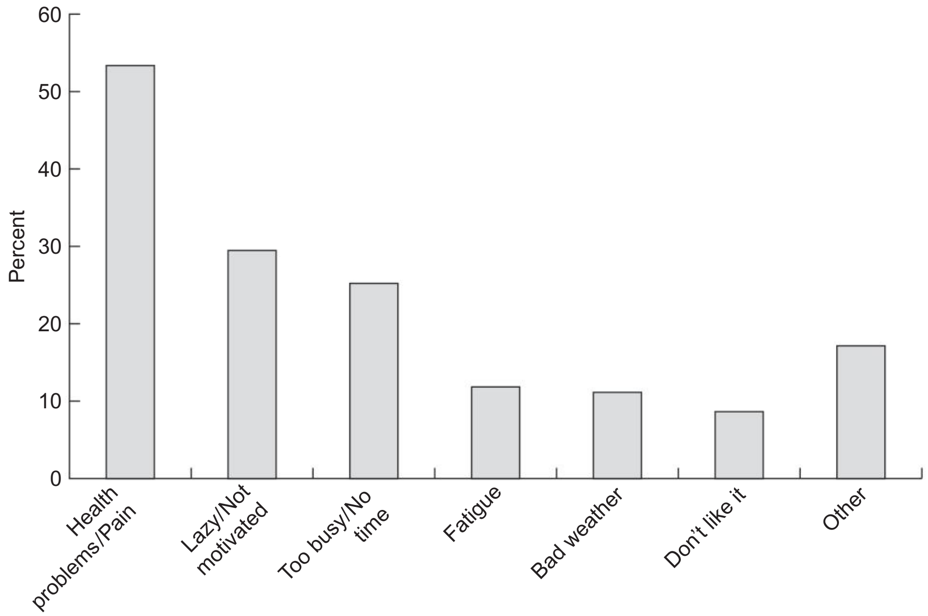


Figure1 8.15 Barriers to exercise with older adults

Source: Data from Cohen-Mansfield, J., Marx, M. S., & Guralnik, J. M. (2003). Motivators and barriers to exercise in an older community-dwelling population. *Journal of Aging and Physical Activity, 11,* 242–253.

SUMMARY

As adults age, they experience a number of changes, many of them detrimental to motor performance. Many of these declines in performance occur as a result of the aging process; others are related to task demands and environmental conditions. The underlying reasons why we age may include changes in cells and/or in whole physiological systems. Recognize that while aging patterns seem to follow a general trend, individual rates of aging may vary widely. Some of these age-related changes can be observed in the musculoskeletal system, the central nervous system, the circulatory and respiratory systems, and the sensory systems. Although many of these observed changes may be a direct result of the aging process, other causes may include disease and lifestyle habits.

Many aspects of the psychosocial domain interact often and in a number of ways with various characteristics of the motor domain. This is observed in many circumstances in which exercise is involved. Factors such as a sense of well-being, body image, locus of control, and depression may be influenced by an adult's involvement in physical activity. Maintaining a physically active lifestyle may also prove beneficial in attaining a sense of integrity during the latter stages of psychosocial development. Older adults, however, will face major decisions about retirement and may encounter ageism that could limit potential opportunities. Older adults who maintain good health and remain physically active can enhance their retirement circumstances while dispelling myths about older adult stereotypes. Health status and levels of physical activity are also recognized as predictors of longevity and successful aging. Motivators and barriers exist that encourage or discourage older adults from leading a physically active life.

Questions for Reflection

1. Why is it inevitable that as we age our motor performance will be affected?
2. Why is it critical that as we progress through adulthood we maintain an active lifestyle?
3. What are the potential physiological benefits of an active lifestyle for an adult?
4. What are the potential psychological, social, and emotional benefits of an active lifestyle for an adult?

Critical Readings

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Santrock, J. W. (2009). *Lifespan Development,* 12th ed. (Chapters 15, 17, 20). St. Louis: McGraw-Hill.

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Web Resources

www.nia.nih.gov

Homepage for the National Institute on Aging. The site provides health and research information as well as press releases, a calendar of events, and general information on the NIA in regard to mission and programs.

http://www.census.gov/

The United States Census Bureau homepage. The site contains population statistics for the U.S. including state-by-state statistical profiles.

http://home.comcast.net/~miller.patrice/SRAD/

The homepage for the Society for Research in Adult Development. The SRAD "includes people from all disciplines who are interested in positive adult development." The site includes information on the *Journal of Adult Development,* a book list, and symposium information.

http:/www.aoa.gov/

The Department of Health and Human Services' Administration on Aging homepage. The site provides recent news releases regarding aging, information for elders and family, and information for professionals.

http://www.apa.org/topics/aging/index.aspx

The American Psychological Association's Web page dedicated to aging issues. Site includes news information, publications, fact sheets, and links to other organizations on aging.

http://www.aarp.org/

The American Association of Retired Persons' homepage. Page contains numerous resources for retired citizens including information on community service, health and wellness, legislation, and research.

http://www.americangeriatrics.org/

The American Geriatrics Society's homepage. The AGS "is the premier professional organization of health care providers dedicated to improving the health and well-being of all older adults." The site contains news information, funding opportunities, education, and health links.

http://www.asaging.org/

The homepage for the American Society on Aging. The ASA is the largest organization of professionals that deals with aging issues. The site is geared toward individuals working with older adults and their families.

http://www.ncoa.org/

The homepage for the National Council on Aging. The NCOA is "dedicated to improving the health and independence of older persons." The site provides news, information, publications, research,a nde ventsf oro lder people.

CHAPTER

19

Motor Performance in Adults

KEY TERMS

Reactiont ime

FractionatedR T

Speed-accuracyt rade-off

Balancea ndp osturalc ontrol

Gait

Activitieso fda ilyli ving(A DL)

CHAPTER COMPETENCIES

Upon completion of this chapter you should be able to:

- Discuss the relationship among aging physiological systems, psychological factors, environmental conditions, and task requirements of motor performance through adulthood
- Describe age-associated changes in reaction time and discuss intervention strategies that may reduce the differences in reaction time observed between older and younger adults
- Discuss balance and postural changes observed in older adults and describe methods that may increase their stability
- Recognize the susceptibility and potential dangers of falls in older adulthood
- Discuss age-related variations in gait patterns and their underlying causes
- Discuss intervention methods to assist older adults in the performance of daily living activities
- Describe the limitations facing the elderly driver and possible interventions to maintain driving independence
- Recognize that high-level motor performance can occur at any age
- Describe motor assessment instruments that target the aged population of adults

KEY CONCEPT

An adult's motor performance depends on the interaction of a wide variety of variables, some of which can be manipulated with ease while others are resistant to change.

When we see an adult throwing a Frisbee, typing a letter, rebounding a basketball, walking with the aid of a walker, or going for a run in the park, we are observing motor performance. The movement tasks of adults range from everyday activities to specialized skills. Some tasks require a high level of accuracy, others require a high degree of speed, and still others may dictate a combination of speed and accuracy.

CONCEPT 19.1

Observed declines in motor performance through adulthood may be the result of physiological degeneration, psychological factors, environmental conditions, task requirements, disease, lifestyle, or combinations of these elements.

As we advance in age, we observe a number of changes in the performance of various movement tasks. Most of these changes involve a decline in successful task accomplishment. These detrimental changes in motor performance may be the result of age-related degeneration of physiological systems, age-associated psychological factors, the changing environment, task demands, or some combination of these four variables. It is important, however, to reemphasize the point made by Spirduso and MacRae (1990) that variability in the motor performance of adults can be high. The interaction of several variables, some age-related, will dictate whether an individual will experience a decline in a specific movement task.

As discussed in the previous chapter, the aging process results in a number of physiological changes. Some of those changes may have little or no impact on the behavior of an aging adult. Certain task demands may not place major burdens on physiological systems that have deteriorated, or demands placed on a declining system may be accommodated by one or more of the healthy physiological systems. Other physiological changes, however, may result in an observable decline in the performance of various motor skills. A particular impaired system may play such a primary role in the performance of a certain motor task that other systems cannot provide sufficient compensation. The interaction of two or more declining physiological systems may have a detrimental effect on the performance of specific movements as well.

The environment in which the movement task is performed may play a role in the level of performance success. The amount of light that illuminates a room, the firmness of the floor surface, and the surrounding air temperature represent examples of environmental conditions that could affect performance. Certain environmental circumstances may be detrimental to the execution of a particular movement whether the performer is a child, young adult, or old adult. Other environmental conditions may inhibit performance only when they interact with a declining physiological system or systems. For example, an older adult standing in a dimly lit room may not be able to catch a tossed ball. While his inability to catch the ball may represent an age-associated decline in the skill of catching, it may also be the result of a low level of illumination interacting with age-associated changes in the structure and function of his eyes. Increasing the level of lighting in the room may enable him to catch a tossed ball with little or no difficulty.

The requirements that define how the task is to be performed may interact with certain age-related characteristics to reduce the level of performance efficiency or success. An older adult may have trouble performing a task that requires both speed and accuracy but no difficulty if the same task requires only accuracy. Changes in the musculoskeletal and central nervous systems may affect the speed at which a task is attempted but not necessarily its accurate completion.

Although the reasons behind age-related changes in motor performance are many and varied, some behavioral changes are consistently observed. These include decreased reaction times, diminished maintenance of balance and postural control, and alterations in walking patterns.

CONCEPT 19.2

Reaction time is an important component in many motor performance tasks.

REACTION TIME

The study of **reaction time** (RT) has long been a vital aspect in the understanding of motor behavior in humans. RT represents the time delay between the presentation of a stimulus and the initial activation of the appropriate muscle groups to carry out that task. The measurement of RT provides insight into the internal processes taking place during voluntary movement.

CONCEPT 19.3

Reaction time can be separated into different components, each of which may be affected by various age-related changes.

Reaction time can be described by various means. Nonfractionated RT is measured by recording the time between the presentation of a stimulus and the first initiation of the movement. **Fractionated RT** represents an attempt to break the complete RT process into various components. Generally, fractionated RT investigations dissect the total RT process into the two components of premotor RT and motor RT. *Premotor RT* represents the time between the onset of the signal and the first indication of electrical activity (as measured by electromyography) in the muscles used to carry out the task. *Motor RT* follows premotor RT and refers to the time between the first indication of electrical activity and the initiation of the movement (Figure 19.1).

Although much more difficult to accomplish, premotor RT may be further sectioned into reception time, motor integration time, and motor overflow time. As a signal travels (via light waves, sound waves, etc.) from its origin through the environment and is picked up by one or more of the body's sensory systems, it reaches a part of the brain that will either attach meaning to the signal or discard it as meaningless. The time it takes to execute this phase represents *reception time.* Once meaning has been attached to the signal, it is followed by activity in the motor cortex of the brain that helps determine the movement needed to respond to the signal. This part of the process represents the *motor integration time.* The time difference between this motor cortex activity and the first indication of electrical activity in the muscles used to carry out the task is referred to as the *motor overflow time.* The process involved in RT is amazingly complex, but it is equally amazing that, when the signal and movement task are fairly simple, the time involved in the RT process is generally less than 1 second.

In addition to investigating the various components of RT, researchers have attempted to alter the environmental conditions under which RT is observed. RT may be examined under such circumstances as multiple-choice responses (i.e., responding one way to a green light and a different way to a red light), different sensory systems receiving the signal to begin a task (i.e., vision-light, hearing-bell, etc.), or the intensity of the signal to begin a task (i.e., vision—bright or dim, hearing—loud or soft).

CONCEPT 19.4

Certain intervention strategies can reduce age differences in reaction time.

