Soviet
Theory, Technique and Training

for

RUNNING and HURDLING

Volume 1

Fred Wilt, Editor
Dr. Michael Yessis, Translator
Editor, Soviet Sports Review

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For information concerning SOVIET SPORTS REVIEW contact:

Dr. Michael Yessis
P.O. Box 2878
Escondido, CA 92025

Preface

For many years, athletes and coaches have been asking, "Why are the Soviets so successful in sports?" The answers popularized by the media claim professionalism, illegal drugs, and various kinds of surgical operations.

Except for a handful of athletes who have spent time training in Europe, no one has asked, "How do they train?" The vast amount of literature pertaining to Soviet sports research and practices and personal contact with Soviet coaches reveals that this is where we should be looking for the answers to their success. The key is in their comprehensive training system which begins in the earliest years (9-13) and culminates in the Olympic Games.

A quick perusal of the specially chosen articles in this book will clearly illustrate the depth and precision which permeates the Soviet system of training track and field athletes. In addition, the articles contain valuable information and ideas that can be put into immediate practice in your training and coaching.

To assist you in clearly understanding these articles, you should know that the Soviet training program is divided into two major cycles and consists of 4 periods. The first cycle culminates in the indoor championships and the second cycle in the outdoor championships. The periods consist of the general preparatory, specialized preparatory (sometimes collectively known as the preparatory period), competitive and transitional. There are *no* deviations from this periodization, only the amount of time spent in each one is altered, depending upon such factors as the schedule of major competition, level of preparation, or area of specialization.

The general preparatory period is used for all-round training and increasing the levels of strength, power, endurance and other physical qualities. It is high volume training and develops the base upon which specialized high intensity work is done to bring the athlete into top shape for competition. The training is very specific in the specialized stage, and in most cases duplicates the competitive skills. After competition and its differentiated training, all athletes go through the transitional period, mainly as a psychological break, since they still continue to train.

Soviet athletes are ranked according to accomplishments. The highest level athlete receives the title Master of Sport, International Class. This is followed by Master of Sport, Class I, Class II, and Class III. All are high level runners, differentiated only by times. For example, there is only 1.8 second difference between the highest and lowest level men's sprinter. Keep these rankings in mind when reading particular articles, since they will enable you to use the information more specifically with your athletes.

Dr. Michael Yessis

Introduction

The contents of this volume were translated from Russian to the English language by Dr. Michael Yessis, and previously published in his "Soviet Sports Review" quarterly magazine, and its predecessor, the "Yessis Review of Soviet Physical Education and Sports." This information deals with numerous aspects of training and competition in running events, and is not necessarily intended for the "raw beginner" athlete and coach.

Progressive coaches and ambitious runners engage in a never-ending search to achieve optimum training in order to produce the maximum of each athlete's competitive potential. Simply stated, the training questions to be answered are how far, how fast, how much, and how often they run. Although the history of racing and training spans even beyond the Ancient Olympic Games more than 3,000 years ago, answers to these questions still remain generally vague. This is because each athlete presents unique individual differences, and is in reality a law unto himself.

A champion runner must strive for his speed, strength, and endurance on a daily basis through the most feasible training available to him. In the same manner, progressive coaches must strive to enhance their knowledge by consulting the best possible sources of technical expertise, wherever it may be found.

Dr. Michael Yessis has rendered an imminently valuable service to athletics by virtue of having made available to the English-speaking world the results of Soviet sports research through his translation and publications.

This volume presents the wisdom of selected research results applicable to track running events. Because of individual differences among athletes, a single "best" method of training applicable to all runners will perhaps always elude those who seek it. Nevertheless, certain basic principles do exist. The contents of this volume may enlighten the coach and athlete as to avenues for improved performances, enroute to the achievement of the maximum of one's competitive potential.

Fred Wilt

"THE LOGIC OF SPORTS TRAINING"

N. Volkov

Achievement of high results in sports is possible only through systematic training that is structured according to known laws governing the development of workability during muscular activities. Sports training is based on three biological principles: the principle of overload, the principle of specificity, and the principle of reversibility of action [influence].

The principle of overload stipulates that functional changes in the body (brought about by physical loads) bring about improved training effects only when the load is sufficient to cause considerable activization of energy and plastic (relating to synthesis of new tissue) exchange in the cells.

The principle of specificity is based on the fact that the greatest functional and morphological changes during training take place only in the organs, cells, and intracellular structures which bear the brunt of the physical load executed. Related to this principle is the "transfer of trainability" phenomenon, the essence of which is the fact that the increased functional capability acquired during training in one exercise can appear in another exercise.

The principle of reverse action holds that bodily changes brought about by training are transitory in nature. Functional changes which follow cessation of work are restored to normal values. Functional and anatomical changes in the body, acquired during the process of training, return to the initial state after cessation of training.

These biological principles of sports training are embodied in its didactic principles: the principle of gradual, systematic training, the principle of uniting general and specialized training, the principle of maximal loading, etc.

The Relationship Between Work and Rest in Training

In order to achieve noticeable changes in the body, intense—but relatively brief—training loads must be repeated numerous times between specified rest intervals. It is very important that the load be repeated after the correct amount of rest.

Restorative processes are accompanied by increased oxygen demands. During exercise the body works in debt and this debt must be paid off with increased aerobic reactions during the rest period.

Restorative processes are tied in with equalization of energy balance and normalization of plastic metabolism during rest, along with other phenomena which depend on increased endocrine gland activity and redistribution of matter throughout the organism. These phenomena are observed for a long period of time—long after oxygen debt is repaid and plastic processes have returned to normal. Such phenomena bear the name "after effects." These phenomena comprise the so-called "training effect," which is observed for a considerable period of time after conclusion of work. The totality of all changes that arise as a direct result of physical loads, plus the after effect appearances that follow work, comprise the essence of post-work restoration.

Restorative processes, by and large, appear immediately after the work is stopped and gradually subside as the length of rest increases. In accordance with the principles of overload and reversibility of action, the speed and magnitude of the restorative processes depend on how heavy the training load was. Physiological changes brought about by physical loads reach their peak at the moment of ending work. During rest they gradually return to normal. At a certain point in time restorative processes exceed the initial, pre-work level (Figure 1).

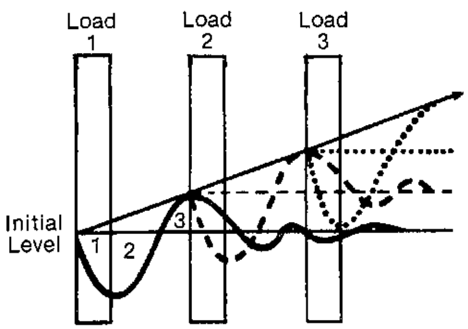


Figure 1

This increased level of functional changes corresponds to the supercompensatory phase (over-restoration). So that training leads to a positive effect, repeat physical loads should be applied during the supercompensatory phase. This stimulates the growth of the body's functional capabilities and provides for an improved state of trainedness. If the next load is applied before complete restoration takes place, it will only aggravate unfavorable changes. If this happens often enough, it will lead to overtraining.

Determining the onset of the supercompensatory phase in practice is far from simple. For example, complete restoration of the creatin-phosphate reserves in the muscles after brief, intense loads, requires approximately 30 minutes; restoration of intramuscular glycogen reserves following intense work takes approximately 1.5-2.0 hours. However, the supercompensatory phase that follows prolonged work is accompanied by considerable expenditure of carbohydrate and fat reserves in the body and usually takes about 2-3 days to be achieved after work ends. The question arises: what bodily functions correlate with the supercompensatory phase and what can the criteria be for sufficient restoration?

An answer to that question has to come from the principle of "specificity of the training effect." Each training session and each exercise is normally aimed at a certain single, most important function. Indices of these "leading" functions should serve as criteria for selecting the ratio between loads and rest in training.

For athletes who specialize in cyclical types of track and field events (running, race walking), such criteria could be indices of muscular strength and aerobic and anaerobic capabilities. Indices of working capacity—controlled tests and competition results—are often used as such criteria. But it is not reliable. Achievement of a high level of work-ability is the goal of the entire training process (preparation for the most important competitions). However, the object of individual training sessions is to achieve optimal changes in necessary functions or qualities. It is not necessary to wait for total completion of the restorative processes in order to achieve marked changes in the "leading" functions, and consequently, in the more significant supercompensatory phase. In accordance with the principle of overload, it would be more desirable to construct the training so that repetitive loads occur during the phase of incomplete restoration. Summing up, these loads will bring about significant changes in those functions that are most effected by the work. However, if immediately after this, sufficient time for rest is given, supercompensation will be much greater than with a one-time load. By observing all the necessary conditions, the positive effect from such training will be considerably higher.

Adaptation to Physical Loads in the Process of Training

Training increases the functional and energy reserves of the body and facilitates the growth of the athlete's work capacity. The functional rebuilding that takes place in the organism during training is determined by the nature of the loads applied, their intensity and volume.

Maintenance of an acquired level of work capacity requires a definite amount of physical loads. Reduction of physical loads below some critical amount will not provide a positive training effect and will lead to reduced functional capabilities of the organism (the detraining phenomenon). An increase in physical loads is accompanied by intensification of positive functional changes in the organism. But it is not infinite. There is a limit to mans adaptive, accommodative capacity. When that limit is exceeded, functional capacity will not increase but will worsen and bring about fatigue. Improvement in functional systems proceeds rapidly at the beginning with a corresponding increase in physical loads. Improvement then gradually slows down until it reaches the limit of adaptation, after which functional capabilities drop (Figure 2).

Each athlete has his range of optimal physical laods which provide the greatest growth in functional capabilities. The limits of this range increase considerably during the training process. As one's trainedness increases there's also an increase in the load limit corresponding to the adaptive capabilities of the organism. Loads which produced the greatest physiological changes at the very beginning of training will not produce similar changes later on (Figure 3).

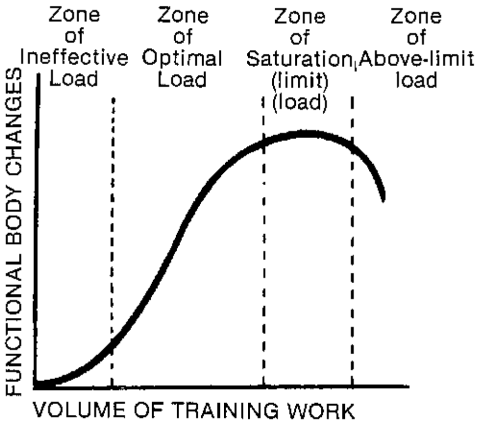


Figure 2

It is possible to determine how close a given physical load is to maximum by comparing the amount of change in the "leading" functions to the maximum allowable changes in these functions. For example, to evaluate a load designed to develop the athlete's aerobic capacity one must compare the intensified aerobic process with the level of maximum oxygen uptake. Adaptation to physical loads during the training process follows definite laws. Physical loads can be viewed as distinctive stress, that is, an action that requires considerable strain on the most important functions of the body. It is known that the body's reaction to stress occurs in several phases.

The beginning phase of adaptation takes place on account of rapidly mobilized functions. Such functions are the vegetative or involuntary functions that participate in aerobic muscular activity. These functions improve under the influence of very different physical loads, but the process of adaptation takes place rather

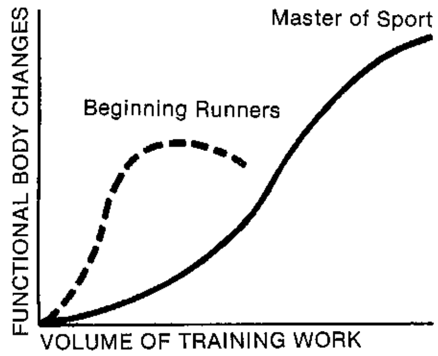


Figure 3

slowly. This beginning phase of adaptation results from nonspecific loads which correspond to the first stage of the prepatory period of training in which many different general-type exercises of moderate intensity are used in great volume. The usual duration of this period of training is from 3-4 months.