It has been consistently demonstrated that RT diminishes with age. Early cross-sectional studies indicated that RT reaches its peak somewhere in the early to mid-20s, begins a slow drop through

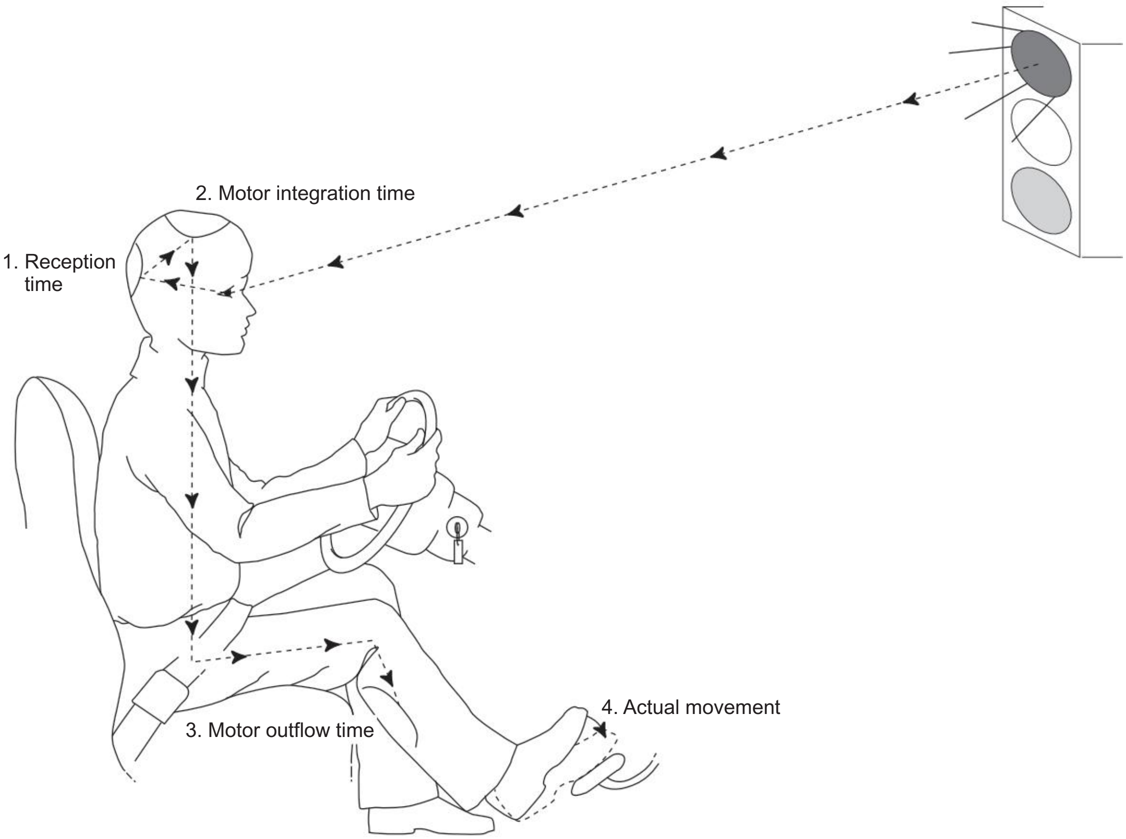

Figure 19.1
Components of fractionated reaction time.

the middle adulthood years, and declines sharply during older adulthood (Hodgkins, 1963; Pierson & Montoye, 1958). However, even these early investigations indicated that the variability in RT is large when people grow older. More recently it has been demonstrated that RT studies placing greater control on certain variables will elicit much smaller age differences than previous studies. Factors such as providing a familiar signal to start the task, allowing sufficient opportunities to practice the specific task involved in the investigation, and enhancing the quality of the starting signal represent ways to greatly reduce age-related differences (Spirduso & MacRae, 1990), particularly in RT studies that deal with a single signal and a single response. Reduction of age-related differences in RT when more complex signals and responses are involved is generally less significant.

Although factors such as practice and the quality and familiarity of the signal help minimize age differences in RT, younger adults consistently have faster RT than older adults. The breadth of the age-related difference depends on factors associated with each individual's physiological and psychological characteristics, the environment in which the task is performed, and the nature of the task.

Physiologically, several possibilities might contribute to slower responses as a person ages. Spirduso (1986) suggested that "to some extent psychomotor tasks requiring speed may be considered a behavioral window through which the central nervous system's integrity may be viewed" (p. 153). As discussed in the previous chapter, the central nervous system undergoes a number of age-related changes ranging from a loss of brain cells to decreases in blood flow and, subsequently, the amount of oxygen that reaches the brain. These central nervous system changes can be harmful in all aspects but particularly in the central components of the RT process. The functioning quality of the brain, influenced by the amount of blood and nutrients it receives, has the potential to affect the RT components of reception time, motor integration time, and motor overflow time.

Reception time can be impaired by age-associated changes in the systems that receive sensory information requiring a quick response. Decreases or distortions in the light waves or sound waves received by an aging visual system or auditory system, respectively, could be responsible for an increase in the amount of time it takes to transmit pertinent information to the processing centers of the brain. Additionally, the motor time component of RT may be slowed by a decline in the time required to activate the muscles of an aging muscular system.

Psychologically, a number of factors, either individually or in interaction with other variables, have the potential to slow an older adult's ability to respond quickly. Dacey, Travers, and Fiore (2009) suggest that variables such as motivation, depression, and anxiety may be important factors in RT difference between older and younger adults. The older adult, because of a greater number of lifetime experiences, may not emphasize tasks requiring quick responses. An older adult may be more motivated to perform a task accurately rather than rapidly, whereas a younger adult may emphasize speed and sacrifice accuracy. This involves a phenomenon referred to as the **speed-accuracy trade-off.** The speed-accuracy trade-off is a principle that describes the trend toward a decline in the accuracy of a movement when its speed is increased (Schmidt & Wrisberg, 2008). An older adult experiencing a state of depression may be less motivated to perform to her potential on a given task. Older adulthood is a time when factors such as health problems or the death of a spouse or friend create the potential for a psychologically depressed state. Older adults may also experience a sense of anxiety when asked to perform a task with which they may not be familiar.

Altering the environment can, in many cases, aid the older adult in performing a movement task requiring a quick response. As discussed in the previous chapter, many older adults experience a loss in rod cells of the retina causing problems with visually adapting to the dark. An older individual attempting to perform a movement task in a dimly lit room will probably perform the task slowly and with reduced accuracy. However, when the lighting is increased, the amount of light transmitted by the eyes to the processing centers of the brain is heightened and the RT process is enhanced. When movement instructions or signals are auditory, increasing the amplitude or altering the frequency of auditory information increases the possibility that more information will reach the brain and enhance the RT process.

Modifying specific task requirements or conditions enhances the performance speed of older adults. As mentioned earlier in this chapter, providing opportunities to practice a movement task improves the RT of older adults. Practice, likewise, helps reduce any anxiety that an individual may have when attempting an unfamiliar task. Reducing the number of possible movements from which to select following a signal is also a proven means of boosting the RT of older adults.

In addition to environmental conditions and task requirements, many investigators have found that a person's level of physical activity can play a key role in determining RT status (Gauchard et al., 2003; Chodzko-Zajko, 1991; Christensen et al., 2003). In an interesting study comparing the RT of young physically active men (YA), young nonphysically active men (YNA), old physically active men (OA), and old nonphysically active men (ONA), Spirduso (1975) found that the RT of the OA men were similar to the RT of the YNA men. Of even greater importance, however, was the finding of a marked difference between the OA and ONA men. In a comparable study researchers investigated the psychomotor function of older adults who were very active, moderately active, and low active (Christensen et al., 2003). They found that generally increased levels of physical activity were related to superior reaction times.

When the influence of more specific fitness factors on reaction time is examined, it has been determined that aerobic endurance and muscular strength levels have a positive impact. Etnier et al. (2003) concluded that psychomotor performance might be preserved by aerobic fitness, whereas Hunter, Thompson, and Adams (2001) found that muscular strength appeared to be inversely related to reaction time in women. In other words, older women who were stronger than women of similar age had faster reaction times.

The faster performances of older active adults can be attributed to good central nervous system circulation, which is necessary for optimal brain cell longevity and processing efficiency. Such circulation is maintained through exercise. Spirduso (2005) adds that inactivity for both young and old adults may contribute to the wear and tear on the central nervous system due to the accumulated effects of increased blood pressure and higher lipofuscin concentrations. She conclude that exercise can serve as the best protection against senile involution of brain cells in cerebral activity due to its ability to stimulate metabolism, respiration, and blood circulation. Physical activity may, likewise, enhance the functioning of some neurotransmitter systems of older adults. Ari et al. (2004) found that exercise-related decrease in the reaction time of older males was associated with elevated serum testosterone and growth hormone levels. They speculated that these increased hormonal levels may be advantageous for brain functions. While representing a positive influence on the central RT functions of the brain, exercise appears to promote better functioning of the more peripheral components of RT as well. Physical activity fosters healthy blood circulation to the extremities. Increased circulation provides for adequate extremity temperatures, important for the rapid transmission of nerve signals to the muscles.

Balance and Postural Control

As mentioned earlier in this chapter, the RT process usually involves a time factor of less than 1 second, depending on the complexity of the circumstances. Some motor performance tasks do not require fast RTs for their successful completion, whereas other tasks do. The ability to maintain one's **balance and postural control** efficiently appears to require an adequately functioning RT process. However, RT is only one of many factors that interact for the purposes of maintaining balance and the control of posture. Woollacott and Shumway-Cook (1990) suggest that multiple neural and biomechanical factors work together to achieve the goal of balance. They list the following components that may play an influential role in the control of an individual's balance: (1) postural muscle response synergies; (2) visual, vestibular, and somatosensory systems; (3) adaptive systems; (4) muscle strength; (5) joint range of motion; and (6) body morphology.

Concept 19.5

Several factors serve as interacting components in the maintenance of balance and posture.

Postural muscle response synergies refer to the timing and sequencing of the activation of muscle groups needed to maintain balance or postural control. Several muscle groups in both the lower body and upper body may be called on to maintain a controlled upright posture or to regulate balance smoothly in a variety of movement situations. The visual system provides valuable information regarding body position in relationship to the environment, and the vestibular and somatosensory systems contribute sensory input regarding body and head position in relation to gravity and joint position awareness.

Adaptive systems allow for the modification of sensory input and motor output when changes take place in the task requirements or in the characteristics of the environment. The strength of the muscles at the ankle, knee, and hip must be adequate to be able to either maintain a specific postural position or to control the restoration of balance when equilibrium is disturbed. The range of motion of the body's various joints determines how restrictive or free a movement can be when that movement requires a high degree of balance. Finally, body morphology elements such as height, center of mass, foot length, and body weight distribution affect the biomechanical function of maintainings tability.

CONCEPT 19.6

Older adults display different motor patterns than younger adults when attempting to regain stability after their balance has been disturbed.

With age, the process of maintaining postural control and balance becomes less efficient, particularly in the older adult (Johnson, Mihalko, & Newell, 2003; Rankkin et al., 2000). For many older adults the decrements in controlling posture may represent irreversible changes. It has been demonstrated that when the stability of older adults is disturbed, the restoration process is often different and less effective than the process exhibited by younger adults (Woollacott et al., 1986). One difference is the timing of the muscle activation. When a person is standing upright and something causes him to lose his balance and begin to sway backward, the balance recovery procedure generally involves the activation of the ankle dorsiflexors followed by the activation of the knee extensors. The muscle activation response in younger adults tends to be quicker than the muscle response of older adults. Some older adults have even demonstrated a reversal of the muscle activation pattern when attempting to restore balance. They may occasionally activate the knee extensor muscle group first followed by the ankle dorsiflexors. In addition, in an attempt to restore balance, some older adults may incorporate additional muscle groups (i.e., muscles of the hip) not used by younger adults, or activate the agonist muscle group (i.e., knee extensors) and the antagonist muscle group (i.e., knee flexors) at the same time (Manchester et al., 1989), an occurrence observed in very young children (Forssberg & Nashner, 1982).

This cocontraction of the agonist and antagonist muscle groups by older adults may represent a strategy of compensation for the inability to fine-tune the postural control to the same degree as young adults (Woollacott et al., 1988). The proper functioning of the vestibular and visual systems and their interactions appear to be critical in the postural control differences of older and younger adults. As long as these two systems are intact and able to receive and transmit accurate sensory information, the ability of older adults to recover from disturbed balance is similar to that of younger adults. However, when the amount of visual and vestibular input available to both younger and older adults is substantially reduced, the ability of older adults to restore stability following a loss in balance is much weaker than that of younger adults (Teasdale, Stelmach, & Breunig, 1991; Woollacott et al., 1986).

CONCEPT 19.7

Intervention strategies can be incorporated to increase the stability of older adults.

Although many adults experience age-related declines in balance and postural control that may become irreversible (particularly in the older adulthood years), various intervention possibilities may be useful in reducing the magnitude of the decline, promoting compensation strategies, or both. Age-associated changes in the vestibular and visual systems may be difficult or impossible to counter, but alterations in the environment may provide for stronger sensory stimuli. For example, when an older adult is standing or moving on a soft surface, the amount or quality of sensory information sent from the joint, muscle, and vestibular receptors to the processing centers may be decreased. A firmer surface, however, may allow for sharper and more distinct sensory input, particularly for the joint and muscle receptors of the ankles. From a visual standpoint, an increase in room illumination could enhance the number of light waves that reach and are transmitted by the retina.