The phase of specific adaptation follows the general adaptation phase. Of greatest importance here are the specific adaptive changes in the "leading" functions which are most important for producing results in the given exercise. This phase of adaptation corresponds to the period of training in which wide use is made of special exercises along with methods of general physical training. This phase of training commonly takes 5 to 12 weeks.

After passing through the phases of general and specific adaptation, the athlete reaches the phase of complete adaptation which corresponds to the period of entering into and maintenance of sports form. This phase is characterized by a maximum level of work capacity, which ensures optimal development of the "leading" functions and improved regulation of their reciprocal activity. The length of this phase varies from 3 to 6 weeks, after which comes the phase of readaptation which leads to loss of sports form.

The reason for loss of sports form is the fact that maintenance of maximal working capacity puts great strain on the activity of the "leading" functions. During the course of time, functions which carry the biggest share of the load, and which have relatively low adaptive reserve, become exhausted. Discoordination then sets in on the activity of the "leading" functions, which determine the athlete's working capacity. Results of experimental studies show that a crucial role is played by the functions of the endocrine glands (hypophysis, adrenal cortex) which regulate the body's adaptive reaction to stress. A general chart of the adaptive changes during the training process is presented in Figure 4.

As is visible from the figure presented, the speed of the adaptive changes during training and the duration of the individual phases of adaptation depend on the nature and magnitude of the applied loads. The greater the influence of the physical load on the organism, the faster the adaptive capacity limit and readaptation phases are reached. The positive functional changes acquired during the training process do not disappear during the readaptation period. In this case the lowering of functional capabilities of individual organs and tissues is temporary and can be successfully overcome by intelligent varying of the size of the training load during this period. If the load is maintained at a constant level without regard to the phase of adaptation, then sooner or later it will lead to an overtrained condition.

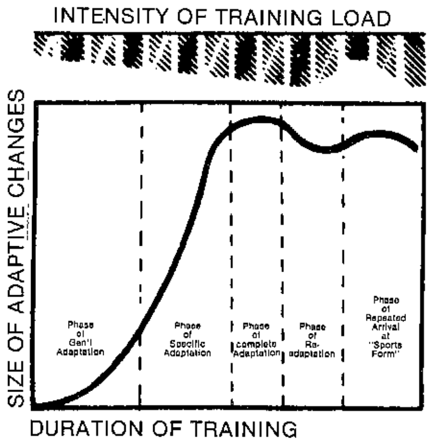


Figure 4

Deep metabolic changes underlie the functional "reconstruction" that occurs at various stages of training. Numerous experimental research studies have shown that the processes of biochemical adaptation to physical loads take place in a definite sequence. Training is affected first of all by biochemical processes that are distinguished by complex regulation and require the participation of a large number of physiological functions. In the human organism such processes are tissue respiration, or internal respiration.

The adaptive changes that are connected with aerobic capacity take place slowly and require a long training period. Adaptation in the synthesis system of specific proteins which provide high contractile capability in muscles is just as slow. But, when developed as a result of training, these changes are maintained at a given level for a long time.

Biochemical changes associated with the glycolytic anaerobic process develop much faster under the influence of physical loads. But they are lost just as fast after the cessation of training. This peculiar feature of biochemical adaptation to physical loads should be studied both from the standpoint of the "dosage" of the training loads and its distribution throughout the different stages of training.

"RESISTANCE LOAD AND POWER"

Y. Popov, O. Stepanenko, & V. Bolvat

Development of special strength training methods has been given a lot of attention in the scientific-methodical literature. For example, the "hit" method of improving the reactive ability of the neuro-muscular apparatus has been recommended for jumpers, throwers, and sprinters. Included are: depth jumps, squatting and rising with a barbell, and jumping out with the standard weight (32 kilogram dumbbells), irrespective of the athlete's qualifications. Precise recommendations for the use of weight resistance training for athletes of different qualifications have not been proposed.

The purpose of our experiment was, on the basis of a selected exercise, to find the optimal (from the point of view of maximum power development) amount of resistance in accordance with a sprinter's qualifications. Pedagogical observations during training, discussions with leading specialists (in short distance running), and analysis of many exercises led us to the weight resistance exercise described below.

The exercise consists of springing up (with a barbell on the shoulders) on alternate legs (Figure 1). The leg, is placed in support with an angle of 90° between the shin and thigh. When performing the exercise it is necessary to have complete extension of the support leg at the knee and ankle joints. The exercise is performed at maximum speed.

The effect of this exercise consists in the following: first, there is both overcoming (concentric) and yielding (eccentric) regimes of strength work which corresponds to the main structure of the sprint run. Secondly, the exercise assures maximum development of speed-strength endurance.

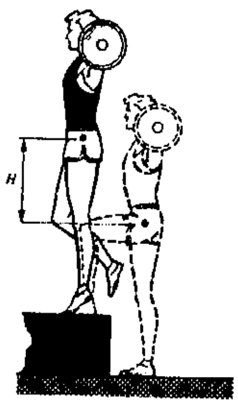


Figure 1

The participants in the experiment were runners specializing in the 100, 200, and 400 meters, including the hurdles. In all, there were 35 athletes of different qualifications who participated in the study. In preliminary experiments it was shown that the minimum resistance weight was 25 kilograms. Less weight does not provide a strong enough stimulus to develop special qualities, but can be used to increase the level of general physical preparation.

In the first stage of the research the amount of resistance load corresponding to the maximum power developed, in relation to the runner's qualification, was determined. The athletes performed the exercise with a barbell with the initial weight at 25 kg. The weight was increased by 5 kg. on subsequent trials.

Since the absolute amount of power does not lend itself to simple calculation, we determined relative power which was derived from the expression N/N_{max}, where N equals the current power value in an individual cycle and N_{max} equals the maximum value of power attained during the whole experiment. The results are shown in the graph (Figure 2). As we see, maximum power developed by sportsmen of different qualifications corresponds to a specific amount of resistance. The "family" of curves produced also shows that the amount of absolute power developed depends on athletic qualifications.

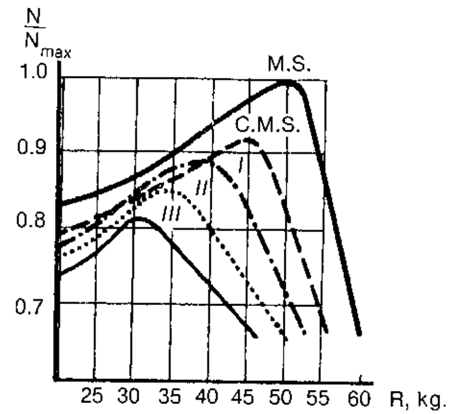


Figure 2

The optimal amount of resistance for this exercise, for athletes of different qualifications, is shown in Figure 3.

In the second stage of the research we determined the number of repetitions, number of attempts and sets for performing this exercise. The athletes performed the exercise with optimal weight corresponding to their qualifications (at maximum speed) to complete exhaustion.

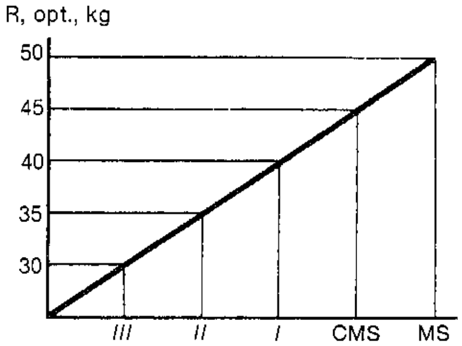


Figure 3

The speed of the athlete's recovery between attempts was controlled by letting the pulse rate drop to 120 beats per minute. The number of trials was limited by the athlete's fatigue during the process of the experiment (as expressed by inability to maintain the structure of the movement). The total number of attempts approached 8. Results of the experiment are shown in Figure 4.

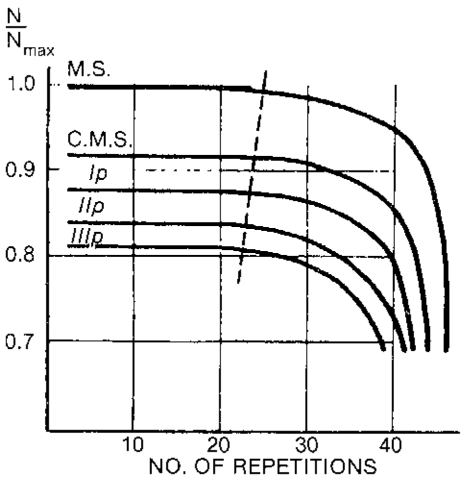


Figure 4

As we see, after a certain number of repetitions a smooth drop in developed power begins and continues up to the moment of acute fatigue. The stable nature of the power curves in the first part of the graph are explained by the constant speed at which the exercise is performed and provide the basis for determination of repetitions. Practical recommendations for use of the exercise are presented in Table 1.

Table **1**

Rank	Number of Repetitions	Number of Sets	Number of Series: In Combination With the Main Training	Number of Series: Strength Training	Resistance Load, kg.
Master Sport	18-25	6-8	1-2	2-3	50-55
Candidate, Master Sport	18-22	6-8	1-2	2-3	45
I	16-22	5-6	1	2	40
II	19-23	4-6	1	1-2	35
III	15-20	4-6	1	1	30

"WEIGHT TRAINING FOR SPRINTERS"

Y. Popov & O. Stepanenko

Views differ on the use of special strength exercises. Hence, we were faced with the following task: to develop and scientifically establish a battery of effective speed-strength training methods for sprinters. More than 20 of the most commonly used exercises were investigated in our study, which included 120 runners, ranging from Class III to Master of Sport. The study was conducted in three stages.

In the first stage we determined optimal (from the standpoint of maximum power production) amounts of resistance, depending on the athletes' skill level (rating). Using one exemplary exercise, Figure 1 reflects the correlation between maximum power output, resistance and rating level.

It can be seen that each skill level corresponds to a specific weight resistance. It is as if there is a "natural zone" of weight resistance. At the same time, athletes of different skill levels, working within their corresponding "zones," develop absolute power values that are exclusively individual. Depending on the athlete's fitness, slight changes in weight resistance may occur in the "zone." For example, these changes range within ± 1.5-2.0 kg for Class II and III rated athletes; for the highest ratings, ± 1.2 kg.

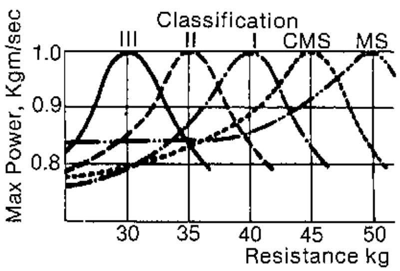


Figure 1

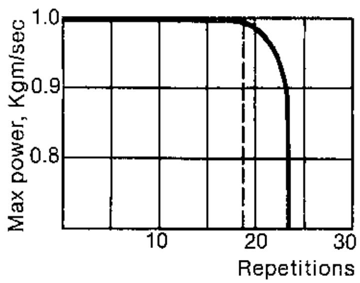


Figure 2

In the second stage, the number of repetitions, sets and series were determined (Figure 2). The graph shows a repetition curve for a specific exercise. It is evident that after a certain number of repetitions there appears a drop in power output up to the point of acute fatigue. The undeviating power curve in the first part of the graph provides a basis for determining the number of repetitions. Relying on the obtained data (intensity, number of repetitions and recovery regimen), it is possible to recommend the number of sets and series when executing these given exercises.

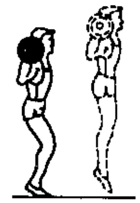
The third stage involved classification of exercises. The most effective exercises, which approximated running most closely in

their technical-dynamic parameters, were identified and arranged in order of their significance. Of prime importance was maximum speed in executing the exercises. Several exercises and the technique of execution are given below.

Squat Jumps (1). The trunk is erect and legs are flexed at the knee joints (angle between thigh and shin is 130-140°). The jump is executed by rapid and simultaneous extension in the ankle and knee joints. Emphasis is on full and active extension in these joints.