An increase in muscular strength may moderate the degree of instability of older people. Increases in muscular strength following training programs have been observed at all levels of adulthood. As mentioned in the previous chapter, even adults who were in their nineties experienced muscular strength gains following a strength-training program. Adequate levels of muscular strength in the lower and upper legs are particularly important for both the maintenance of balance and the avoidance of falls resulting from balance disruptions (Gregg, Pereira, & Caspersen, 2000). The consequences of a fall can be substantially more devastating for the older adult than for someone younger (Tinetti, 1990), as will be discussed later in this chapter.

As previously mentioned, a second musculoskeletal-associated factor that may play an influential role in maintaining balance is the range of motion of the body's joints. Although the joint flexibility of older adults tends to be more restricted than that of younger adults (Shephard, Berridge, & Montelpare, 1990), participation in physical activity and exercise has been shown to improve the range of motion of older adults and close the flexibility gap usually observed between young and old adulthood (Rikli & Edwards, 1991).

There is sufficient evidence to suggest that older adults who participate in exercise programs can experience improvements in their balance and stability. A review of the research indicates that programs designed to enhance balance should incorporate muscular strength, joint flexibility, and aerobic endurance activities along with exercises that stimulate multiple sensory systems and their central integration (Kronhed, Möller, Olsson, & Möller, 2001). Additional activities that have been demonstrated to improve standing balance control include tai chi and golf (Li et al., 2005; Tsang & Hui-Chan, 2004).

FALLS

Falls represent a major concern for many elderly individuals. Falling is much more common and serious when an adult is older than during early adulthood. Each year approximately 30% of adults over the age of 65 experience a fall. Many will endure multiple falls during a one-year period. With age, the likelihood of falling increases. Although the majority of falls experienced by older adults are minor and do not result in injury, more serious falls may result in soft tissue injuries, fractures, the development of psychological fears, or death.

CONCEPT 19.8

Hip fractures resulting from falls are a major concern for older adults.

Soft tissue injuries can range from various degrees of contusions (bruising) to muscle sprains and strains that could reduce an older individual's mobility and restrict her level of independence. Of even greater concern to older adults is the threat of falls that result in fractures. Fractures may occur at the humerus or wrist when the arm is outstretched in an attempt to cushion or stop a fall. These fractures, however, generally do not decrease mobility. *Hip fractures,* on the other hand, are much more devastating. Of those older adults who experienced a fall, 20 to 30% suffer moderate to severe injuries that include hip fractures or head traumas (Sterling, O'Connor, & Bonadies, 2001). Such injuries result in an extensive period of immobility, greater dependency on others for daily living functions, and heightened possibility of institutional care.

Of all fall-related fractures, hip fractures result in the greatest number of deaths. The Centers for Disease Control (2010) reported that in 2005 more than 15,800 older adults died from fall-related injuries. Many fractures in older adults can be attributed to osteoporosis. The loss of bone mass from *osteoporosis* not only makes bones weaker and more prone to fractures but also lengthens the time required for recovery. Another problem associated with hip fractures includes a susceptibility to instability and deformity of the fracture site (Jackson & Lyles, 1990).

A number of physical injuries can occur as a result of falls, but older adults may also develop a sense of fear and/or depression after falling. Approximately half of individuals who have fallen admit to a certain level of fear (Tinetti, 1990). The fear level of these older individuals may lead to overprotectiveness and unnecessary restrictions of mobility and independence. An older adult may begin to avoid even everyday functional tasks such as bathing and dressing. Depression may accompany the sense of fear and compound the psychological effects of a fall.

A number of factors link falls with the death of older adults. As mentioned earlier in this chapter, the majority of falls are not serious. However, falls do kill a small percentage of persons. More common are deaths that occur from fall-related injuries or from circumstances created by a fall. For example, an older adult who fractures her hip in a fall may experience a decline in overall health due to a long-term reduction in mobility and a decreased ability to care for herself. This may eventually lead to death. Finally, multiple falls in an older individual may indicate underlying factors that elevate the risk of death (Dunn et al., 1992). Age-related and disease-related declines in a number of physiological systems may make a person more susceptible to falls. In these instances falling reveals rather than causes more serious health problems. These health problems may be moving an older adult closer to death.

CONCEPT 19.9

A number of circumstances predispose the older adult to falls.

A number of interacting factors appear to predispose older individuals to falling. Many of these factors are physiological; others relate to the environments in which falls take place. Task demands can likewise play a role in creating a precarious situation. Physiological factors may include age- or disease-associated changes in various sensory systems, the central nervous system, or the musculoskeletal system. Environmental conditions often involve potentially hazardous circumstances interacting with declining or drug-impaired physiological systems. The demands of certain tasks may require an individual to move beyond a comfort zone of stability, making him or her vulnerable to other forces.

As discussed in the previous chapter, declines in the visual, auditory, and vestibular system are common in adults as they age. These declines add to the jeopardy that older adults face in relation to falling. Falls can occur when an individual trips over a hazardous object because she is unable to see it in a dimly lit room. The inability to distinguish the sounds made by the feet on different types of floor surfaces may reduce or eliminate certain feedback beneficial in maintaining stability. Improper functioning of the vestibular system may result in dizziness and place the person at risk for falling.

A slowing or disruption of the central nervous system can increase an older person's vulnerability to falling. Rapid RT may help a person catch his balance to avoid a fall when stability is lost. Under similar circumstances, a somewhat slower RT may restrict the restoration of balance, causing the person to outstretch his arm and break the fall. Although this action may cushion the impact of a fall, it places the person at risk for a fracture of the wrist or humerus. An older adult with an even slower RT may be unable to extend her arms quickly enough to break the fall and may land directly on an unprotected hip. Additional central nervous system conditions such as Parkinson's disease and strokes increase the older adult's susceptibility to falls.

Adequate muscular strength (particularly in the lower extremities) is important for maintaining balance and restoring lost stability. Age-related loss in muscle mass and a subsequent loss in strength can be detrimental to maintaining balance and preventing falls. Arthritis of lower extremity joints can also decrease fall prevention strategies.

DEVELOPMENTAL DILEMMA

What Does This Pill Do?

As the health of older adults declines, medication is often prescribed for a variety of conditions. Many of these prescription meds are considered lifesaving in nature. A dilemma often manifests as a number of medications predispose the older adult to falling. Certain sedatives and antidepressants are known to increase the risk of falling. In addition, taking more than one drug at the same time without knowledge of the drug interaction consequences also represents numerous potential problems. Often an older adult with certain medical conditions must sacrifice one aspect of health for another.

An older person's home or work environment can present a number of hazards that increase the likelihood of falling. Falls can occur when a person climbs or descends stairs; bathes; moves in and out of a wheelchair; or trips over electrical cords, low furniture, or small pets. Other falls may occur as a result of shoes that fit poorly. Additional environmental hazards include low levels of room illumination, surfaces that produce glare when light strikes them, and soft, uneven, or unstable floor surfaces. It is possible that the optical patterns on floors and stairs may contribute to falling due to a decline in the older adult's visual perception process (Tinetti, 1990).

The demands of certain tasks can place older adults in situations in which they are at greater risk for falling, particularly when the tasks require intense concentration. Attention to balance may be diverted. Reaching for an object high on a shelf while using a stepladder, bending over and attempting to lift a heavy object, or carrying a full laundry basket down a flight of stairs are potentially hazardous tasks for older adults. Older individuals who participate in more physically active lifestyles appear to have an increased incidence of falls (Tinetti, 1990). Reasons probably include greater exposure to hazardous circumstances and increased intensity in active participation.

Because of the many and varied factors that can contribute to instability and subsequent falling, intervention strategies may require a variety of approaches. Gillespie et al. (2003) found that the interventions with the greatest impact included health/environmental risk factor screening/intervention programs in the community, home hazard assessment and modification, and a program of muscle strengthening and balance retraining. Gregg, Pereira, and Caspersen (2000) concluded that increasing the physical activity of sedentary older adults can result in a 20 to 40% decreased risk of hip fracture. Lamoureux et al. (2003) found that improving strength to aid locomotion can decrease the risk of falling. A list of risk factors for falling and additional intervention strategies can be found in Table 19.1.

GAIT

Walking appears to be a simple, almost automatic task performed without much effort. It is, however, a complex skill requiring the interaction of the central nervous system, the body's muscles and joints, several sensory systems, gravitational forces, and environmental circumstances. Age-related and/or disease-related changes in one or more of the body's systems can interact with physical and/or environmental conditions to cause decrements in the **gait** process. Neurologically, gait uses an intricate combination of voluntary and reflexive action. The muscles and joints of the ankle, knee, pelvis, and to some degree the trunk and shoulder are vital ingredients in an efficient walking pattern. The gait process makes use of information obtained through the visual, auditory, and vestibular systems, as well as others. The forces related to the earth's gravitational pull are involved with the continual altering of the body's center of gravity and the constant reestablishing of the base of support during the walking cycle. Environmental conditions such as walking surface or objects placed in the path of a walker can alter the gait pattern.

The walking cycle or gait pattern has two phases: the *swing phase* and the *support phase.* Generally speaking, when one leg is in the swing

TABLE 19.1 Risk Factors for Falling and Possible Intervention Strategies

PossibleR iskF actorso ft heO lder Adult	Possible Intervention Strategies
• Decreasei nm usculars trength	—strength training exercises —assistance devices (canes, walkers, handrails)
• Decrease in joint flexibility	—active lifestyles —stretching exercises
• Decrease in visual abilities	—increased room lighting —reduced glare —eyeglasses —surgical treatments
• Decreasei n auditory abilities	—removal of cerumen —hearing assistance devices
• Decreasei n proprioception	—firm walking surfaces —proper footwear —enhanced visual environment —avoiding uneven surfaces —assistance devices (canes, walkers, handrails)
• Slowing of reaction time	—active lifestyles —focused attention on task —allowance for practice of task —increased motivation
• Medication	—awareness of drug side effects —awareness of drug interaction side effects

phase, the other leg is in the support phase. The swing phase begins when the toe pushes off the ground surface and ends when the heel strikes the ground surface. During the swing phase, the leg moves through the air in a pendulumlike motion. The support phase begins when the heel first strikes the ground surface and ends when the toe pushes off the ground surface. During the entire support phase, the foot maintains contact with the ground surface. In addition to the support and swing phases, for a brief time in the walking cycle, both feet contact the ground surface at the same time. This is referred to as a *period of double support* and is the major characteristic that differentiates running from walking. Other elements of walking include stride length, stride frequency, stride width, toe-floor clearance during the swing phase, arm swing, and hip and knee rotation.

CONCEPT 19.10

Differences in the gait patterns of older adults and younger adults often originate in different walking speeds.

As individuals move into older adulthood, a variety of gait characteristics undergo changes. Older adults may differ from younger adults in several walking components. Older adults characterized as healthy have displayed decreases in *stride length,* increases in the double support period, reductions in *toe-floor clearance,* alterations of the strategies used when the foot clears obstacles on the floor, and decreases in *gait velocity* (Chen et al., 1991; Elble, Hughes, & Higgins, 1991; Ferrandez, Pailhous, & Durup, 1990; Hortobágyi & DeVita, 1999;

Wall et al., 1991). However, some investigators have reported that many of the declines or reductions observed in the walking patterns of older adults can be attributed to slower paces, rather than to particular physiological problems (Elble et al., 1991; Ferrandez et al., 1990). Although a slower walking speed appears to be characteristic of an older person's gait and may cause a number of other decreases in gait efficiency, intervention strategies such as weight training can improve the gait speed and other gait factors of older adults (Fiatarone et al., 1990; Lamoureux et al., 2003). Also, physically active older adults had better gait characteristics when compared with sedentary individuals of similar age (Rosengren et al., 1995).

While it is speculative to state that age alone causes declines in the gait cycle, a number of diseases that often afflict older adults contribute to gait problems. Disorders of the central nervous system such as Parkinson's disease, multiple sclerosis, tumors, or strokes can affect balance control and, in turn, the quality of the gait pattern (Koller & Glatt, 1990). Orthopedic conditions such as arthritis and bunions, often experienced by older adults, may also alter an individual's gait pattern.

Activities of Daily Living

Concept 19.11

Older adults may have difficulty carrying out daily living activities without some environmental modifications.

A multitude of movement-oriented tasks that individuals carry out throughout their lives are required for basic everyday needs. **Activities of daily living (ADL)** such as getting out of bed, getting dressed, bathing, and preparing meals are a few of the many tasks that require the attention of adults. Whereas most young and middle-aged adults take for granted the ease with which these ADL tasks are performed, many older adults find them difficult. Older adults demonstrate less efficient movement patterns when attempting to rise from the floor to a standing position (VanSant, 1990). When attempting to stand from a horizontal position, an older adult may break down the process into discrete segments (i.e., sit up, get onto all fours, move to a kneeling or a squatting position, then pull up to a standing position). Younger adults tend to move from a horizontal position to a standing position in one fluid motion. This *segmental approach* demonstrated by an older adult may be evident when he rises to a standing position from a bed or a chair.

While some age-related movement patterns in certain ADL have been noted, it has also been observed that greater efficiency in those movement patterns can be achieved when the task conditions are modified. VanSant (1990) pointed out that altering environmental conditions, such as varying the height of objects (chair, bed, etc.), can enhance an older person's motor performance. In addition, Hart et al. (1990) found that by providing assistance modifications to various household items, older adults were able to put on their shoes, get on and off the toilet, pour from a teapot, and turn on the tap with less difficulty and greater speed. Cavani et al. (2002) also found that a moderately intense strength training and stretching program can improve the functional fitness of older adults allowing them to perform ADL more easily. Additional home environment factors to aid older adults in ADL are listed in Table 19.2.

Table 19.2 Activities of Daily Living Assessment for the Home Environment

- Sturdy hand railings in stairwells
- Wide doorways for ease of access with ambulation aids
- Grab bars in the shower and tub area
- Nonskid bathtub surface
- Equipment and supplies for activities of daily living within easy reach
- Side rails on the bed, if applicable
- Heating and cooling as needed
- Good lighting
- Clear pathways and stairwells

Source: Adapted from Hoyer, W. J., & Roodin, P. A. (2009). *Adult Development and Aging,* 6th Ed. New York: McGraw-Hill.

Community and societal awareness can add significantly to the independence of older adults and assist them in carrying out daily living activities outside of the home often by making modest environmental changes. For example, crosswalk timer settings are often based upon gait studies performed in indoor laboratory settings. Additional outdoor environmental factors that can significantly slow the pace of an older adult crossing the street include negotiating curbs; adjusting to weather conditions such as wind; and dealing with visual distractions such as traffic or sun glare, which decreases the ability to see the crosswalk sign (Carmeli, Coleman, Omar, & Brown-Cross, 2000). Adjusting the crosswalk timer setting to allow additional time to cross a street safely can increase the comfort and independence levels of older adults and keep them engaged in their community.

Automobile Driving

While some individuals might classify automobile driving as an ADL, for many older adults it represents the key factor in whether they have maintained or lost their independence. A variety of factors may contribute to the cessation of driving for older adults. A reduced level of physical activity has been associated with older adults giving up their driving privileges (Marottoli, 1993). Visual functioning has also been shown to contribute to the avoidance of driving by older adults (Satariano et al., 2004). Visual problems are particularly evident when older drivers have to deal with the glare from the sun or other automobile lights.

The loss of driving abilities in older adults is not necessarily a given for everyone. Intervention programs focusing on applicable psychomotor and cognitive factors have been shown to assist older adults in maintaining their driving abilities (Klavor & Heslegrave, 2002). Attention to such attributes as reaction time, muscular strength, and cognitive attention may provide an older adult the opportunity to continue driving independently for manyy ears.

Elite Performance

Concept 19.12

A physically active lifestyle throughout adulthood can benefit an individual in a variety of motor performance–related aspects.

The quantity of motor performance activity observed at all levels of adulthood is extremely variable. The health status of various physiological systems, past and present lifestyles, genetic characteristics, environmental conditions, and task demands interact to generate a range of movement outcomes (performed extremely well, performed adequately, or performed poorly). Upon examining cross-sectional and longitudinal track and field accomplishments of masters-level athletes, Stones and Kozma (1982) suggested that non–age-related factors such as amount and quality of training, frequency and quality of competitive experience, motivation, and injury proneness may affect the performance trends through adulthood. It has also been suggested that the level of age-associated performance declines may be activity-specific (Stones & Kozma, 1980, 1981, 1986). Salthouse (1976) stated that "when one refers to slowing with age it is necessary to be quite specific about the activity to which one is referring because different activities decline at different rates" (p. 349). Ericsson (2000) found that healthy older adults can attain high levels of performance in specific task domains by regularly engaging in deliberate practice with suitably designed training activities. Fisk and Rogers (2000) examined the skill acquisition characteristics of older adults and developed a list of guidelines for assisting them in learning new skills. These guidelines include providing active rather than passive learning, teaching procedures, not just concepts, and providing extended practice opportunities. These guidelines, and others, are summarizedi nT able19. 3.

Many of the age-related changes discussed in this chapter and the previous chapter can cause

TABLE 19.3 Guidelines for Assisting Older Adults in Acquiring New Skills

- Provide active rather than passive learning
- Teach procedures, not only concepts
- Provide opportunities for modeling requisite behavior
- Train in smallg roups
- Providee xtendedp racticeo pportunities
- Provide environmentals upports

Source: Data from Fisk, A. D., and Rogers, W. A. (2000). Influence of training and experience on skill acquisition and maintenance in older adults. *Journal of Aging and Physical Activity, 8,* 373–378.

motor performance declines. However, evidence continues to mount that many adults who remain physically active and adapt and compensate for changing environmental and task demands inhibit the typical age-related declines much more effectivelyt hant heirseden tarypeer s.

INTERNATIONAL PERSPECTIVES

The Spirit of the Games

In the summer of 2013 in the city of Torino, Italy, the eighth edition of the World Masters Games (WMG) will be held. Thousands of athletes and fans from across the globe are expected to attend. The WMG represents a sports festival for athletes who are 35 years of age or older. The mission is to promote and encourage mature athletes around the world to participate in sports with the knowledge that competitive sports can continue throughout a person's life and have a positive impact on physical fitness. These athletes participate in a wide variety of sports such as archery, track and field, badminton, football (soccer), field hockey, squash, and weightlifting. In the true nature of encouraging participation there are no competition qualification requirements. Athletes just pay their registration fee, show up, and compete.

CONCEPT 19.13

Certain individuals may be able to perform motor tasks at elite levels regardless of their age.

There are, also, those older adults who continue to perform certain motor tasks at extraordinarily high levels. Although the records of *master athletes* are consistently lesser than the records of their younger counterparts, their performances are nonetheless noteworthy, and, in many cases, better than the performances of younger nonelite athletes. A few individuals continued to remain competitive in the open division of their sport after reaching master athlete status. Some notable master track and field age records are listed in Table 19.4.

ASSESSMENT

The motor performance of adults is variable, and that variability increases with advancing age. Assessing motor characteristics of the adult is a key ingredient in establishing intervention strategies for the maintenance of functional abilities or the perpetuation of an active lifestyle.

CONCEPT 19.14

Several assessment instruments have been developed for the motor performance measurement of adults.

While the number is limited, there are a few assessment instruments that have been developed to examine the fitness and/or motor performance characteristics of older adults. One assessment example is the Senior Fitness Test Manual (SFTM) (Rikli & Jones, 2001). The SFTM is published by Human Kinetics and represents an easy-to-use set of test items that examine the functional fitness of older adults. The instrument is considered reliable and valid and contains performance norms based on actual performance

TABLE 19.4 Selected Master Track and Field Age World Records

Men

Event/Record Holder	Age (Years)	Record	Year
100 METERS (SEC)			
Usain Bolt, Jamaica	Open	9.58	2009
Troy Douglas, Netherlands	40–44	10.26	2002
Bill Collins, USA	50–54	10.95	2002
Ron Taylor, Great Britain	60–64	11.70	1994
Payton Jordan, USA	70–74	12.72	1987
Payton Jordan, USA	80–84	14.35	1997
Frederico Fischer, Brazil	90–94	17.53	2007
MARATHON (HR:MIN:SEC)			
Haile Gebrselassie, Ethiopia	Open	2:03:59	2008
Andres Espinosa, Mexico	40–44	2:08:46	2003
Titus Mamabolo, South Africa	50–54	2:19:29	1991
Yoshihisa Hosaka, Japan	60–64	2:36:30	2009
Ed Whitlock, Canada	70–74	2:54:48	2004
Robert Horman, Australia	80–84	3:39:18	1998
Robert Horman, Australia	85–89	4:34:55	2004
HIGH JUMP (METERS)			
Javier Sotomayor, Cuba	Open	2.45	1993
Glen Conley, USA	40–44	2.15	1997
Thomas Zacharias, Germany	50–54	2.00	1997
Thomas Zacharias, Germany	60–64	1.80	2007
Carl Erik Särndal, Sweden	70–74	1.59	2007
Emmerich Zensch, Austria	80–84	1.34	2000
Donald Pellmann, USA	90–94	1.15	2005
LONG JUMP (METERS)			
Mike Powell, USA	Open	8.95	1991
Aaron Sampson, USA	40–44	7.68	2002
Tapani Taavitsainen, Finland	50–54	6.84	1994
Tom Patsalis, USA	60–64	6.07	1982
Vladimir Popov, Russia	70–74	5.22	2004
Melvin Larsen, USA	80–84	4.19	2004
Donald Pellmann, USA	90–94	3.26	2005

scores of over 7,000 men and women between the ages of 60 and 94.

In addition to fitness/motor performance–related instruments such as the SFTM, numerous instruments exist that purport to assess functional ability in activities of daily living (ADL). These activities include basic self-care skills such as eating, dressing, toileting, grooming,

TABLE 19.4 *Continued*

Women			
Event/Record Holder	**Age (Years)**	**Record**	**Year**
100 METERS (SEC)			
Florence Griffith Joyner, USA	Open	10.49	1988
Merlene Ottey, Jamaica	40–44	10.99	2000
Phil Raschker, USA	50–54	12.49	1998
Phil Raschker, USA	60–64	13.67	2007
Margaret Peters, New Zealand	70–74	15.16	2004
Mary Bowermaster, USA	80–84	17.94	1998
Nora Wedemo, Sweden	90–94	23.18	2003
MARATHON (HR:MIN:SEC)			
Paula Radcliffe, Great Britain	Open	2:15:25	2003
Ludmila Petrova, Russia	40–44	2:25:43	2008
Tatyana Pozdniakova, Ukraine	50–54	2:31:05	2005
Claudine Marchadier, France	60–64	3:02:50	2007
Christa Wulf, Germany	70–74	3:44:15	2004
Helen Klein, USA	80–84	4:31:42	2002
Helen Klein, USA	85–89	5:36:15	2008
HIGH JUMP (METERS)			
Stefka Kostadinova, Bulgaria	Open	2.09	1987
Patricia Porter, USA	40–44	1.76	2004
Debbie Brill, Canada	50–54	1.60	2004
Phil Raschker, USA	60–64	1.44	2007
Christiane Schmalbruch, Germany	70–74	1.27	2007
Helgi Pedel, Canada	80–84	1.04	2004
Olga Kotelko, Canada	85–89	0.94	2004
LONG JUMP (METERS)			
Galina Chistyakova, Soviet Union	Open	7.52	1988
Tatyana Ter Mesrobyan, Russia	40–44	6.64	2008
Phil Raschker, USA	50–54	5.40	1997
Christiane Schmalbruch, Germany	60–64	4.75	1997
Paula Schneiderhan, Germany	70–74	4.24	1992
Johanna Gelbrich, Germany	80–84	2.90	1993
Norma Creais, Australia	85–89	2.39	2009

Source: Information from *Track and Field News* (2010), http://www.trackandfieldnews.com/records and *Masters Athletics* (2010), http://www.mastersathletics.net.

and functional mobility. Law and Letts (1989) conducted a critical review of scales of ADL and compared the purpose, clinical utility, reliability, and validity of thirteen instruments. For greater detail on specific scales of ADL, refer to the Law and Letts study.

Summary

A number of factors affect how adults perform motor tasks. These factors include the health status of various physiological systems, psychological characteristics, the changing environment, task demands, or some combination thereof. With age we see declines in motor performance. These declines may be attributed to aging, disease, lifestyles, or a combination of these elements. Reaction times tend to slow. Intervention strategies that reduce reaction time decrements include allowing practice of a task, increasing the intensity of the stimulus, using a task already familiar to the individual, and participating in a physically active lifestyle.