Step-ups with alternate legs (2). The foot rests on the box so that a 90° angle is formed between the shin and thigh. Intensity can be increased by changing the height of the step; for example, climbing the steps of a staircase (angle between the thigh and shin 120-130°). Full extension of the knee and ankle joints is essential.

1



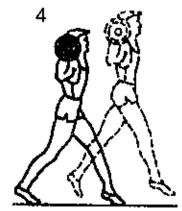
2

Deep lunge walk (3). Executed by rising high on the toes of the support leg (forward-upward). This exercise can be executed in place as jumps with alternate legs.

Scissor jumps (4). Executed with simultaneous pushing off from both feet by means of vigorous flexion and extension in the ankle joints. Attention should be focused on pushing off with the feet, the minimal knee joint flexion.

3

4

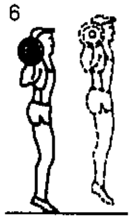


Jumps from a deep squat (5). From a deep squat one rises rapidly on the toes, with a subsequent leap upward. Strive for erect back position and full extension in the knee and ankle joints.

Straight-legged jumps (6). Executed with simultaneous pushing off from both legs with a vigorous leap upward. Focus attention on quick ankle joint extension and momentary, springy movement in the knee joints.

5

6



Running with high thigh lift (7). Executed with alternate, rapid switching of legs. Strive for full extension of the support leg and correct pelvis position relative to the projection of the push off spot. The exercise is executed both "in place" and with slow forward movement.

7

To develop special strength, we used various methods: repetitive, circuit, the brief effort method and the variable effect method. Individual types of special strength can be developed by varying intensity of execution and the time and character of rest.

Presented below is the approximate weekly strength training program for athletes of the highest skill levels.

1st day. Strength training combined with the main training: (a) step-ups on alternate legs (angle between thigh and shin 90°): 50kg x 20 for 6 sets; recovery to HR of 120/bpm. The exercise is executed at maximum speed; (b) jumps with alternation of legs: 50kg x 20 for 5 sets; recovery to 120 HR. Maximum speed of execution.

The rest interval between exercises (a) and (b) is 2-3 minutes and is taken up with walking, medicine ball exercises, etc. for maintaining optimal CNS excitability.

4th day. Strength training combined with the main training: (a) jumps from a half-squat: 45kg x 20 for 8 sets, 2 series; (b) jumps with changing of legs: 50kg x 20 for 5 sets; (c) running with high thigh lift: 45kg x 20 for 3 sets, 2 series. Speed of execution is maximal. Rest to the point of full recovery. The varied selection of exercises in this training session allows for elimination of stabilization and stereotyped repetition of dynamic-temporal characteristics.

For athletes in the lowest ranks (ratings) the loads are considerably less, but they take more time in the weekly training cycle.

1st day. Strength training combined with the main training: (a) step-ups with alternate legs or climbing stairs (angle between the shin and thigh is 120-130°): 35kg x 15 for 4 sets; (b) jumps from a deep squat: 35kg x 10 for 2 sets. Speed of execution is maximum; recovery between sets to 120 HR. Active rest between exercises in order to maintain optimal CNS excitability.

3rd day. General physical training combined with the basic training: (a) varied selection of means, permitting the objective of general physical training to be accomplished effectively.

4th day. Strength training combined with the main training: (a) jumps from a half-squat: 35kg x 10-12 for 4 sets; (b) running with high thigh lift (moving slowly forward): 30kg x 12 for 2 sets; (c) jumps with changing of legs: 35kg x 12 for 2 sets. Speed of execution—slow, recovery between sets—complete.

This training load plan applies to the preparatory period, when the main purpose is to achieve a quality level of strength. The strength-training load volume at this stage comprises 25% of the total weekly training time.

The main purpose of the competitive training stage is to maintain a high level of previously developed fitness. At this stage the allocation of training load volume comprises 10-12% of total weekly training time for the highest rated athletes and 15-20% for those with the lowest ratings. Use of strength training throughout the training year, in accordance with our approach, markedly facilitated effective improvement of physical preparedness.

"STRIDE LENGTH AND STRIDE FREQUENCY"

A. Artinuk

The purpose of this study was to answer the following questions: a) How does a change in length and frequency of strides occur in the process of many years of training with an increase in a runners qualifications? b) How does the speed of the run vary with a change of one or the other component? c) What is the relationship between stride length and stride frequency when running during training and in competition, in sportsmen of various qualifications? d) Is it possible to differentiate the approach to development of each separate component?

As a result of a correlational analysis, the relationships between length and tempo and concrete results by runners of various qualifications (from Class II to Master of Sport, international class) it was found that the coefficient of correlation between tempo and running results was equal to 0.83 (a strong relationship). The dependency between stride length and running results was 0.26 (no relationship). In looking over the dynamics of running speed in relation to a change in one or another component separately, it is possible to notice that, for example, with a stride length of 160 cm and a tempo of 2.5 strides/sec, speed will be equal to 4 m/sec. In order to increase speed to 4.5 m/sec. it is possible to either not change the tempo and increase stride length by 20 cm or to leave the stride length as before and increase the tempo to 0.31 strides/sec. Consequently, it is possible to get this same speed by either increasing stride length by 6.33 cm or by increasing the tempo by 0.1 strides/sec.

The correlation with great significance of stride length becomes different. With stride length at 250 cm and tempo at 2.5 strides/sec, the runner achieves a speed of 6.25 m/sec. In order to increase speed by 0.5 m/sec (that is, up to 6.75 m/sec) it is necessary to increase stride length by 20 cm and tempo, with the previous stride length, only by 0.2 strides/sec.

We will now look at this relationship at even higher running speeds (with a stride length of 170 cm, a tempo of 5 strides/sec, and speed equal to 8.5 m/sec). In order to increase running speed up to 9.0 m/sec it is necessary to increase either stride length by 10 cm, or bring the stride frequency up to 5.3 strides/sec. In this case a tempo of 0.1 strides/sec will have the equal value of 3.3 cm of stride length. With a stride length of 250 cm and a tempo of 4.6 strides/sec speed increases up to 11.5 m/sec. In order to achieve a speed of 12.0 m/sec it is necessary to increase the stride by 10 cm or the tempo up to 4.8 strides/sec. In this variant, a 0.1 strides/sec tempo will correspond to a 5 cm stride length.

Here is an obvious case. If the runner with a stride length of 160 cm has a result of 2.02.0 in the 800 m then the mean tempo is 4.1 strides/sec. In order to achieve a result of 1.49.0 it is necessary for him to either increase stride length to 180 cm or bring the

tempo up to 4.6 strides/sec. But if the sportsman possesses a stride length equal to 210 cm with a time of 2.02.0 (mean tempo of 3.1 strides/sec), then to better his result to 1.49.0 he must achieve an increase in tempo up to 3.5 strides/sec or an increase in stride length up to 236 cm.

Thus an increase in stride from 150 to 200 cm is advisable in order to better running time. But with an increase in stride length from 200 cm and more, an increase in speed would be more effective with an increase in tempo. In the first case it was necessary to increase the tempo by 0.5 strides/sec, in the second case by 0.4 strides/sec, but the stride length in these cases had to be increased by 20 cm and by 26 cm respectively.

Naturally, a question arises: which of these two components appear to be decisive? A study of the correlation between stride length and stride frequency showed that in the overwhelming majority of cases, a decrease in running speed is accompanied with a decrease in tempo, even with an increase in stride length. This shows us the decisive significance of tempo for an increase and maintenance of speed. It was displayed that even with expressed fatique, the runner is capable of maintaining great stride length, however, with a clear decrease in tempo. This is essentially characteristic for young runners. Some stride length decrease in the process of running observed with stabilization of speed, can be considered as reflexive switching in order to maintain speed and is not tied in with fatigue.

Thus the given mathematical analysis and biometric investigation shows that of the two components of which speed is composed—stride length and frequency—the deciding factor which determines running speed is tempo. To corroborate the above it is possible to carry out an obvious example with hurdlers where better results are achieved with an increase in running tempo as stride length is determined for all qualifications of hurdlers (from Class III to the world record holder) by one condition—placement of the hurdle. This is especially characteristic for the 400 m hurdle distance where there are great possibilities for varying speed by changing frequency or stride length. Even here, however, runners give preference to tempo.

The above stated mutual ties can be illustrated by the following example. Many time champion and record holder of the USSR, E. Ozolin, in running the 100 m distance in 10.6 sec had a stride length of 217 cm and a tempo of 4.32 strides/sec (Ionov and Chernyaev, 1968). According to our calculations, if the runner increased his tempo up to 4.66 strides/sec while maintaining this stride length, he would have achieved a result of 10.0-10.1 sec. To achieve such a result with the former tempo it would have been necessary to increase stride length up to 234 cm, which in the given case, is significantly more complex than increasing tempo up to the given amount.

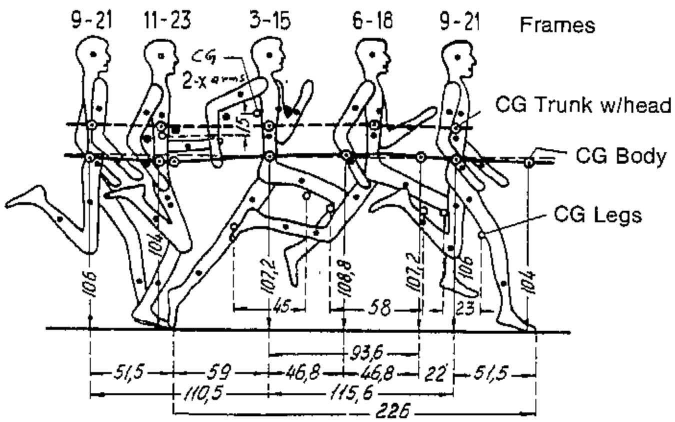
ON THE TRACK WITH VICTOR MARKIN

A. Stukolov & V. Mansvetov

During the 1980 Olympic Games, sprinter Victor Markin, coached by Bukhasheev, achieved shining success. Not only did he win 2 gold medals in the 400m and 4x400m relay but he set a new European record—44.60! In looking at the cinematogram of his run during the finals on July 30, 1980, 40-45m from the start (film speed 50 frames/sec) we can see the effectiveness of his running technique even without deep analysis of his movements.

At the 40-45 meter point, Markin's speed is still not at maximum, and although he is still striving to increase his speed (from 8.76 to 9.80m/sec), there is no excessive, distorted movement or tension.

By using the basic method of studying this cinematogram, which was taken at an angle to the runner, not from the side, we were able to determine a contourgram of his run and a series of spatial and temporal parameters of his movements, which give a sufficiently full presentation of the running technique of our record holder.



The following spatial and temporal running parameters were determined for Victor (height 184 cm, weight 72 kg):

1. The double stride cycle is 4.52m (0.48sec)
2. Single stride length is 2.26m (0.24sec)

Running stride length (2.26m) corresponds to running speed for the 40-45m distance with continued acceleration (speed about 8.76m/sec). For the second 100m, speed increased to 9.80m/sec, and stride length correspondingly increased to 2.50m.

3. The center of gravity of the body (CG) in the support period moves 110.5cm (0.12sec).

The duration of the support period corresponds fully to the phase of accelerating.

4. Placement of the foot is 51.5cm in front of the vertical projection of the CG (frames 9 and 21).

Such foot placement is also in agreement with the 400m run principle: the more active the pawing action, the less is the "braking" loss.

5. The CG moves 59cm beyond the vertical projection of the support leg during the push-off (frames 3 and 15).

Such movement of the CG beyond the vertical projection of the support base allows for powerful movement and acceleration of the runner's body.

6. Body flight (according to CG) over the horizontal chord (straight line horizontal distance of the flight arc) is 93.6cm (0.107sec).