The maintenance of balance and posture decreases in efficiency with age, and particularly in older adulthood. Declines in muscle strength and control, the sensory systems, joint flexibility, and physical characteristics interact to alter the balance and posture process. Poorer balance as well as other conditions increase an older person's susceptibility to falling. For the older adult, falling can result in serious consequences, such as hip fractures. The walking pattern of older adults often differs from that of younger adults. However, many of the observed differences result from slower walking speeds. When the walking speed is increased, many differences disappear. Daily living activities are often more challenging for older adults than for their younger counterparts. However, altering environmental conditions can increase the speed and decrease the difficulty level of many daily living activities. Driving a car can also represent a challenge for the older adult, but intervention strategies may assist maintaining driving abilities for many years. Although we note many age-associated declines in motor performance, a number of individuals remain physically active and, in some cases, perform motor tasks at exceptionally high levels.

Questions for Reflection

1. What factors either separately or in combination can contribute to a decline in motor performance throughga dulthood?
2. Why is falling such a significant concern for older adults?
3. What intervention strategies are important for older adults to maintain their independence?
4. Why is it important to recognize high-level performance in older athletes?

Critical Readings

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Web Resources

http://www.go60.com/home.html

Go60.com is a Web page dedicated to senior citizens. There are a number of resources for seniors including health news, information on continuing education for seniors, tips for traveling, a message board, and additional links.

http://www.geri.duke.edu/

Duke University's Center for the Study of Aging and Human Development website. The site describes the center through a history, its leadership, and what the future holds for the center.

http://www.uwm.edu/Dept/IAE/

The Institute on Aging and Environment homepage. The institute "promotes research, scholarship, and service concerning environments for older persons." The site holds information about the organization, its services and projects, research and publications, as well as related links.

http://www.healthandage.com/

Healthandage.com provides free health information related to healthy aging. Topics range from Alzheimer's disease to nutrition to respiratoryd isease.

Appendix A

Professional Position Papers Related to Motor Development Issues

Position Papers Related to Infants and Children

Aluminum Toxicity in Infants and Children

American Academyo fP ediatrics
Committee on Nutrition (1 Mar 1996)
Pediatrics, 97(3),413–416.

Combination Vaccines for Childhood Immunization: Recommendations of the Advisory Committee on Immunization Practices (ACIP), the American Academy of Pediatrics (AAP), and the American Academy of Family Physicians (AAFP)

American Academyo fP ediatrics
Committee on Infectious Diseases, 1998–1999 (1 May 1999)
Pediatrics, 103(5),1064–1077

Controversies Concerning Vitamin K and the Newborn

American Academyo fP ediatrics
Committee on Fetus and Newborn (1 Jul 2003)
Pediatrics, 112(1),191–192

Developmental Surveillance and Screening of Infants and Young Children

American Academy ofP ediatrics
Committee on Children with Disabilities (1 Jul 2001)
Pediatrics, 108(1),192–195

Environmental Tobacco Smoke: A Hazard to Children

American Academy ofP ediatrics
Committee on Environmental Health (1 Apr 1997)
Pediatrics, 99(4),639–642

Eye Examination and Vision Screening in Infants, Children, and Young Adults

American Academy ofP ediatrics
Committee on Practice and Ambulatory Medicine, Section on Ophthalmology (1 Jul 1996)
Pediatrics, 98(1),153–157

Fetal Alcohol Syndrome and Alcohol-Related Neurodevelopmental Disorders

American Academy ofP ediatrics
Committee on Substance Abuse and Committee on Children with Disabilities (1 Aug 2000)
Pediatrics, 106(2),358–361

Fetal Therapy—Ethical Considerations

American Academyo fP ediatrics
Committee on Bioethics (1 May 1999)
Pediatrics, 103(5),1061–1063

Folic Acid for the Prevention of Neural Tube Defects

American Academyo fP ediatrics
Committee on Genetics (1 Aug 1999)
Pediatrics, 104(2),325–327

Infant Exercise Programs

American Academyo fP ediatrics
Committee on Sports Medicine (1 Nov 1988)
Pediatrics, 82(5),800

Maternal Phenylketonuria

American Academyo fP ediatrics
Committee on Genetics (1 Feb 2001)
Pediatrics, 107(2),427–428

Newborn Screening Fact Sheets

American Academyo fP ediatrics
Committee on Genetics (1 Sep 1996)
Pediatrics, 98(3),473–501

Noise: A Hazard for the Fetus and Newborn

American Academyo fP ediatrics
Committee on Environmental Health (1 Oct 1997)
Pediatrics, 100(4),724–727

Swimming Programs for Infants and Toddlers

American Academyo fP ediatrics
Committee on Sports Medicine and Fitness and Committee on Injury and Poison Prevention (1 Apr 2000)
Pediatrics, 105(4),868–870

The Treatment of Neurologically Impaired Children Using Patterning

American Academy ofP ediatrics
Committee on Children With Disabilities (1 Nov 1999)
Pediatrics, 104(5),1149–1151

Prenatal Screening and Diagnosis for Pediatricians

American Academy ofP ediatrics
Christopher Cunniff and and the Committee on Genetics (1 Sep 2004)
Pediatrics, 114(3),889–894

Selecting Appropriate Toys for Young Children: The Pediatrician's Role

American Academy ofP ediatrics
Danette Glassy, Judith Romano, and Committee on Early Childhood, Adoption, and Dependent Care (1 Apr 2003)
Pediatrics, 111(4),911–913

Prevention of Drowning in Infants, Children, and Adolescents

American Academy ofP ediatrics
Ruth A. Brenner and the Committee on Injury, Violence, and Poison Prevention (1 Aug 2003)
Pediatrics, 112(2),440–445

Late–Preterm Infants: A Population at Risk

American Academy ofP ediatrics
William A. Engle, Kay M. Tomashek, Carol Wallman and the Committee on Fetus and Newborn (2007)
Pediatrics, 120,1390–1401.

The Apgar Score

American Academy ofP ediatrics
Committee on Fetus and Newborn, American College of Obstetricians and Gynecologists, and Committee on Obstetric Practice (2006)
Pediatrics, 117,1444–1447.

Age Terminology during the Perinatal Period

American Academyo fP ediatrics
Committee on Fetus and Newborn (2004)
Pediatrics, 114,1362–1364.

Position Papers Related to Children and Adolescents

Athletic Participation by Children and Adolescents Who Have Systemic Hypertension

American Academyo fP ediatrics
Committee on Sports Medicine and Fitness (1 Apr 1997)
Pediatrics, 99(4),637–638

Climatic Heat Stress and the Exercising Child and Adolescent

American Academyo fP ediatrics
Committee on Sports Medicine and Fitness (1 Jul 2000)
Pediatrics, 106(1),158–159

Intensive Training and Sports Specialization in Young Athletes

American Academyo fP ediatrics
Committee on Sports Medicine and Fitness (1 Jul 2000)
Pediatrics, 106(1),154–157

Medical Concerns in the Female Athlete

American Academyo fP ediatrics
Committee on Sports Medicine and Fitness (1 Sep 2000)
Pediatrics, 106(3),610–613

Medical Conditions Affecting Sports Participation

American Academyo fP ediatrics
Committee on Sports Medicine and Fitness (1 May 2001)
Pediatrics, 107(5),1205–1209

Organized Sports for Children and Preadolescents

American Academy ofP ediatrics
Committee on Sports Medicine and Fitness and Committee on School Health (1 Jun 2001)
Pediatrics, 107(6),1459–1462

Participation in Boxing by Children, Adolescents, and Young Adults

American Academy ofP ediatrics
Committee on Sports Medicine and Fitness, 1994 to 1995 (1 Jan 1997)
Pediatrics, 99(1),134–135

Physical Fitness and Activity in Schools

American Academy ofP ediatrics
Committee on Sports Medicine and Fitness and Committee on School Health (1 May 2000)
Pediatrics, 105(5),1156–1157

Triathlon Participation by Children and Adolescents

American Academy ofP ediatrics
Committee on Sports Medicine and Fitness (1 Sep 1996)
Pediatrics, 98(3),511–512

Injuries in Youth Soccer: A Subject Review

American Academy ofP ediatrics
Committee on Sports Medicine and Fitness (1 Mar 2000)
Pediatrics, 105(3),659–661

Guidelines for After-School Physical Activity and Intramural Sport Programs

National Association for Sport and Physical Education

National Intramural Sport Council (Sep 2001)

American Alliance for Health, Physical Education, Recreation,a ndD ance

Choosing the Right Sport and Physical Activity Program for Your Child

National Association for Sport and Physical Education

American Alliancef orH ealth,P hysicalE ducation, Recreation,a ndD ance

What Constitutes a Quality Physical Education Program?

National Association for Sport and Physical Education

http://www.aahperd.org/naspe/standards/upload/What-Constitutes-a-Quality-PE-Program-2003.pdf

Fluid Replacement for Athletes

National AthleticT rainers' Association

Douglas J. Casa, PhD, ATC, CSCS; Lawrence E. Armstrong, PhD, FACSM; Susan K. Hillman, MS, MA, ATC, PT; Scott Mountain, PhD, FACSM; Ralph V. Reiff, Med, ATC; Brent S.E. Rich, MD, ATC; William O. Roberts, MD, MS, FACSM; Jennifer Stone, MS, ATC (June 2000)

Journal of Athletic Training, 35(2),212– 224

Youth Resistance Training: Updated Position Statement Paper

National Strength and Conditioning Association

Avery D. Faigenbaum, William J. Kraemer, Cameron J. R. Blimkie, Ian Jeffreys, Lyle J. Micheli, Mike Nitka, Thomas W. Rowland (2009)

Journal of Strength and Conditioning Research, 23(Supplement5),S 60–S79.

Inter-Association Task Force on Exertional Heat Illness Consensus Statement

North American Society for Pediatric Exercise Medicine

http://www.naspem.org/LinkClick.aspx?fileticket=yRFeKM7Y9nw%3d&tabid=64

Prescribing Therapy Services for Children with Motor Disabilities

American Academy ofP ediatrics

Linda J. Michaud and Committee on Children with Disabilities (2004)

Pediatrics, 113,1836–1838.

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American Academy ofP ediatrics

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American Academy ofP ediatrics

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American Academy ofP ediatrics

Committee on Sports Medicine and Fitness (2005)

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American Academyo fP ediatrics

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American Academyo fP ediatrics

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American Academyo fP ediatrics

Joel S. Brenner and the Council on Sports Medicine and Fitness (2007)

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American College of Sports Medicine (Oct. 2007)

Medicine & Science in Sports & Exercise, 39(10),1867–1882.

A Philosophical Position on Physical Activity & Fitness

National Association for Sport and Physical Education-NASPE(2009)

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National AthleticT rainers' Association

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American Alliance for Health, Physical Education, Recreation, and Dance

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Appropriate Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults

American College of Sports Medicine

John M. Jakicic, PhD, FACSM (Chair); Kristine Clark, PhD, RD, FACSM; Ellen Coleman, RD, MA, MPH; Joseph Donnelly, EdD, FACSM; John Foreyt, PhD; Edward Melanson, PhD; Jeff Volek, PhD, RD; and Stella L. Volpe, PhD, RD, FACSM (2001)

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Progression Models in Resistance Training for Healthy Adults

American College of Sports Medicine

William J. Kraemer, PhD, FACSM (Chairperson); Kent Adams, PhD; Enzo Cafarelli, PhD, FACSM; Gary A. Dudley, PhD, FACSM; Cathryn Dooly, PhD, FACSM; Mathew S. Feigenbaum, PhD, FACSM; Steven J. Fleck, PhD, FACSM; Barry

Franklin, PhD, FACSM; Andrew C. Fry, PhD; Jay R. Hoffman, PhD, FACSM, Robert U. Newton, PhD; Jeffrey Potteiger, PhD, FACSM; Michael Stone, PhD; Nicholas A. Ratamess, MS; and Travis Triplett-McBride, PhD (2002)

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Exercise for Patients with Coronary Artery Disease

American College of Sports Medicine

Medicine & Science in Sports and Exercise, 26(3), i–v (1994)

Physical Activity, Physical Fitness, and Hypertension

American College of Sports Medicine

Medicine & Science in Sports and Exercise, 25(10), i–x (1993)

Exercise and Physical Activity for Older Adults

American College of Sports Medicine

Robert S. Mazzeo, PhD, FACSM (Chair); Peter Cavenagh, PhD, FACSM; William J. Evans, PhD, FACSM; Maria Fiatarone, PhD; James Hagberg, PhD, FACSM, Edward McAuley, PhD; and Jill Startzell, PhD (June 1998)

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Exercise and Physical Activity for Older Adults

American College of Sports Medicine

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Physical Activity and Bone Health

American College of Sports Medicine

Wendy M. Kohrt, PhD, FACSM (Chair); Susan A. Bloomfield, PhD, FACSM; Kathleen D. Little, PhD; Miriam E. Nelson, PhD, FACSM; and Vanessa R. Yingling, PhD (Nov 2004)

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Exercise and Type 2 Diabetes

American College of Sports Medicine

Ann Albright, PhD, RD (Chairperson); Marion Franz, MS, RD, CDE; Guyton Hornsby, PhD, CDE; Andrea Kriska, PhD, FACSM; David Marrero, PhD; Irma Ullrich, MD; and Larry S. Verity, PhD, FACSM (July 2000)

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Exercise and Hypertension

American College of Sports Medicine

Linda S. Pescatello, PhD, FACSM (Co-Chair); Barry A. Franklin, PhD, FACSM (Co-Chair); Robert Fagard, MD, PhD, FACSM; William B. Farquhar, PhD; George A. Kelley, DA, FACSM; and Chester A Ray, PhD, FACSM (2004)

Medicine & Science in Sports and Exercise, 36(3), 533–553

Exertional Heat Illness

National AthleticT rainers' Association

Helen M. Brinkley, PhD, ATC, CSCS, NSCA-CPT (Chair); Joseph Beckett, EdD, ATC; Douglas J. Casa, PhD, ATC, FACSM; Douglas M. Kleiner, PhD, ATC, FACSM; and Paul E. Plummer, MA, ATC (2002)

Journal of Athletic Training, 37(3),329–343

Appendix B

Professional Organizations Related to Motor Development Issues

Organization Name	Acronym	Website
International Council for Health, Physical Education, Sport, and Dance	ICHPER-SD	www.ichpersd.org
International Council of Sport Science and Physical Education	ICSSPE	www.icsspe.org
International Society on Infant Studies	ISIS	www.isisweb.org
Society for Research in Child Development	SRCD	www.srcd.org
WorldH ealthO rganization	WHO	www.who.int/en/
American Associationo f RetiredP ersons	AARP	http://www.aarp.org/
American Academy of Kinesiology	AAKPE	www.aakpe.org
American Academy of Pediatrics	AAP	www.aap.org
American Alliance for Health, Physical Education, Recreation, and Dance	AAHPERD	www.aahperd.org
American College of Obstetricians and Gynecologists	ACOG	http://acog.org/
American College of Sports Medicine	ACSM	www.acsm.org
AmericanGer iatrics Society	AGS	http://www.americangeriatrics.org/
AmericanP hysicalT herapy Association	APTA	www.apta.org
AmericanSoc iety on Aging	ASA	http://www.asaging.org/
Canadian Academyo f SportM edicine	CASM	http://www.casm-acms.org/
Canadian Association for Health, Physical Education, Recreation, and Dance	CAHPERD	www.cahperd.org
Centers for Disease Control and Prevention	CDC	www.cdc.gov/
Marcho fD imes	MOD	www.modimes.org/
TheN ational Alliancef or YouthS ports	NAYS	www.nays.org/

NationalI nstituteo n Aging	NIA	www.nia.nih.gov
TheN ational Strengtha nd Conditioning Association	NSCA	http://www.nsca-lift.org/
North American Society for the Psychology of Sport and Physical Activity	NASPSPA	http://www.naspspa.org/
British Association of Sport and Exercise Medicine	BASEM	www.basem.co.uk/index.php
British Association of Sport and Exercise Sciences	BASES	www.bases.org.uk
North American Society for Pediatric Exercise Medicine	NASPEM	http://www.naspem.org/

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CHAPTER 13
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Glossary

A

Abilities. One's present level of functioning in a particular movement skill. During infancy especially, movement abilities are a function of biological maturation, later environmental influences impact one's abilities.

Accelerometer. Ane lectromechanicald evicew orn by the subject that detects and records motion in a single plane or in multiple planes.

Accommodation. Adaptation that the child must make to the environment when new and incongruent information is added to his or her repertoire of possible responses. A process that reaches outward toward reality and results in a visible change in behavior.

Accommodation (Visual). The ability of the lens of each eye to vary its curvature to bring the retinal image into focus.

Activity Concepts. Knowledge of where the body should move in terms of patterns, formations, rules, andst rategies.

Activity Theory. A theory of aging that states that as adults grow older they require interaction with other people and continued physical activity to be happy and satisfied.

Activities of Daily Living. Movement-oriented tasks that individuals carry out throughout their lives that are required for basic everyday needs.

Adaptation. The process of making adjustments to environmental conditions and intellectualizing these adjustments through the complementary processes of accommodation and assimilation.

Adolescent Growth Spurt (Circumpubertal Period). The adolescent growth spurt that lasts up to four and a half years.

Advanced/Fine-Tuning Level. The third stage of learning a movement skill characterized by the performer gaining a complete understanding of the skill. At this level the skill is performed smoothly, fluidly, and in a highly coordinated manner. The performer places emphasis on refining and fine-tuning the skill.

Aerobic Endurance. The ability to perform numerous repetitions of a stressful activity requiring considerable use of the circulatory and respiratory systems.

Affordances. Factors that tend to promote or encourage developmental change.

Ageism. The stereotyping or discriminating against older adults on the basis of prejudice.

Age Markers. Abnormal formations that appear in the older brain and increase in number as the brain continues to age.

Agility. The ability to change direction of the entire body quickly and accurately while moving from one point to another.

Air Displacement Plethysmography. A procedure for determining body composition that differs from hydrostatic weighing in that it incorporates air displacement in a chamber rather than water displacement in a tank.

Algorithm. A procedure or set of rules to follow that will lead to the solution of a given problem. From a dynamic systems perspective of development, algorithms are tested to predict and explain motor behavior.

Amenorrhea. The temporary or permanent cessation of menstrual periods of an adolescent or adult female who previously experienced a regular cycle.

Anabolic Hormones. Muscle-enhancing hormones such as human growth hormone and testosterone.

Anorexia Nervosa. A severee motional disorder typified by an aversion to food and an obsession with thinness that may result in death.

Antioxidant. A substance that when ingested prevents or inhibits oxidation by binding with free radicals before they harm healthy body cells. Serves as a basis for a theory of aging reversal intervention.

Apoptosis. The process of programmed cell death.

Application Stage. The stage within the specialized movement phase that represents a heightened awareness of personal physical assets and limitations, and where more complex skills are refined and used in official sports and designated recreational activities for both leisure and competition.

Arteriosclerosis. An age-related condition in which the arterial walls become less elastic.

Assimilation. Interpretationo fn ew information based on present interpretations by taking in information from the environment and incorporating it into one's existing cognitive structures.

Associative Stage. The movement skill learning stage at which the learner is able to make conscious use of environmental cues and associate them with the requirements of the movement task.

Atherosclerosis. A cardiovasculard isease represented by fatty deposits collecting within arteries.

Atrophy. A decrease in the size of muscle fibers.

Attitude. An emotion that results in a feeling of like or dislike about something.

Auditory Perception. The ability to receive and process information that is obtained by the sense ofh earing.

Autonomous Stage. Them ovements killl earning stage at which performance of the movement task becomes habitual, with little or no conscious attention given to the elements of the task.

Awareness Stage. The movement skill learning stage at which the cognitive state of the learner involves being naive and ignorant about the nature of the task, its basic requirements, and its appropriate terminology.

B

Balance. The ability to maintain one's equilibrium in relation to the force of gravity. Balance may be static, dynamic, or rotational.

Balance and Postural Control. The maintenance of a state of equilibrium of the body and its parts in response to the force of gravity. Interaction of the muscles and joints, vision, vestibular and somatosensory systems, and body morphology contribute to the maintenance of balance and postural control.

Beginning/Novice Level. The first level in learning a new movement skill often characterized by slow, uncoordinated, and jerky movements accompanied by conscious attention to every detail of the activity.

Behavior Setting Theory. A branch of ecological psychology that contends that the specific environmental conditions of one's life space account for a large portion of individual variation. Different settings evoke different responses and hence lead to different patterns of development.

Belief. Something held to be true based on a strong cognitive component.

Between-Child Differences. Variations in the level of skill performance maturity from one child to the next.

Between-Pattern Differences. Variations in the level of skill performance maturity from one fundamental movement skill to the next.

Bifoveal Fixation. Alignment of the fovea of both eyes in such a manner that visual fusion can occur.

Binge Eating Disorder. An eating disorder in which an individual engages in an eating binge, followed by purging through either self-induced vomiting or using a laxative.

Binocular Vision. The working together of both eyes to provide depth perception.

Bioelectrical Impedance Analysis. A method of determining body composition by measuring the opposition to the flow of an electric current through the body fluids contained mainly in the lean and fat tissue.

Biological Age. A variable age that corresponds roughly to chronological age, determined by measures of morphological, skeletal, dental, or sexuala ge.

Body Awareness. Thed eveloping capacityt o accurately discriminate among body parts and to gain a greater understanding of the nature of the body and its movement in space.

Body Composition. The proportion of lean body mass to fat body mass.

Body Mass Index (BMI). Ane stimationo f percent body fat arrived at by calculating:

$$\text{wt(kg)} \div \text{stature(cm)} \times 10{,}000$$
or
$$\text{wt(lb)} \div \text{stature(in)} \times 703$$

Bonding. A strong emotional attachment that endures over time, distance, hardship, and desirability.

Bone Mineralization. A process promoted by physical activity that makes bone stronger and less brittle.

Brain Plasticity. The ability of the brain to adapt to trauma through mechanisms such as the establishing of compensatory neuronal pathways when primary pathways have been destroyed.

Bulimia Nervosa. A severee motional disorder typified by regular bouts of food binging and purging that has serious health consequences.

C

Capabilities. One's inherited genetic potential for success in the performance of a specified task.

Catabolic Hormones. Muscle-destroyingh ormones.

Category of Movement. Observablem ovement classified as either stabilizing, locomotor, or manipulative movements, or a combination of the three.

Chemical Pollutants. Ac ategoryo fe nvironmental substances such as lead and mercury to which exposure by an expectant mother may result in birth defects.

Chromatic Intensity. The brightness or hue of a given color that may be measured across the entire colors pectrum.

Chronic Malnutrition. Severea nd prolonged undernourishment that may result in growth retardation in young children and a variety of nutrition-related conditions, including rickets, pellagra, scurvy, and kwashiorkor.

Cognitive Stage. The movement skill learning stage during which the learner tries to form a conscious mental plan for performing the skill.

Color Perception. The ability of the eyes to distinguish among different colors.

Combination Stage. The movement skill learning stage at which the learner begins to put movement skills together in different combinations, first in pairs and then in increasingly complex forms.

Competence. One's ability to meet particular achievement demands.

Component Developmental Sequences A series of highly predictable patterns of movement that involve description of how different body components are moving during the movement. These body component actions start with inefficient initial patterns of movement and shift to more proficient and skilled patterns of movement.

Congenital Malformations. Abnormal conditions with which an infant is born.

Consensual Pupillary Reflex. Pupil dilation in dim light and constriction in bright light.

Constraints. Factors that serve to impede development.

Content Areas. The major areas of physical activity through which fundamental and specialized movement skills may be developed. They include educational games, dance, and gymnastics activities.

Contralateral Pattern. A movement pattern (generally creeping and walking) in which the arm and leg on the opposite side of the body move in unison.

Convenience Sample. The selection of subjects for research investigations based on availability rather than representation.

Coordination. The ability to integrate separate motor systems with varying sensory modalities into efficient movement.

Crawling. Forward motion from a prone position in which a homolateral pattern is used and the abdomen remains in contact with the supporting surface.

Creeping. Forward motion from a prone position in which a contralateral pattern is generally used and the abdomen is up off the supporting surface.

Criterion-Referenced Tests. Assessment instruments that incorporate a preestablished standard to which the individual's scores are compared.

Cross-Sectional Method. A method of study that looks at age-related differences in behavior by permitting the researcher to collect data on different groups of people at varying age levels at the same point in time, yielding average differences across real time, but not individual changes across developmental time.

Cultural Socialization. A lifelong process by which an infant becomes an adult in a cultural setting, accomplished by modifying one's behavior to conform to the expectations of a group.

D

Decoding Stage. The time during the reflexive movement phase when higher brain centers gain greater control of the sensorimotor apparatus and the infant is able to process information more efficiently.

Deductive Method. An approach to theory building based on statistical inference. Deductive theories integrate existing facts, lend themselves to the formulation of testable hypotheses, and yield results that either refute or lend further support to the theory.

Degrees of Freedom. Reflects the number of independent elements or components of a system.