7. Flight of the body (according to CG) after the horizontal chord (when touchdown occurs) is 22cm.

Flight of the body over the horizontal depends on horizontal speed and height of the flight, which in Markin is all of 1.6cm (which is extremely low and effective). Body flight after crossing the horizontal chord is 22cm, which shows that Markin is striving

to increase the support period at this distance (45m from the start) and maximally use it for acceleration.

8. Length and time of body flight (according to CG) is 115.6cm and 0.12sec respectively.

The temporal relationship between the support and flight phase corresponds completely with horizontal speed at this segment of the run and with the task of further increasing speed. In the second 100 meters this relationship changes and goes to a pure sprint relationship: 0.125sec for support and 0.156sec for flight.

9. The height of the CG at the moment of landing is 106cm (frames 9 and 21).

10. Height of the CG at the moment of being vertical is 104cm (frames 11 and 23).

11. The amount of rise of the CG during the push-off is 3.2cm.

12. The level of the CG at the end of the support period is 107.2cm (frames 3 and 15).

13. The lift of the CG over the horizontal chord is 1.6cm.

14. Vertical oscillation of the CG is 4.8cm.

The height of 104cm for the CG at the moment of landing is ideal for a body height of 184cm. Markin does not allow great vertical displacement (oscillation) of the CG of the body which, from a biomechanical standpoint, is very effective.

15. The distance between the CG of the legs at the end of the push-off is 45cm (frames 3 and 15).

16. The distance between the CG of the legs in the flight phase is 58cm (frames 6 and 18).

17. The distance between the CG of the legs at the moment of touchdown is 23cm (frames 9 and 21).

The wide "split" of the legs in the sagittal plane during the flight phase with vigorous "closing" of the legs from 58 to 23cm allows for effective placement of the foot in support by moving it

backward (pawing action) and speeding it up during the acceleration phase.

18. The vertical displacement (oscillation) of the CG of the arms is 15cm (frames 3 and 15).

All of the above-noted parameters of movement determined from analysis of Markin's running technique show its great effectiveness. All the parameters are in strict accord, maintaining an optimal relationship over the entire distance and are biomechanically sound.

"ON THE TRACK WITH L. VIREN AND K. LOPESH"

Legkaya Athletika

The most integral indices of winning technique are the rhythmic characteristics of the stride: duration of the support phase; duration of the flight phase; stride frequency and relative coefficient of rhythm,

$$A = \frac{\text{flight time}}{\text{support time}}$$

Mean running speed is determined by stride frequency multiplied by stride length.

In the table are the comparative characteristics of these parameters in qualified and less qualified runners (mean data).

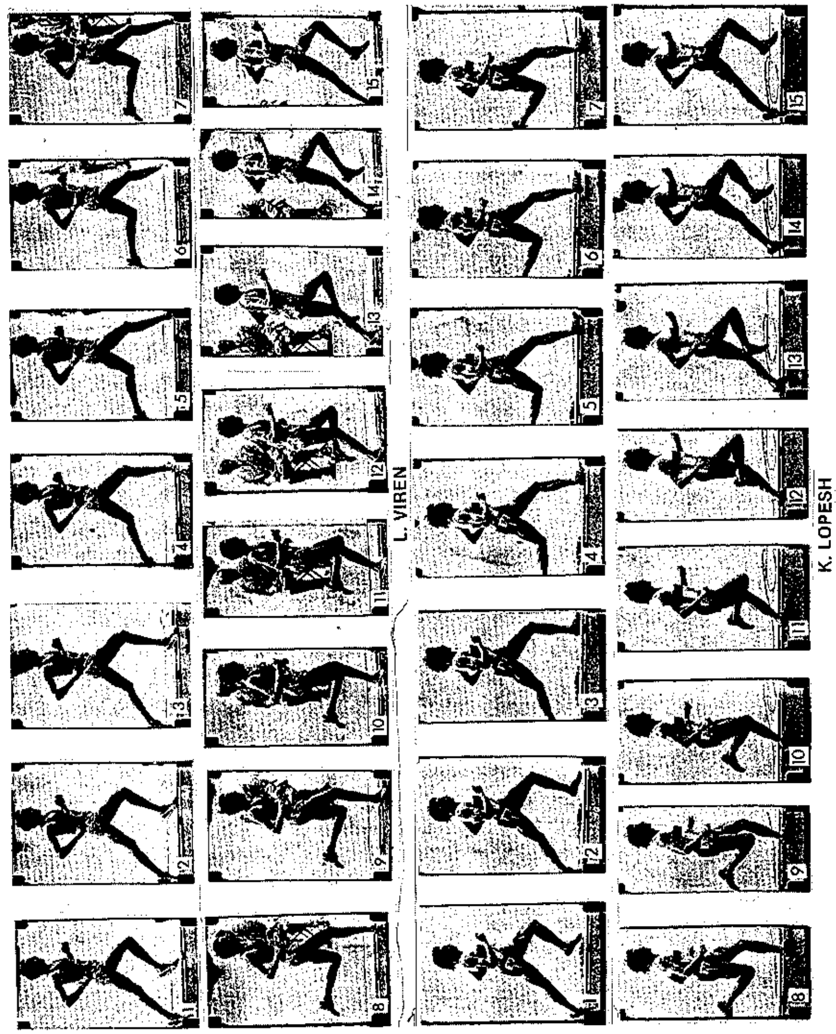
From the table it can be seen that the strongest runners run with greater frequency. The increase in frequency basically occurs as a result of less flight time. This is well expressed in the coefficient of rhythm.

Rhythmic indices of the running stride by qualified and less qualified runners at a speed of 6 m/sec (mean data)

Parameters	Accomplished Runners	Less Qualified Runners
Support time (sec)	0.150	0.148
Flight time (sec)	0.143	0.152
Stride frequency strides/sec	3.41	3.34
Coefficient of rhythm $A = \frac{\text{flight time}}{\text{support time}}$	0.957	1.025

The strongest runners have the A coefficient on the order of 0.88-0.9. Biomechanical characteristics of such technique are distinguished by less effort during the support phase, less oscillation of the center of gravity, lesser angle of thigh lift and less "whipping" of the shin backwards. Such a technique variant is more economical from the point of view of energy expenditure. But even the strongest runners in the world have individual technique deficiencies.

In the cinematogram of L. Viren (born 1949, height 180 cm, weight 60 kg) and K. Lopesh (born 1947, height 167 cm, weight 55 kg) taken in Montreal during the final phase of the 10,000 m it can clearly be seen that the run of the Olympic champion is distinguished with greater economic movements. The run of the silver medal winner, K. Lopesh is characterized by a more greatly expressed strength component in the take-off phase, characterized by greater flexion in the knee joint (frames 9-10) and excessive effort in the take-off (frames 10-12).



Forward-upward thigh carry (lift) in Lopesh is more active (frames 1-2). This tells of the extra effort during the "accelerated" movement of the thigh of the swing leg and a later "braking." Such delayed braking of the swing leg leads to excessive "whipping" of the shin forward which in turn calls forth the creation of a braking effort in the support phase at the moment of placing the foot on the ground.

Frames 7-8 show that placement of the foot by Lopesh occurs under a sharper angle which is less favorable. The "whip" of the swing leg thigh backward (frames 10-11) in Lopesh is greater which likewise is "extra" movement.

Untimely effort in the take-off in the support phase and late braking of the thigh in the flight phase are typical running errors. When this occurs, there arises a so-called "bachelor zone" as a result of which unnecessary "hanging" of the body during flight occurs. Such running technique is characterized by great flight time and a large coefficient of rhythm.

The coefficient of rhythm for Viren is 0.9 and for Lopesh—0.95. The techniqe of Viren can serve as a model of economy, which is very important in long distance running. Correction of individual errors is a supplementary reserve for improving sports results.

On the cinematograms only separate shots of the athletes are presented, but in order to analyze the technique of the strongest runners, it is necessary that camera film speed be not less than 120 frames per second because, as can be seen from the table, the differences in time in a non-full stride and in separate phases of the run are determined by hundredths of a second.

"ON TACTICS"

Peter Bolotnikov

Very often runners, even very experienced ones, concede victory only because they do not make use of all of their capabilities up to the end. Said another way, errors in tactics takes away from those conditions which give the most favorable conditions for achieving maximum results and victory in competition.

On the other hand, you cannot overevaluate the role of tactics. It is clear that no kind of tactical tricks will help to wittingly win over a stronger opponent. Tactical mastery will not compensate for poor preparation, but in meeting an equally strong opponent it plays a determining role. It does not follow to think that tactical questions are important only for masters. Runners of the lower caliber who meet among themselves should not forget tactical moves. I have in view not only the noted tactics (steady tempo for distance and speed up at the finish) but finer details.

Many years on the road and hundreds of meets have taught me much. And if at the beginning I functioned on basic intuition then at the end I learned to think that what happens on the road of running significantly approaches creativeness which is carried to all competition and every run.

With sorrow, very often it can be observed how strong runners look at the time of competition. They are utterly helpless and too soon doom themselves as another statistic. This happens from a non-thinking and unwilling approach to competition and to their opponents. And yet the most important aspect for victory is to want it very much, to be infinitely sure in your strengths, ("It is a poor soldier who does not carry in honor a Marshall's baton") to fear nothing and no one, to be able to quickly and precisely evaluate the situation on the running lanes. [Examples are given of various races through the years, in Olympics and so on.]

With the years I have also been able to determine my tactical "face." But this was far from always guarding me from unpleasantries (this is not of defeats where the opponents were better prepared but of the losses from tactical errors). Trials of victories and defeats made me work out a "code of tactical reserves," with which I teach approaching competition.

FIRST, what I always strongly remembered—to know your opponent well. Coming up to the start I knew not only the best results of my competitors, how they trained for the meet, in what shape they were in at the present time, at how many meters from the finish they began their push, how they could "endure" when strength was no longer there, and so on. Besides this we, with the trainer, usually prepared a schematic of the race, and prepared a graph of the run.

SECOND, "don't let off" the main runner. In the III Sports Games I lost to Australian Alan Lawrence in the 5,000 meter run because I allowed him on the finish turn to get away from me. [Other examples given.] This does not apply to all situations. In the 1959 USA-USSR Meet, Alex Desyatchik at the 7-m kilometer did not pick-up the dash from American Robert Sota. He saw that Sota was fatigued from the heat but not less than the others and that the dash in such conditions was useless even if he endured final strength. The American who could have surely won couldn't complete the distance and Desyatchik won.

THIRD, attentively observe the top competitor, not letting him get away, and at the same time see all the competitors behind you and not for a second to let out of sight, the constant reshuffle that is going on in the running lanes. Example: In the 10,000 meter I figured to let a runner by on the final turn to overtake him on the straight away. I could have but when he passed so did two others and they then blocked the running lanes and by the time I came around them I was in 2nd place. In another race, I figured my opponent to be Dytov and put all my concentration in on him. I did not but slightly notice Baiduk pass me as I was preparing to sprint and when I realized it, it was too late. The same thing happened in Tokyo to Ron Clark who was thinking of anyone but Mills who at the determined moment tore out in front and achieved victory.

Here it pays to tell that it is not always wise to place yourself in the role of the leader, when it becomes clear that victory is won in a tough race at the finish. Remembering that much strength is used in fighting the wind and the leader experiences a definite mental pressure from the sides by those who are running behind him. They see him well but he can only hear them. Besides this, at the favorite moment they start the attack and here the leader appears as the pursuer. You cannot also lower from sight the fact that many runners intentionally pressure the leader as they are found almost behind and slightly to the right of him almost touching his shoulder and at times almost stepping on his heels. This unnerves one in holding to a definite direction.

FOURTH, prepare tactical novelties and boldly carry them out. Before the Olympic run in the 10,000 m in Rome I knew my main opponents would be the Pole Zdislav Kshishkovyak and German Hans Grodotski. Three laps from the finish Kshishkovyak began his dash and it was necessary for both of us to follow suit. Besides this, I knew that the finish speed of Grodotski was faster than mine and he was waiting for me to start my sprint usually at the 250 m mark. The plan was such: the dash of Kshishkovyak would lessen Grodotski's chances and I will start to finish at 400 m. By the time Grodotski thinks this over, to take up this dash, I will have a sufficiently great gap opened. And so I did it. True,

after 3 laps from the finish Grodotski speeded up but not Kshishkovyak but this was for my hand. Exactly at 400 m I started a very strong finish (the last lap in 57.6). Grodotski took up the dash but considered that I would weaken in my tempo but after 150 m of coming on he stayed behind.