Depth Perception. The process by which one sees three-dimensionally through the use of monocular and binocular depth cues, and is accurately able to judge distance from oneself.

Descriptive Theory. Anyt heoretical framework that views development as occurring within typical age periods across the life span.

Development. Changes in an individual's level of functioning over time.

Developmental Direction. Ap rincipleo f development used for explaining increased coordination and motor control as a function of the maturing nervous system in a predictable sequence from the head to the feet (cephalocaudal), and from the center of the body to its periphery (proximodistal).

Development Milestone Theory. A theory that focuses on subtle strategic indicators of how far development has progressed and views development as an unfolding and intertwining of developmental processes, not as a neat transition from one stage to another.

Developmental Sequences A series of highly predictable patterns of movement starting with inefficient initial patterns of movement, to increasingly more efficient emerging patterns of movement to proficient and skilled movement.

Developmental Task Theory. A predictive theory that contends that there are essential tasks that individuals must accomplish within a specified time if they are to function effectively and meet the demands placed on them by society.

Directional Awareness. A developing sensitivity to internal (laterality) and external (directionality) sidedness.

Discovery Stage. The movement skill learning stage at which the learner is consciously forming a mental plan of how the task should be performed.

Disengagement Theory. A theory of aging that states that as people age they begin to lose relationships, gradually abandon past interests, and eventually withdraw from society.

Dishabituation. Measurable increase in reaction to a stimulus after habituation has occurred.

Down Syndrome. A condition that results from an extra chromosome and results in motor and mental delays and distinct physical features.

Dynamic Flexibility. The range of motion achieved when rapidly moving a body part to its limits.

Dynamic Systems Theory. A branch of ecological psychology that views development as a nonlinear, discontinuous, self-organizing process composed of several factors—the task, the individual, and the environment—operating separately and in concert that determine the rate, sequence, and extent of development.

Dynamometer. A calibrated device that permits measurement of grip strength, leg strength, and back strength.

E

Early Intervention. Enrichment strategies implemented with high-risk infants in an effort to counteract conditions that may lead to later developmental impairment.

Ecological Task Analysis. An approach to examining performance in light of the relationships among the task goal, the environment, and the performer.

Ecological Theory. Also known as "contextual theory"; a theory that is descriptive and explanatory and views development as a function of the environmental "context" and historical time frame in which one lives. The study of human ecology from this developmental perspective is a matter of studying the relationship of individuals to their environment and to one another.

Ectoderm. The layer of cells during the embryonic period that represent the origins of the sense organs and nervous system.

Ectomorphic. A classification of physique characterized by a tall, thin, lean appearance.

Ejaculation. A male's sudden ejection of seminal fluid.

Electrical Impedance. A method of determining percent body fat by administering a small electrical current through the body and estimating body composition from the current's velocity through the body.

Embryo. The human organism that begins at the time when the cells differentiate into three layers and continues until it is firmly implanted in the uterine wall and receiving nourishment through the placenta and umbilical cord.

Encoding Stage. The time during the reflexive movement phase when reflexes play a role in gathering information for storage in the developing cortex.

Endoderm. The layer of cells during the embryonic period that represent the origins of the digestive, respiratory, and glandular systems.

Endomorphic. A classification of physique that represents soft and rounded physical features.

Environmental Constraints Aspects of the world outside of the person that influence the pattern of motor performance. They are more global in nature such as the influence of sociocultural factors or physical factors such as the floor surface or equipment.

Estrogens. The female hormones that account for the initiation of the events of female puberty.

Experience. Environmental factors that may alter the appearance of various developmental characteristics through the process of learning.

Explanatory Theory. Anyt heoretical framework that proposes explanations for questions about developmental processes.

Exploratory Stage. The movement skill learning stage at which the learner has a conscious awareness of the basic requirements of the task and begins to experiment with performing the task in a variety of ways.

Externally Paced Skills. A category of skills in which the performer must make rapid responses to changes in environmental cues.

Evoked Potentials. A method for studying changes in electrical brain responses that yields useful stimulus response information.

F

Fetal Alcohol Syndrome. A condition that results from maternal alcohol abuse during pregnancy with the potential results of mental retardation and physical defects of the child.

Fetus. The human organism that begins at the time around the third month following conception and ends at birth.

Field Test. An assessment procedure conducted outside of a laboratory setting.

Figure-Ground Perception. The ability to separate an object of regard (visual, tactile, gustatory, etc.) from its background.

Fixation/Diversification Stage. The movement skill learning stage at which the goal of the learner is to achieve consistency of performance and the ability to adapt to changing conditions and to the task being an open or closed skill.

Force. The effort that one mass exerts on another resulting in movement, cessation of movement, or resistance of one body against another.

Form Perception. The ability to distinguish among shapes.

Fractionated RT. A process of breaking the complete reaction time process into various components.

Free Radicals. Unstable oxygen molecules produced through normal cell metabolism that ricochet around inside cells damaging DNA and other cell structures. Serves as a basis for a theory of aging.

Free Radical Theory. Aging theory that suggests cells deteriorate from exposure to highly reactive molecular components known as free radicals.

Fundamental Movement. An organized series of related movements used to perform basic movement tasks such as running, jumping, throwing, and catching. Fundamental movements may be classified as locomotor, manipulative, or stabilizing.

Fundamental Movement Skills. Observable patterns of motor behavior classified into initial, emerging, and proficient stages and composed of basic locomotor activities such as running and jumping, manipulative activities such as throwing and catching, and stability activities such as balancing on one foot or walking on a narrow beam.

Fundamental Movement Pattern. Theo bservable performance of a basic locomotor, manipulative, or stability movement that involves combining movement patterns of two or more body segments, such as performing an underhand or overhand throw in which developmentally appropriate arm, trunk, and leg actions are integrated.

Fusion. Combining two retinal images into a single visualp attern.

G

Gait. An individual's walking pattern. It consists of the swing phase and the support phase.

Genetic Defects. Congenitald isabilitieso f which autosomal recessive traits are frequently associated with developmental delays.

Genetic Mutation Theory. Agingt heoryt hat suggests cell function may change or mutate as time passes resulting in deterioration of tissues or organs.

Genetic Switching Theory. Agingt heoryt hat suggests cells are programmed to shut down after a certain number of replications.

Genotype. Ani ndividual's geneticg rowth potential.

Gerontology. Thes cientific endeavor that seeks to understand the aging process.

Getting the Idea Stage. Them ovements kill learning stage at which the primary goal of the learner is to obtain a basic awareness of the essential requirements for successful performance of the skill.

Giardia. A condition resulting in severe diarrhea caused by an intestinal parasite frequently transmitted through unsanitary water conditions.

Gonadotrophic (GnRH) Hormones. Them ale hormones that stimulate the endocrine glands to release growth and sex hormones.

Growth. An increase in the size of the body or its parts.

Growth Plate Injury. Damaget ot hee piphyseal growth plate of a growing bone that may result in premature growth cessation of that bone.

Growth Plates. Cartilaginouss tructuresb etween the epiphyses of bone that are susceptible to injury in youth from excessive weight bearing.

Growth Rate. One's unique pattern of growth, resistant to external influence.

Growth Retardation. A condition when a child's height fails to fall within the growth norms for his or her age level.

Growth Spurt. A period during adolescence lasting up to four and a half years in which maximum velocity in height is achieved.

Gustatory Perception. The ability to receive and process information obtained by the sense of taste.

H

Habituation. Measurable decline in reaction to a stimulus.

Health-Related Fitness. The aspect of physical fitness that refers to a relative state of being, not an ability, skill, or capacity. The development and maintenance of health-related fitness are a function of physiological adaptation to increased overload.

Heuristics. Rules of thumb or models that give one guidelines and cues for searching for answers to a given problem.

High-Risk Pregnancy. A pregnancy in which the expectant mother has a condition before or during pregnancy that increases her unborn child's chances of experiencing prenatal or postnatal problems.

Homeostasis. The maintenance of stability in the physiological systems and their interrelationships.

Homolateral Pattern. A movement pattern (generally crawling) in which the arm and leg on the same side of the body move in unison.

Hourglass Heuristic. A visual representation intended to aid in conceptualizing the complex process of human motor development that combines descriptive phases and stages, with an explanatory dynamic systems model.

Hydrostatic Weighing. A method of determining percent body fat by submerging an individual under water and calculating his or her underwater weight from which an accurate estimate of percent body fat can be calculated.

Hypertrophy. An increase in the size of muscle fibers.

Hyponatremia. Reduction in the body's serum sodium level sometimes induced in infants by swallowing excessive amounts of water.

Hypoxia. A condition in which the brain receives an inadequate amount of oxygen.

I

Illicit Drugs. A category of drugs of which the majority are illegal to use or sell and often contribute to problems with pregnancy and fetal development.

Individual Constraints Factors within the individual (structural and/or functional) which influence the pattern of movement. Structural constraints refer to the influence of the child's body (e.g., height, strength, physical growth) while functional constraints are more behavioral in nature referring to psychological factors such as motivation and cognition.

Individualized Stage. The final stage in learning a new movement skill. The learner makes fine-tuning adjustments in skill performance based on unique strengths or weaknesses and attributes or limitations.

Inductive Method. A fact-based approach to theory building around which a conceptual framework is formed in an attempt to organize and explain these facts.

Information Processing Theory. A theoryt hat focuses on the ways individuals process information about their environment and its subsequent influence on movement.

Interindividual Variability. Thed ifferenceb etween individuals in regard to their rates of aging.

Intermediate/Practice Level. Thes econd stage of learning a new movement skill characterized by the performer comprehending the general aspects of the skill. Conscious attention to the skill details diminishes as the mental image of the skill becomes more fixed.

Internally Paced Skills. A type of movement skills that require fixed responses to a given set of conditions.

Interrater Reliability. Thec onsistencyo f accurate measurements by different individuals.

Interskill Sequences Between skill sequences. A predictable sequence of learning one skill and then another skill in a prescribed order.

Intraindividual Variability. Thed ifferenta ging rates of the various body systems within an individual.

Intrarater Reliability. Thec onsistencyo f accurate measurements by the same individual at different times.

Intraskill Sequences. Progressive variations of the performance of a variety of fundamental movement tasks establishing a series of descriptive stages.

Ipsilateral Pattern A pattern of movement where the arm and body on the *same* side act together in unison.

Isokinetic. The ability of a muscle to go through its full range of motion in a contracted state at a constant velocity.

Isometric. The ability of a muscle to maintain a contracted state while exerting force and undergoing little or no change in its length.

Isotonic. The ability of a muscle to go through its full range of motion in a contracted state.

J

Joint Flexibility. The ability of the various joints of the body to move through their full range of motion.

L

Law of Acceleration. Newton's principle of movement that the change in the velocity of an object is directly proportional to the force producing the velocity and inversely proportional to the object's mass.

Law of Action and Reaction. Newton's principle of counterforce that states for every action there is an equal and opposite reaction.

Law of Inertia. The Newtonian principle that a body at rest will remain at rest, and a body in motion will remain in motion at the same speed in a straight line unless acted upon by an outside force.

Learning. An internal process that results in consistent observable changes in behavior.

Lifelong Utilization Stage. The stage within the specialized movement phase that represents an individual's attempt to reduce the scope of his or her athletic pursuits by choosing a few activities to engage in regularly in competitive, recreational, or daily living settings.

Locomotion. Movement patterns that permit exploration through space (i.e., crawling, creeping, walking, running, jumping, hopping, etc.).

Longitudinal Method. A method of study that attempts to explain change over developmental time and involves charting various aspects of an individual's behavior for several years.

Low Birth Weight. A birth weight ranging from 1,500 to 2,000 grams.

M

Malnourishment. A state of inadequate nutritional intake or use by the expectant mother, the fetus, and/or the placenta that can result in later developmental difficulties.

Manipulation. Movement patterns that permit gross and fine motor contact with objects (i.e., grasping, throwing, catching, kicking, trapping, printing, cutting,e tc.).

Manipulative Skills Patterns of movement that involve the child in manipulating an object in order to achieve the movement. Manipulative skills consist of skills such as throwing, catching, kicking, punting, striking, rolling, and dribbling.

Maturation. A process of developmental change characterized by a fixed order of progression in which the pace may vary but the sequence of appearance of characteristics generally does not.

Maturity Assessment. Various approaches used in the determination of how far one has progressed toward physicalm aturation.

Maximal Oxygen Consumption (VO_2 max). The largest quantity of oxygen one can consume during physical work; usually measured using a standardized treadmill or bicycle ergometer.

Menarche. Thefi rst menstrual flow of an adolescent female.

Mesoderm. The layer of cells during the embryonic period that represent the origins of the muscular, skeletal, reproductive, and circulatory systems.

Mesomorphic. A classification of physique with physical features such as well-muscled, broad shoulders, narrow waist, and thick chest.

Mitosis. The process of cell division throughout the prenatalp eriod.

Mixed-Longitudinal Method. Am ethodi n which individuals are selected and studied cross-sectionally and followed longitudinally for several years, thus permitting comparison of results and providing a means for validating age-related change with true developmentalc hange.

Moral Development. Beliefs and attitudes lead to values, which form the basis for character development.

Motor. Underlying biological and mechanical factors that influence movement.

Motor Abilities. (*see* Abilities)

Motor Behavior. Changes in motor learning and development that embody learning factors and maturational processes associated with movement performance.

Motor Control. Study of the underlying mechanisms responsible for movement, with particular emphasis given to what is being controlled and *how* the processes governing control are organized.

Motor Development. Continuous change in motor behavior throughout the life cycle brought about by interaction among the requirements of the movement task, the biology of the individual, and the conditions of the learning environment.

Motor Fitness. The aspect of physical fitness that refers to genetically dependent characteristics that are relatively stable and related to athletic skill.

Motor Learning. A change in motor behavior resulting from practice or past experience.

Motor Skill. The underlying processes involved in the performance of a learned goal-oriented voluntary movement task or action of one or more of the body parts.

Movement. The observable change in the position of any part of the body.

Movement Competence. One's ability to meet particular achievement demands in a movement situation.

Movement Concepts. Knowledge about how the body can move, using the movement framework of effort, space, and relationship awareness.

Movement Exploration. An indirect teaching approach that encourages exploration.

Movement Pattern. An organized series of related movements used to perform a movement task.

Movement Skill. Performance of an observable learned goal-oriented voluntary movement task or action of one or more of the body parts.

Muscular Endurance. The ability of a muscle or a group of muscles to perform work repeatedly against moderate resistance.

Muscular Strength. The ability of the body to exert force.

Myelination. The development of myelin around the neurons.

N

Neuromaturational Theory. A theory of motor development that holds as its foundation that as the cortex develops it inhibits some of the functions of the subcortical layers and assumes ever-increasing neuromuscular control.

Neuromuscular Adaptation. Interactiono f the central nervous system and the muscles that results in enhanced force production of the muscles.

Norm-Referenced Tests. Assessmenti nstruments based on a statistical sampling of hundreds or even thousandso fi ndividuals.

O

Obesity. Excessive increase in the amount of stored body fat, generally considered to be at the 85th to 95th percentile of weight for height.

Obesogenic - causing obesity: tending to encourage excessive weight gain.

Objectivity. A condition when a test will yield similar results when it is administered by different testers on the same individual.

Obstetrical Medication. A serieso fd rugs administered to the expectant mother prior to and during delivery for various purposes including pain relief and the augmentation of labor.

Olfactory Perception. The ability to receive and process information that is obtained by the sense of smell.

Ontogenetic Skills. Movements killsd ependent on learning and environmental opportunities such as swimming, bicycling, and ice skating.

Osteopenia. Mild losses of bone mineral density.

Osteoporosis. A disease characterized by an accelerated loss of bone mineral density.

P

Pace of Sexual Maturation. The tempo or rate of developmental change during adolescence.

Peak Height Velocity. The time during the adolescent growth spurt during which the rate of growth in height reaches its maximum.

Peak Weight Velocity. The time during the adolescent growth spurt during which the rate of growth in weight reaches its maximum.

Perceived Competence. Ani ndividual'sp erception of his or her level of competence for a given task.

Perception. The process by which we become aware of our surroundings through the use of one or more of our sensory modalities.

Perceptual-Motor. Thep rocesso f organizing incoming information with stored information that leads to a movement response.

Perceptual Training. Remedial and readiness programs designed to promote perceptual-motor development in children.

Performance Stage. The movement skill learning stage at which the learner is further involved in refining and applying the elements of the movement task but with emphasis on using it in a specific performance situation.

Peripheral Vision. The visual field that can be seen without a change in the position of the eye.

Phases of Motor Development. The lifelong process of change in motor control seen in typical patterns of movement behavior brought about by factors within the movement task, the biology of the individual, and the conditions of the environment.

Phase-Stage Theory. A descriptive theory that contends that there are universal age periods characterized by typical behaviors that occur in phases or stages and last for arbitrary lengths of time.

Phenotype. An individual's environmental conditions that may influence his or her growth potential.

Phylogenetic Skills. Movement skills that tend to appear automatically and in a predictable sequence and are resistant to external environmental influences such as reaching, grasping and releasing, and walking, jumping, and running.

Physical Fitness. A state of well-being influenced by nutritional status, genetic makeup, and frequent participation in a variety of intense physical activities over time.

Power. The ability to perform one maximum effort in as short a period as possible; sometimes referred to as explosive strength.

Precontrol Stage. A period between the child's first and second birthday when greater control and precision are gained in movement.

Premature. Any newborn weighing under 4.5 pounds (2 kg) coupled with a gestation period of less than 37 weeks.

Presbycusis. Hearing loss associated with aging.

Primitive Postural Reflexes. A subgroup of primitive reflexes that resemble and may serve as precursors to later voluntary movements.

Primitive Survival Reflexes. A subgroup of primitive reflexes that enable the neonate to gain nourishment through involuntary searching and sucking.

Process Instruments. Assessment instruments that focus on the form, style, or mechanics used to perform the desired skill.

Product Instruments. Assessmenti nstruments that are quantitative and focus on the outcome or result of a performance.

Proficiency Barrier. The impairment of the performance of successful specialized movement skills if mature fundamental movement skills have not been mastered.

Puberty. The developmental period that represents the beginning of sexual maturation.

Q

Qualitative Change. Changes in the process or mechanics of executing a movement pattern.

R

Rate Limiters. Constraints that tend to limit or impede developmental change.

Reaction Time. The time delay between the presentation of a stimulus and initial activation of the appropriate muscle groups to carry out a task.

Readiness. The convergence of conditions within a task, an individual, and the environment that make mastery of a particular task appropriate.

Reciprocal Interweaving. The coordinated and progressive intricate interweaving of neural mechanisms of opposing muscle systems into an increasingly mature relationship. Characteristic of the developing child's motor behavior through *differentiation* (i.e., progression from the gross movement patterns of infancy to the more refined and functional movements of childhood and adolescence) and *integration* (i.e., bringing various opposing muscle and sensory systems into coordinated interaction with one another).

Reflexes. Involuntary,s ubcortically controlled movements that form the basis for the remaining three phases of motor development. Frequently classified as "primitive and postural reflexes."

Reflex Inhibition Stage. A period during an infant's first year when many of the reflexes are gradually suppressed.

Relative Sterility of Puberty. Thep eriodf rom the first menstrual cycle until a young female is physiologically capable of conception.

Reliability. A condition when a test will provide consistent scores from one test administration to then ext.

Retirement. The cessation of a career usually occurring in middle to later adulthood.

Rhythm. The synchronous recurrence of events related in such a manner that they form recognizable patterns.

Rhythmical Stereotypies. Infant movements performed over and over that demonstrate developmental regularities as well as constancy of form and distribution.

Rudimentary Movement Abilities. The first forms of voluntary movement beginning at birth and continuing to about age 2. Maturationally determined and characterized by a highly predictable sequence of appearance.

S

Saccades. Quick movements of the eyes in which there is redirection of visual focus from one object to another.

Sarcopenia. Skeletal muscle mass atrophy.

Schema. A pattern of physical or motor action.

Screening Tests. Assessment instruments designed to provide a relatively quick and simple means for recognizing the existence of problems.

Secondary Sex Characteristics. Readily observable evidence, such as axillary and facial hair, associated with progress toward reproductive maturity.

Secular Trend. Generational changes in height, weight, and physical maturity at a given age.

Segmental Assessment. The examination of developmental changes in fundamental movement skill stages using an analysis of the separate components of a movement within a given pattern.

Self-Concept. An individual's awareness of personal characteristics, attributes, and limitations, and the ways in which these qualities are both like and unlike those of others.

Self-Confidence. An individual's belief in his or her ability to carry out a mental, physical, or emotional task.

Self-Efficacy. The conviction that one can successfully execute the behavior required to produce the desired outcome.

Self-Esteem. The value that one attaches to his or her unique characteristics, attributes, and limitations.

Senescence. A gradual, time-related biological process that takes place as degenerative processes overtake regenerative processes.

Senile Miosis. An age-related condition in which the pupils of older adults do not open as widely as they did in previous years, restricting the ability to respond to low levels of illumination.

Sensation. Stimuli received by the various sense modalities.

Sensitive Periods. Broadt imef rames for development of a specific ability or capacity that go beyond the narrow view of the critical period hypothesis.

Sexually Transmitted Diseases. Ac ategoryo f diseases contracted through sexual activity and that place the developing fetus at risk for a wide range of birthd efects.

Skill. (*see* Motor Skill and Movement Skill)

Skill Concepts. Knowledge of how the body should biomechanicallym ove.

Skill Theme. A single movement skill or cluster of skills around which a specific lesson or series of lessons is grouped.

Skinfold Calipers. Ani nstrumentt hatm easures skinfold thicknesses in an effort to determine body fatp ercentage.

Social Roles. The behaviors employed to fulfill a status in a given situation.

Social Status. One's perceived position within a defined group.

Societal Norms. Standards of behavior expected of all members of a given society.

Spatial Awareness. An understanding of how much space the body occupies and the ability to project the body effectively into external space.

Specialized Movement Skills. Ano utgrowtho f mature fundamental movement abilities in which movement becomes a tool applied to a variety of complex movement activities for daily living, recreation, and sport pursuits.

Speed. The ability to move from one point to another in the shortest time possible. Speed is the total of reaction time and movement time.

Speed-Accuracy Trade-off. Thet rend toward a decline in the accuracy of a movement when its speed is increased.

Sport Skill. A movement skill applied to a specific sport activity, as in pitching in softball or baseball.

Sportsmanship. Behaving in a moral fashion within a sportc ontext.

Stability. Movement patterns that place a premium on gaining and maintaining one's equilibrium (i.e., static and dynamic balance abilities).

Static Flexibility. The range of motion achieved by a slow and steady stretch to the limits of the joints involved.

Stereopsis. The process of visually detecting depth brought about by retinal disparity between the eyes.

Stratified Random Sample. A collection of research participants, using probability theory, that attempts to provide a valid representation of a much larger group.

Successful Aging. An older adult's perception of effective and productive living often based on the characteristics of longevity, health, and life satisfaction.

T

Tactile Perception. The ability to receive and process information obtained by the sense of touch.

Tanner Stages. A universally accepted means for classifying sexual maturity.

Task Specificity. The task requirements under which a given movement skill is performed.

Task Constraints Refer to aspects of the task, the environment and learner that interact with each other to shape the resulting quantitative output and qualitative patterns of movement.

Temporal Awareness. The acquisition of an adequate time structure within an individual.

Teratogen. Any substance that may cause the unborn child to develop in an abnormal manner.

Testosterone. The primary sex hormone associated with the tremendous gains in muscular strength seen in adolescent males.

Timing of Puberty. When developmental change occurs during the period of adolescence.

Total Body Assessment. The examination of developmental changes in fundamental movement skill stages using an analysis of movement variations incorporating the whole body.

Total Body Developmental Sequences A series of highly predictable patterns of movement that involve description of the whole body starting with inefficient initial patterns of movement and shifting to more proficient and skilled patterns of movement.

Tracking. The ability of the eyes to attend to a moving object.

Transition Stage. The stage within the specialized movement phase that represents the first attempts to refine and combine mature movement patterns.

V

Validity. A condition when a test measures what it claims to measure.

Values. Views of what is desirable based on strong cognitive and affective components that lead to an action.

Very Low Birth Weight. A birthw eightu nder 1,500g rams.

Visual Acuity. The ability to distinguish detail in objects. Visual acuity is both a static and a dynamic phenomenon.

Visual-Motor Coordination. Thea bilityt o visually track and make interception judgments about a movingo bject.

W

Within-Pattern Differences. Within a given pattern, an individual may exhibit a combination of initial, elementary, and mature elements.

Y

Young-for-Date. An infant born at the expected birth weight for gestational age but before full term (i.e., 37 weeks or less).

Z

Zygote. The human organism represented by the union of the sperm and ovum cell nuclei and its continuous growth through the first week following conception.

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