Another example in the USA-USSR Meet in Palo Alto. No one doubted that the Americans had better times and faster finishing speeds. But Belitskii from the very start placed himself in front with a very fast tempo and 150 m from the finish began his dash. All this disheartened the Americans who did not struggle so much as they did wait until Belitskii would get scared of his boldness and give up. But he did not and managed to beat Formen who was stronger. Belinskii in this race set a new USSR record.

Of course you cannot go too far with this scheme. Michel Jazy, for example, in Tokyo began his finish at 350-380 m. For him without doubt this was too much. It is not hard to understand that Jazy comes out quickly but at the finish he ceded victory. His distinguished speed would have been sufficient and far greater in a shorter dash. If he started at 150 m he would have become the Olympic champion.

FIFTH, to be prepared for unexpectancies, to tactical novelties of your opponents, and to quickly and positively make use of them to your interest. The USSR-USA Meet in Kiev in 1965 can serve as an example when I and Orentas had to struggle with Olympic champion Robert Schul and the powerful Pole Larey at the 5-kilometer distance. The prior plan was such: the Americans consider me as the main contender with no attention to Orentas. I will lessen my pace and allow Orentas to get out in front as much as possible. However, the Americans thought otherwise and did not want to let Orentas go. And so we went in a file to the last lap: in front Orentas, immediately behind was Larey then Schul, and myself. Our plan was not working and something had to be done. At 250 m from the finish I made a speed up, practically a sprint from a low start, (at the time of the dash speed increases gradually). By the time the other competitors figured out what had transpired I had managed to get out in front several meters. Schul threw himself in pursuit but it was not that simple, as I from the start, included the predetermined speed and held it to the very end. Schul had to cross over to the next lane to pass Orentas and Larey. Later, already on the straightaway I gradually left the American behind in the third lane. At the very finish, feeling the American even with me I was able to muster up a little more speed and achieve victory, the last of my victories over major international competitors. [Other examples given.]

SIXTH, subordinate yourself to the interest of the team and your comrades. [An example is given to show how runners sacrificed their chances for victory by changing their runs to throw off or keep behind an approaching opponent to allow their teammate in front to go on to victory.]

THE LAST, the ability to be master of all these sides of tactical mastery in the total complex. Or, as is correct, hurdles in competition show up as such complexities and when guided by what is taught by one or two of these "reserves" then I would be assisted greatly in this sad position. Especially now that there are a sufficient number of masters possessing leading tactical sharpness and ingenuity in the world.

In closing, I want to underline the role of the trainer in training the sportsman in skills of tactical fighting. I will always be thankful to my trainer, Gregory Isaichu Nikiforov, in that he not only helped me prepare tactical variations for competition but also educated me in outstanding tactical thinking. This is the most important because no matter how smart and experienced the trainer, he cannot disclose his thoughts to the runner who is in a race, in a struggle which requires that he undertake individual decisions every minute. And at times the correctness is dependent upon all.

"THE OPTIMAL STARTING POSITION IN SPRINTING"

Valery Borzov

Starting positions have for some time been defined by the placement of the starting blocks and their distance from the starting line. For just as long, there has been controversy concerning which start—the "bullet" (bunch), "bullet" (stretched out), or "conventional"—is the most effective. The start, or starting position, for each sprinter is determined in accordance with his anthropometrical data. However, long-term observations of top national and international runners show that at times the same start is used by athletes who have totally different body dimensions. At the same time, some athletes of identical height and leg strength use different starting positions.

Studies on this topic have shown that the leading sprinters, in spite of having different body proportions, have similar angles of flexion in the primary body segments. This similarity suggests that it is possible to establish an optimal starting position model.

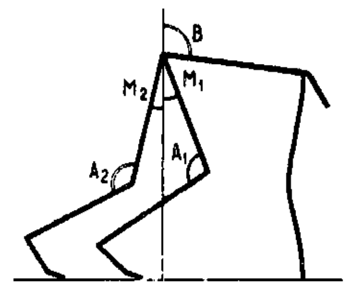
In order to determine this model, it was first necessary to find the optimal angles between the primary body segments and then establish the starting position in accord with them. Maintaining optimal starting position angles provides the sprinter with the fastest start out of the blocks.

Our study emcompassed a group of the top Soviet sprinters of recent years.

According to our data, in spite of the differing heights of the athletes in the group (from 165 to 183cm), the angular values are of similar magnitude in most cases. This substantiates the presence in top-class sprinters of an optimal starting position, which can be represented as shown in the illustration and table.

These angular values can be used to design an optimal starting position. Similarity of angular values is possible in the presence of different block placements which, in turn, depend on the individual sprinter's body proportions.

Hence, when teaching starting technique to beginning runners, we recommend use of a straightedge (ruler) (see illustration), positioned at the athlete's center of mass. Using a



protractor, position the athlete's body in accord with optimal angles of flexion in the primary body segments, and then "place" the starting blocks "under" him. This provides the beginning sprinter with the prerequisites for the most effective and fastest start at the very beginning of his training.

Table 1

Angles	Degrees (Average)	Range of Variation
B	104	98-112
A_1	100	92-105
A_2	129	115-138
M_1	21	19-23
M_2	13	8-17

Note: Angle B: between the sprinter's trunk and a vertical line drawn through the center of mass.
Angle A_1: between the thigh and shin of the forward leg.
Angle A_2 between the thigh and shin of the rear leg.
Angle M_1: between the thigh of the forward leg and the vertical.
Angle M_2: between the thigh of the rear leg and the vertical.

"MORE ON THE LOW START"

K. Baranov & V. Baranov

In previous articles published in *"Physical Culture in School"* (No. 8, 1964, and No. 9, 1965) we presented a hypothesis regarding the possibility of starting a run from a low start, pushing off first with the leg on the rear starting block, and not with both legs as recommended in specialized literature.

During the course of several years we conducted experiments on the movements of sprinters in a run from a low start and during the starting acceleration run (surveys, discussions, observations and myography of the leg muscles simultaneously with high-speed camera filming). The results showed that trainers and sportsmen pay too little attention to mastering the technique of the run from a low start.

For the most part our sprinters use the widely-spaced variant of angle placement of the support platforms of the starting blocks, placing the front at an angle of 40-45° and the rear at 60-85°. The psychological setting of sportsmen is first directed towards pushing off from the support platforms with both legs and after this, on bringing forward the thigh of the leg, on the rear block.

We determined that sprinters psychologically oriented in this way employ only partially the elasticity of the gastrocnemius muscles. This is due to the fact that with the 45-86° angles of the support platforms the gastrocnemius muscles in the "Set" position do not receive optimal stretching (photo 1) as the angle formed between the shin and the foot is only 75-85°.

Drawing 1 shows the results (in the form of cyclograms) of the high speed camera filming with simultaneous electromyography of the leg muscles. It shows the speed of movements at the time of the start of the rear leg during the push-off from the support platform placed at an 80° angle. After the gun extension of the legs takes place (including the rear leg). Simultaneously, the sprinter should start moving his trunk forward, but this does not occur, as the gastrocnemius muscles do not receive the necessary load. As a result the trunk of the runner, being at rest and having greater weight than other parts of the body, stays in place. At this time the heels start a backward movement. This movement takes two frames (1-3) on the cyclogram and, according to our calculations, takes 0.08 sec. In order to return the heel to the initial position at the moment of the starting signal (frames 3-4) the sprinter expends another 0.04 sec.

Drawing 1

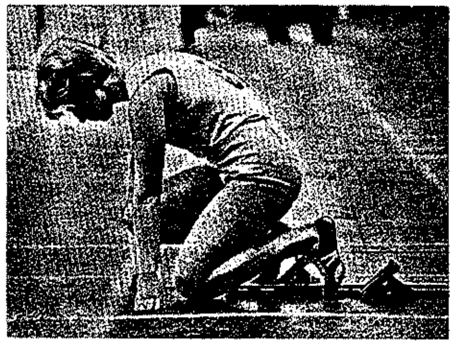
Further movement of the leg, beginning with the movement of the heel from the starting block up to the moment of placing it on the ground (frames 4-11) takes another 0.32 sec.

Thus, in executing the first running stride in this variant the sprinter expends 0.44 sec. Here we can observe the lack of coordination in the work of the muscle groups ensuring movement of the legs forward which leads to a holding of the foot on the rear block, a slowing down in taking the hands off the track, to non-rational rhythm in the starting run and, consequently, to a loss of time.

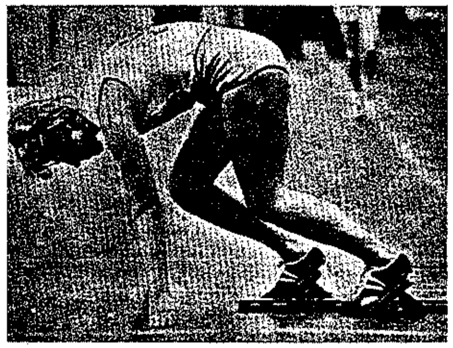
In search of a faster start and a more convenient position at the command "On your mark" we decided to reduce the angle of support platforms to 25-30° for the front block and 30-40° for the rear block (depending on the flexibility of the ankle joints).

In order to better utilize the elastic qualities of the gastrocnemius muscles and the foot as a lever, we recommended that the sprinters place their feet on the support platforms not with the tips of their toes, but so that their toes are situated in front of the support platforms of the starting blocks at a distance of 5-8 cm (photo 2). Such positioning of the blocks is more convenient for the sprinter.

The sprinter was then given a motor setting: in taking the position at the command "Set!", without moving the shoulders, raise the hips (keeping the leg muscles relaxed) and place the feet on the support platforms. This position is likewise more suitable for the sprinter and more steady. Besides this, the angle between the shin and the foot reaches 45-50° (photo 3).



Then we somewhat changed the psychological setting: on the starting signal the sprinter had to push off with the foot from the rear block as quickly as possible and simultaneously "grab" the beginning movement of the thigh forward.



This setting creates optimal conditions for loading of the gastrocnemius muscles, which, in turn, allows for a better and faster push-off from the blocks. As a result, the sprinter, after the starting signal, immediately takes the foot off the rear block and carries the leg forward with the thigh (drawing 2). All of this, up to the moment of placing the foot on the ground, is accomplished in eight frames (instead of eleven) and lasts 0.32 sec. (instead of 0.44).

Drawing 2

Hence, the analysis shows that the sprinter bettered his result by 0.12 sec. All of this is due to the fact that he executed the first running step from the starting blocks with sharp angles of the support platforms and, of course, to his strict execution of the motor setting. Calculations of the film-analysis are substantiated by the electromyographic data on the gastrocnemius, rectus femoris and the external head of the biceps femoris muscles.

What then are the practical recommendations resulting from our research?

1. With the angles of the support platforms at 25-30° for the front and 30-40° for the rear block the runners are in a more convenient and steady position at the commands "On your mark" and "Set."

2. With sharper angles of the support platforms the gastrocnemius muscles of the sportsman are optimally stretched which lengthens the path of force application and contributes to increasing the force and speed of the push-off, obtaining a more rational rhythm in the transition from the starting run to the run for the distance.

3. The motor setting on the fastest push-off with the foot from the rear block teaches the sprinter to start the distance run with the first step at the start.

Running and the Glute-Ham Developer

Michael Yessis, Ph.D.
Biomechanics and Sports Training Specialist
Editor/Publisher, SOVIET SPORTS REVIEW

For many years, I noticed that Soviet runners and other track and field athletes did an exercise that appeared to be what we know as back raises or hyperextensions. They would lie over a buck (short gymnastics horse) situated close to wall bars, with the feet secured between the wall bars against the wall. Since the exercise appeared to be the same as what was typically done in the U.S., I never gave it much thought.

That is, until I talked to a Soviet coach about specialized exercises for runners and how they prevented hamstring injuries. He proceeded to describe what I thought was the hyperextension exercise. How could working your lower back develop the hamstrings? It didn't make sense!

But, examination of how the exercise was executed gave the answer. Body support was on the middle of the thighs, not on the pelvic girdle. The "back raise," therefore, was a trunk raise via hip joint extension-hyperextension in which the hamstrings play a major role. This is the same action that occurs in running!

Biomechanical studies have shown that hip joint extension is the key action in driving the body forward in running, from the moment the foot is planted until it leaves the ground. The major muscles involved in this action are the gluteus maximus (especially at the beginning of the drive phase) and the hamstrings (as the body passes the vertical position). Knee joint extension provides some horizontal force, but only when the body's center of gravity is far in front of the ankle joint push-off point. In addition, eccentric contraction of the gluteus maximus and hamstring muscles (together with the knee and ankle joint extensors) assist shock absorption and preliminary tensing of the muscles before the push-off.

Up to this time, development of the ankle and knee joint extensor muscles has been relatively easy. The runner merely executed heel raises and squats or other similar exercises with free weights or exercise machines. However, development of the hip joint extensor muscles has been very difficult and limited. Only straight leg pull backs or running drills were used for their development, which are only partially effective. Was it any wonder that upper hamstring injuries occurred?

To duplicate the Soviet exercise is relatively easy. You would only need correct positioning on a gymnastic horse with the feet secured in wall bars. But, where can you find a buck and wall bars in a typical gym? Therefore, to make this exercise available for everyone to do, the Glute-Ham Developer (G-HD) was created by

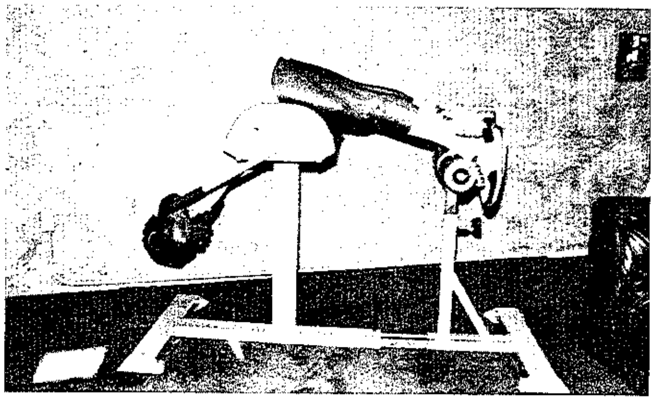


Figure 1

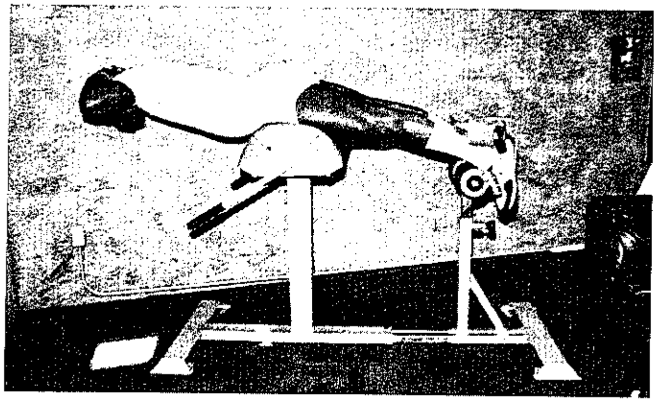


Figure 2

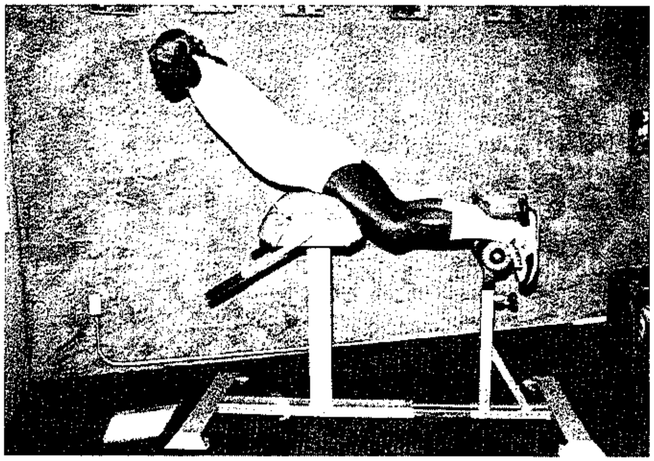


Figure 3

Dr. Yessis and is manufactured exclusively by the Polaris Equipment Company. It was developed specifically for development of the gluteus maximus and entire hamstring muscle group. However, it is also effective for the erector spinae muscles, all exercises typically done on a Roman chair, and other unique exercises.

Therefore, to develop the muscles as needed for the push-off in running (drive phase), it is necessary to execute glute-ham-gastroc raises, which duplicate the actions involved in the Soviet exercise.

To do this exercise on the G-HD, the feet are secured in the rear pads, which are adjusted so that the pelvic girdle hangs over the curved seat. With the back (trunk) kept straight, the upper body is pulled up by the gluteal and hamstring muscles until the entire body is straight or slightly arched. In other words, maximal hip joint extension is performed. This movement maximally develops the gluteus maximus and upper hamstring muscles and duplicates the key force-producing action in running.

To involve the entire hamstring muscle group and to ensure a maximum contraction, the trunk is raised even higher by knee joint flexion. In so doing, the upper hamstring maintains its maximal contraction (along with the gluteus maximus) and then brings in, with a maximal contraction, the lower portion of the hamstring muscles. This produces a double maximal contraction of the hamstrings. This is the main reason why this exercise is so effective for total hamstring development, especially for prevention of hamstring pulls.

It is important to keep in mind that the glute-ham-gastroc raise exercise can *only* be done on the G-HD (or on the horse-wall bar set-up). Trying it on a Roman chair or other similar device will lead to injury.

Detailed instructions for execution of the glute-ham-gastroc raise and other exercises can be found wherever the G-HD is located. If one is not available in your locale, please contact Dr. Yessis, P.O. Box 2878, Escondido, CA 92025, or call (619) 480-0558 for information. Then your runners will be able to say, "I've been Glute-Hammed!"

"ON THE TRACK WITH VALERY BORZOV"

L. Oyfebakh

This cinematogram was taken during the 200m run in Kiev, site of the "Znamenski Memorial Games," in which Valery Borzov repeated the national record of 20.5 sec. The cinematogram was taken when the runner was at the 165-170 meter mark. Speed of the film was 32 frames per second.

Before going to the pictures of Borzov's run, we will determine the limits and duration of the running phases. The vertical position can be taken as that found in frame 1 and the middle interval between frames 8 and 9. The moment the foot leaves the ground can be seen in figures 3 and 11. The moment the foot touches the ground—the moment the reactive phase begins—is found in the middle of the intervals between frames 7-8 and frames 15-16. The rounded out mean duration of the reactive phase is equal to 0.03 sec., the active phase is equal to 0.07 sec., and the flight phase is equal to 0.14 sec. Corresponding data on the rhythm of our champion's run are as follows: activeness of the run (A) is equal to 1.4 and the support indicator ($o\pi$) is equal to 2.3.

It should be noted that analysis of cinematograms of many of the strongest runners in the world showed that only a few of them were able to achieve or surpass the activeness of the run as found in Borzov. With regard to the support indicator, only Enrico Figerola is ahead of this time.

Calculation of other parameters of Borzov's running technique shows that for the first time since Vladimir Sukhareva there is a runner in the USSR who is outstandingly prepared in the strength plan. These techniques include mean vertically composed reaction support during the time of the reactive phase (Rp) to a portion of the runner's weight and during the time of the active phase (Rα), and the relation of the amount of lowering of the center of gravity during the reactive phase to the total amount of vertical displacement of the center of gravity—"relative squat"—which characterize the level of his specialized strength preparation ($o\pi$).

As we see in Table 1, according to activeness of the run, Borzov yields to Figerola and prize winners of the Olympic Games in Mexico. With regard to (Rp) and ($o\pi$) he yields to Figerola and Smith. The amount of (Rα) in Valery is the same as in Carr, Figerola, and Ozolin, but less than in Smith, Carlos, Norman, and Sukharev. Thus, Borzov is behind most in the "difficult" (Rα) parameter which is determined by well-timed inclusion of the work of the muscles of the foot and the speed of summation of forces in the push-off after passing the vertical. Externally this appears in the early lifting of the heel and the rapid rise on the toes. At this time Borzov still has unused reserves, although he possesses an obvious advantage over the rest of our sprinters. To

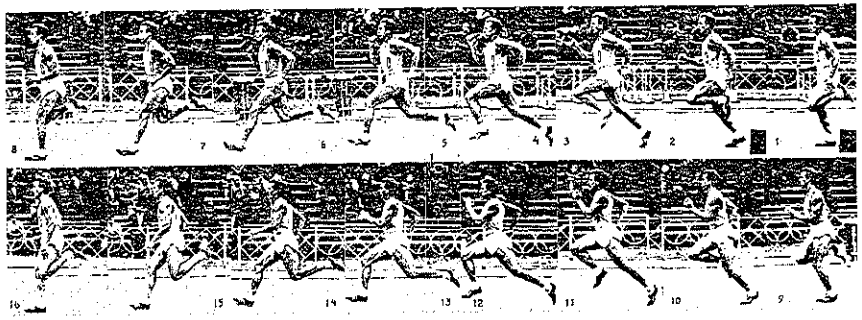


Table 1

Athlete	Distance	A	Rp	Rα	$o\pi$
V. Sukharev (USSR)	100m	1.4	3.1	2.0	0.32
E. Ozolin (USSR)	100m	1.23	2.82	1.89	0.354
E. Figerola (Cuba)	100m	1.48	4.0	1.92	0.250
V. Burzov (USSR)	200m	1.4	3.5	1.9	0.29
G. Carr (USA)	200m	1.34	3.2	1.9	0.314
T. Smith (USA)	200m	1.75	3.96	2.2	0.252
P. Norman (Australia)	200m	1.53	3.3	2.1	0.302
J. Carlos (USA)	200m	1.58	3.42	2.12	0.293
A. Ignatyev (USSR)	400m	1.17	2.9	1.8	0.341

be convinced of this, it is sufficient to compare frame 9 of this cinematogram with frames 7-8 of the cinematogram of the run of Sape, Sinyaev, and Khlopotnov (*Track and Field,* No. 8, 1968).

And, finally, before we go on to a first-hand analysis of Borzov's movements, we will bring out several factors which characterize the kinematics of his movements. The spread of the vertical displacement of the center of gravity is equal to 4.2 cm and the amount that the center of gravity rises during the phase of pushing off is 2.2cm. Vertical speed of the center of gravity at the moment the foot leaves the ground is 0.62 m/sec. and at the moment of touching the ground it is 0.76 m/sec.

Valery's trunk is carried with a slight forward inclination during the run. In completing the push-off (frames 4 and 11-12), the runner noticeably hyper-extends in the lumbar spine, tilting the pelvic girdle forward. According to our view, this is indicative of insufficient mobility in the hip joint and leads to extra loading of the trunk muscles. These movements insure Borzov, even with insufficient mobility in the joints, the possibility of creating a wide amplitude of running movements.

The fingers of the hand are held in a flexed position and the forearms are brought forward moderately (frames 3-4 and 11-12). The leading of the elbow to the rear, according to our ideas, is insufficient and leads to loading of the muscles of the shoulder girdle (frames 4 and 12). It is possible that this causes insufficient mobility in the shoulder joints.

In lowering the foot to the ground, Valery executes movements so that the foot meets the ground (frames 6-8 and 14-16). With this he prepares the leg for amortization work by creating preliminary loading of the muscles of the foot and shin. This is a very important detail of Borzov's running technique.

The landing is carried out on the foot with the shin vertical (frames 7-8 and 15-16). The heel of the foot appears to be low over the ground in the landing, but the foot is placed on the base of the toes with some accent on the external arch. In the process of amortization, the runner lowers himself on the entire foot (frames 1, 8, 16). In carrying the shin of the swing leg forward, Borzov accomplishes its "run on" very well (frames 1-2 and 9-10). In doing this, the toes (and this is very important) are dorsi-flexed (frame 2).

At the end of the push-off and at the beginning of flight, incomplete extension of the leg is seen (frames 3-4 and 11-12). This means that toward the time of falling reaction speed the runner does not execute "single" work as do many of his peers. From the other side, this shows timely summation of forces by the athlete in the push-off.

In concluding the analysis of Borzov's technique, we should recall that the pictures were taken at the end of the run when all insufficiencies in technique, as a consequence of increasing fatigue, become especially noticeable. The fact that the rhythm of the run maintained its high "quality" shows the stability of his technique and the high level of his specialized preparation. It can be said that he executes all the basic elements correctly and that his technique can be used as an example.

MICROCYCLES FOR YOUNG SPRINTERS

G. Maksimenko & S. Demerkov

Speed is the most important physical quality for a sprinter. Because of this, including speed in the preparatory and competitive periods predetermines, to a great extent, the structure and content of the corresponding weekly cycles. Up to the present, many coaches who work in the sports schools have not considered how often speed is included in their workouts. They have either not planned for speed work in the preparatory period, or only use it sporadically, leaving the main speed work for the precompetitive and competitive periods. This is an error because the development of speed should be done year round. In the preparatory period, the weekly training cycles should be constructed as follows:

1st day—development of speed and speed-strength (power).
2nd day—development of strength and speed endurance.
3rd day—rest.
4th day—development of speed and speed-strength.
5th day—development of strength and speed endurance.
6th day—increasing general physical preparation.
7th day—rest.

In our experiences (we prepared 3 Masters of Sport and 7 Master of Sport Candidates) such training made it possible to better the group's results in the 30m run from a low start by 0.2 sec (4.2 to 4.0), in the 20m run with a flying start by 0.2 sec (2.2 to 2.0), in the standing triple jump by 30cm (8.00 to 8.30), and in the 100m sprint from a low start by 0.5 sec (12.2 to 11.7).

In earlier methodological texts for young track and fielders, the following micro-cycle was recommended:

1st day—improvement of technique and speed.
2nd day—rest.
3rd day—development of strength and speed-strength (power) qualities.
4th day—rest.
5th day—development of specialized endurance.
6th day—low intensity speed-strength work.
7th day—rest.

For beginning athletes such planned weekly cycles are still appropriate. However, when using them it is necessary to keep in mind that a microcycle which includes only 3 main and one supplementary workout is insufficient for ranked runners. Today, youth 15-16 years of age train 4-6 or more times per week, which eliminates a day of rest after each main training session. The key question in planning a weekly cycle of 5-6 training days (practically every day), is how to plan for development of physical qualities during restoration.

During incomplete restoration, speed and general endurance can be improved for short distance runners. What has to be made more precise, however, is which quality—speed or speed-strength—should be planned for during the period of higher workability.

A six-month study showed that the development of speed capabilities in young short distance runners takes place most effectively when training sessions devoted to this quality are carried out during the period of higher workability. This means that in constructing the weekly cycle of training work for speed it should be included 24 hours after sessions with light loads or restorative measures. If sessions for training speed precede moderate training loads, which lead to restoration of workability after 24 hours, speed will improve but the rate of speed increases will be lower than when training for speed after restoration (during high workability).

Thus, for ranked sprinters of junior age, the following schematic for constructing the weekly cycle can be recommended—

For Class I athletes:

Monday—development of speed and speed-strength (power) qualities.

Tuesday—improvement of strength and speed endurance.

Wednesday—increasing general physical preparation, improving running technique and general endurance.

Thursday—development of strength, improvement of running technique and general endurance. The load in this session should be light.

Friday—improvement of speed and speed-strength qualities.

Saturday—development of strength and speed endurance.

Sunday—rest.

In cases of preparing juniors who mainly run the 200m, it is necessary to increase the volume of work for speed endurance.

For Class II athletes:

Monday—development of speed and speed-strength.

Tuesday—improvement of strength and speed endurance.

Wednesday—rest.

Thursday—development of speed and speed-strength.

Friday—increasing general physical preparation, improving running technique and general endurance.

Saturday, Sunday—rest.

If the competitive distance is 200m, there should be a supplementary session on Saturday for the development of strength and speed endurance. Class II athletes who can work out twice a day can use the following weekly cycle:

Monday—development of speed and speed-strength.

Tuesday—improvement of strength and speed endurance.

Wednesday—raising general physical preparation, improving running technique and general endurance.

Thursday—rest.

Friday—development of speed and speed-strength.

Saturday—improvement of strength and speed-endurance.

Sunday—rest.

The aim in the morning training session should be the same as in the evening training session.

Special significance is given to correct microcycle construction several days before competition. In various texts the following scheme of competitive preparation is recommended: a week of high intensity training, a week of training with 50-60% volume but with high intensity, then 1-2 days of rest and a warm-up the day before competition. Such a plan is intended for senior runners but it can be used successfully by junior sprinters with one modification. It is best to rest only one day before the warm-up, one day prior to competition.

"TECHNIQUE ANALYSIS: ALBERTO JUANTORENA"

Legkaya Athletika

The cinematogram shows a "double" stride of Juantorena during the 400m semi-final (45:10) at the Montreal Olympics 40m before the finish.

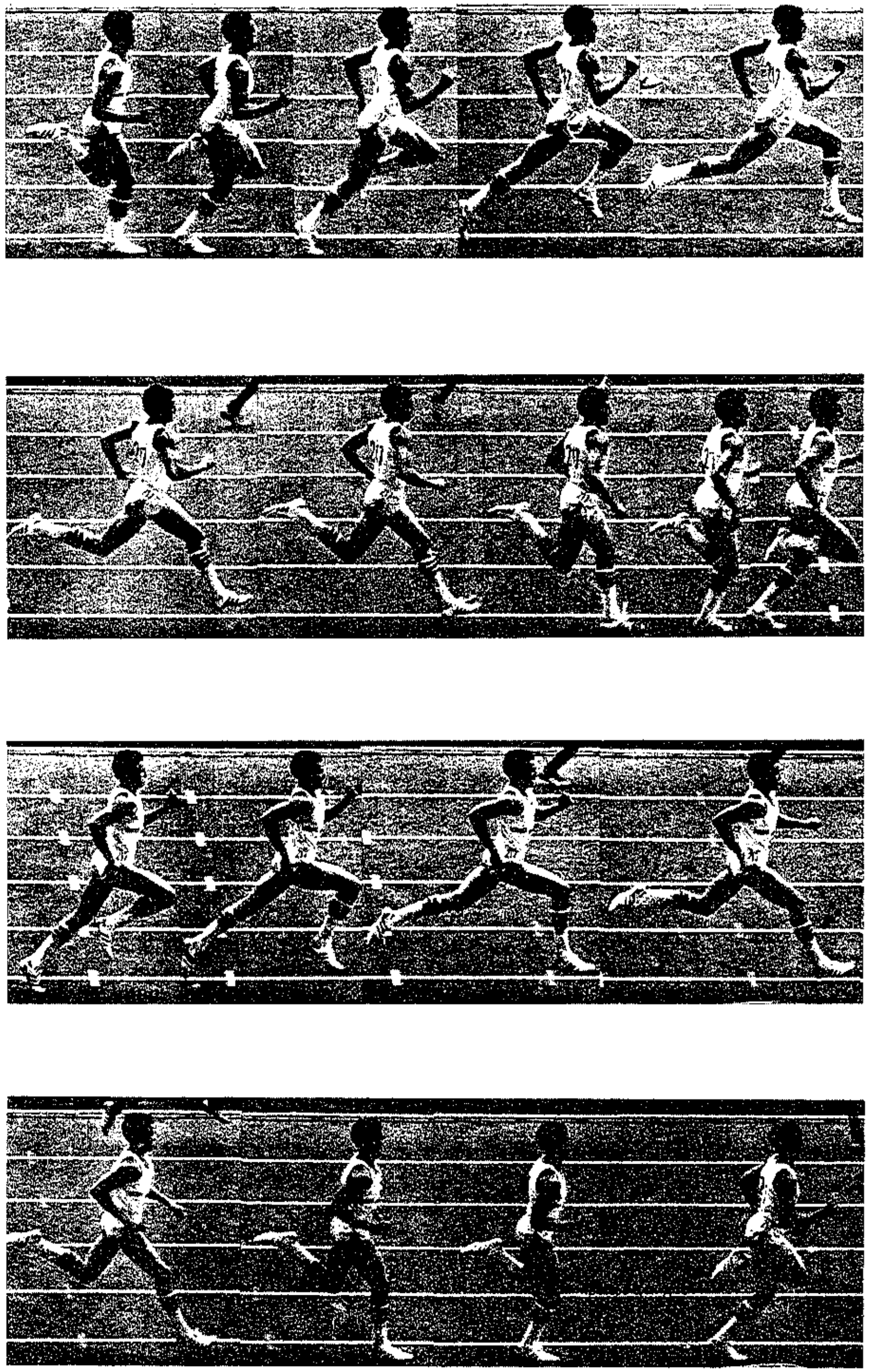
The objective—to qualify for the finals with minimal outlay of strength—determines the character of Juantorena's running: relaxed, but also powerful, with good forward movement.

When analyzing running technique, two main phases are usually isolated: the runner's interaction with the support (ground) and the interaction of leg movements (and other body segments) in the flight phase. It is from this position that we will examine Juantorena's technique.

Juantorena accomplishes his leg plant with a "pawing" movement (frames 6-8 and 14-16), planting the leg on the entire foot (frames 8 & 16). This plant makes it possible to shorten the braking phase, i.e., to rapidly diminish the negative horizontal component of the support reaction. Vigorous movement of the swing leg (frames 1-2, 8-9, 16-19) also facilitates this. (Editor's Note: The pawing movement is one in which the lower leg starts coming back after the forward knee joint extension. This allows the foot to contact the ground under the body with no resistance. If the foot hit the ground in front of the body with a straight leg, it would act against forward movement—the horizontal component of the support reaction.)

The greatest "loading" on the support leg occurs at the moment of the vertical, ". . . i.e., when the center of gravity passes through its lowest point" (Bernstein). However, great muscular strength allows Juantorena to effectively counteract the vertical pressure at this point—flexion angles in the knee and hip joints are within appropriate limits (frames 1, 9, 17). Vertical fluctuations of the center of gravity are thereby "smoothed out." Active foot placement allows Juantorena to utilize the elastic qualities of the shin and foot muscles of the support leg at this moment—contracting reflexly, the muscles work at executing the push-off. This is clearly evident in frames 9 & 17, in which the heel of the support leg has already lifted off the track and the knee is drawn forward (in relation to the heel).

The continuing active movement of the swing leg facilitates the push-off process (frames 2, 10, 18). Together with vigorous extension of the support leg, this creates positive acceleration of the body's center of gravity (frames 3, 11, 18). Juantorena completes the push-off with full extension of the support (push-off) leg in all joints (3-4, 11-12), but does it as if "in pursuit"—a certain delay of the push-off by the foot creates an "intensification of the effect of the complete push-off" (Donskoi). The most pronounced horizontal component of the support reaction and the greatest



acceleration of the body's center of gravity are usually observed at this moment.

Arm and shoulder girdle movements are accurately coordinated with leg movements and counterbalance the powerful push-off. There is a wide amplitude (range) of arm work (arms are bent at the elbows in all phases) and a little shoulder girdle rotation around the vertical axis in each stride (frames 4-5, 13-14), which aggregately impart smoothness, coordination and balance to all movements.

The wide range of leg action (frames 5-6, 13-14) in the flight phase distinguishes Juantorena from other 400m runners.

In principle, movements during the flight phase influence the speed dynamics of the center of gravity. But they do create the favorable conditions for execution of effective movements in the active phases—the push-off phases. In this sense, Juantorena's movements in the non-support phases, as is evident from the cinematogram, are sufficiently effective, and vigorous "reduction" of the thigh (knee joint flexion) as seen in the movements from frames 6 to 8 and from 14 to 16, provides the necessary tempo and corresponding running speed.

"THE SPECIFIC CHARACTER OF THE INFLUENCE OF TRAINING METHODS ON THE DEVELOPMENT OF ENDURANCE"

A. A. Viru, Y. U. Urgenstein, & A. P. Pisuke

It has been known for a long time that various training methods and different regimes of their use result in qualitative and quantitative changes in the athlete. However, for practical athletic training, it is not enough to know this only in principle, and it is necessary to have well-organized study of the rational utilization of training methods, as well as concrete information on the specific effect of each training method. For clarification of the specific influence of training methods in the past, many investigators conducted individual investigations concerning the development of endurance. However, the goal of our research—carried out in the Problem Laboratory of Muscular Activity at the Tartu University—was the study of the essentials of the physiological effect of various training methods.

Although there are many methods for developing endurance, in the history of training runners there have been periods when only one method was selected. When one of the outstanding runners broke away from traditional training, others immediately followed suit, and it was not uncommon for such blind imitation to heap irreparable damage on the athletes. We decided, therefore, to try to identify the influence of basic training methods. In this plan we were supplied with pedagogical experiments, together with a complex of physiological investigations.

Method: Ninety-four untrained students were divided into nine groups. In the course of six weeks, each group trained three times a week, using only one of the following training methods:

1. Long uniform run, (25-40 minutes).
2. Fartlek (running in place with changing speed for 20-30 minutes).
3. Repeat running of 200 to 600 meters at full speed. (The rest pause was sufficient to avoid a build-up of oxygen debt.)
4. Interval sprinting (alternating 40-50 meter sprints with jogging).
5. Interval run in series (after 3-4 brief interval rests, a lengthy series pause).
6. Extensive interval running (intervals of rest comparatively short, and running speed 60-80% of maximum).
7. Intensive interval running (repeat 100-200 meter runs with a speed of 80-90% of maximum and a rest interval of 1.5-3 minutes).
8. Running up a hill with a slope of 15 degrees.
9. Combined use of a long uniform run, fartlek and interval running.

Up to and after the six-week stage of training, the subjects underwent a complex of physiological investigations which included determination of heart volume, maintenance of erythrocytes and hemoglobin, alkaline blood reserve, and a study of the changes in frequency of heart contractions, blood pressure, EKG (with a hydrogen drain in the chest, according to Butchenko) and alkaline blood reserve after a three-minute workout on the veloergometer at a maximum pace. Up to and after this stage of training, the results of running the 100, 400, and 800 meters were also determined. Upon finishing the run, pulse count was taken.

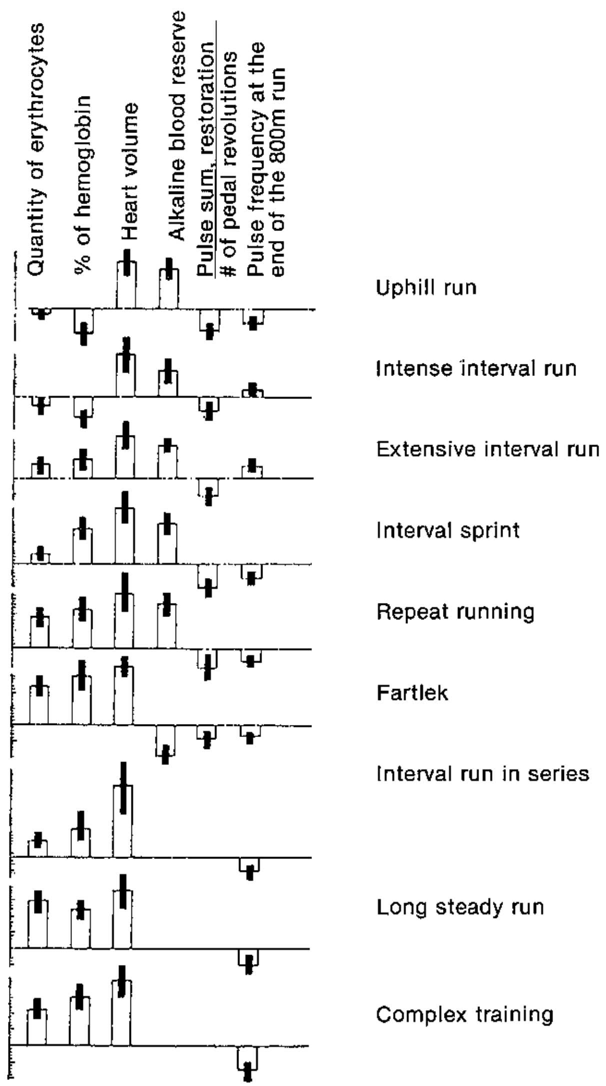
Results: All groups in the 100, 400, and 800 meters runs showed improvement. The most effective, in relation to improvement in running the 400 and 800 m were the two very demanding forms of training: the hill run, and the intensive interval run (see Table 1). Nearly as effective was the repeat run, but it did not cause as significant a decrease in speed time as the first two. The improved results were based on the corresponding changes in the organism, which are indicative of the results of the complex physiological investigation (see drawing).

Training exercises of an anaerobic nature, such as, hill running and interval running, caused a significant increase in heart volume and a substantial rise in blood alkaline reserves (larger than the other exercises). Expansion of the heart accompanied the improvement of its functional capabilities seen by a decrease of the ratio of pulse-sum recovery, registered after three minutes of maximum work on the velo-ergometer to the number of pedal revolutions. Results of training by the interval methods, showed a decrease in displacement of the S-T interval of the EKG downwards during the three-minute maximum workout on the velo-ergometer. However, these training methods turned out to be in-

Table 1

Changes in Running Results after the 6-Week Training Period

Method of Training	100m	400m	800m	Speed Reserve: Ozolin
Long steady run	−0.3 ± 0.1	−5.9 ± 0.7	−13.6 ± 1.0	−0.6 ± 0.7
Fartlek	−0.4 ± 0.1	−5.0 ± 0.9	−18.6 ± 2.9	−1.9 ± 0.6
Repeated running	−0.5 ± 0.1	−8.3 ± 0.5	−20.0 ± 3.2	−1.8 ± 0.4
Interval sprint	−0.7 ± 0.2	−7.8 ± 1.0	−18.2 ± 2.6	−1.6 ± 0.3
Interval run in series	−0.5 ± 0.1	−6.8 ± 0.9	−18.3 ± 2.3	−1.8 ± 0.4
Extensive interval run	−0.3 ± 0.1	−5.0 ± 1.1	−16.0 ± 1.0	−1.5 ± 0.1
Intensive interval run	−0.7 ± 0.1	−8.3 ± 1.1	−23.9 ± 1.8	−2.3 ± 0.3
Uphill running	−0.7 ± 0.1	−8.1 ± 0.4	−27.6 ± 2.0	−2.7 ± 0.4
Running complex; long steady run, fartlek, and interval running	−0.6 ± 0.1	−7.5 ± 0.9	−19.6 ± 1.8	−1.9 ± 0.2



effective with respect to the rise in oxygen capacity of the blood (judging by the red corpuscle and hemoglobin content). There were even observed tendencies toward a decrease of red corpuscles and hemoglobin in the blood.

In spite of this, training methods of a more aerobic nature, such as, steady running and fartlek, were more effective with respect to an increase in oxygen capacity of the blood, but less effective in raising alkaline increase. Long uniform running was the other exercise which contributed most to a decrease in pulse rate at the finish of the 800-meter run, which compels us to consider the economizing action of this training method.

Repetition running, which was anaerobic by the nature of the repeated loads, but with lengthy intervals of rest, did not bring about an accumulation of oxygen debt. It was effective, although to a lesser degree, with respect to the increase in both oxygen capacity and alkaline reserve in the blood. The same, but to a lesser degree, may be said about interval running in series and interval sprinting.

Alkaline reserve decreased following the three-minute workout on the velo-ergometer at maximum effort and increased after the training stage in those groups where extensive and intensive interval training, interval sprinting, and hill running were used.

Evidently, in this case, anaerobic output increased as a result of an increase in the rate of work (the number of pedal revolutions during the three minutes was increased). The decrease in alkaline reserve did not change substantially in the groups employing the repetition run or fartlek, even though they also increased their workout effort on the veloergometer. Here, apparently, an increase in efficiency was based mainly on an increase in aerobic output.

Consequently, the utilization of only one of the training methods results in an intensified development of only one function, sometimes even to the detriment of other functions. Of course, such uncoordinated development cannot guarantee stable sports success. Fully valued perfection of the necessary activities of the organisms upon which endurance is based, can be achieved only with a skillful combination of the influence of various methods of training. Testifying to this fact is the data on twelve women specialized in running (Masters of Sport and Class I and II sportswomen) who used a complex of training methods. Significant increases in the oxygen capacity of the blood and cardiac output were observed.

For evaluation of the effectiveness of training exclusively, it is important to know what the missing links are in the chain comprising the bases of sports results. With knowledge of the corresponding changes in relation to the training method, a lag in the development of any function is eliminated. Also, with this evaluation it is necessary to make conclusions not only on the basis of the sports results, but, also, according to the data from a complex of physiological investigations.

Conclusion: Each training method has its own particular specific influence on the organism. Each, on the one hand, has a strong positive influence on one function, while, possibly, having a negative effect on other functions. In order to produce a truly scientific study of the rational application of training methods, it is necessary to know in detail the influence of each method.

IMPROVING THE TRAINING OF MIDDLE- AND LONG-DISTANCE RUNNERS

V. Gorshkov, A. Yakimov, & M. Monastyrsky

During the last ten years, world records in running (800, 1500, 5000, 10,000m) have been bettered by 0.9, 0.9, 8.2, and 17 sec, respectively.

At the same time, attention has been drawn to accomplishments in swimming, where rapid improvements are taking place. The attack on swimming records has been led by a multi-national flock of athletes, including some who are quite young, and not a small group of well-known competitors (as in running). World records in the men's freestyle have progressed at rates that are 7, 15, 8, and 11 times higher than in running. What explains this progress?

Many experts trace the successes of swimmers to their voluminous training schedules. However, American coach Counsilman states that the recent vast progress in swimming is related to improvements in training methods.

Running experts have often advocated increasing the volume of the training loads significantly. In their opinion, runners are still not achieving the volume that is required today. We do not share this point of view as we feel that today's runners have achieved high training volumes and are not inferior, in this respect, to competitors in other endurance sports. In our view, the main role in the progress of middle- and long-distance runners should be played by more modern (in comparison with the existing) training methods.

Even though there are essential differences between running and swimming, "development of training methods in running and swimming occurs in parallel fashion, which is the result of their similarity and makes it possible to use many common training principles in both sports," maintains Counsilman. He writes: "The history of the development of training methods in track & field is similar to that seen in swimming. The main difference in the development of these two sports consists in the fact that development of new training methods in running always preceded development of the same methods applicable to swimming, at least in the last ten years. To a great degree, swimmers learned from track & field athletes and followed principles developed by them. Many swimming coaches disagree with the assertion that training methods in swimming were borrowed from track & field. It is possible that these methods would have developed naturally and without the help of track & field athletes, however, a fact remains a fact: most training methods appeared in the training of swimmers after their use in running. Hence, track & field athletes used them longer and had greater opportunities to substantiate them experimentally."

Presently, runners use the multi-methods system of training in their preparation; on the other hand, swimmers prefer the integrated training system. A full understanding of the training systems of runners and swimmers can hardly be attained without knowing how these systems developed. A brief survey of the history of the development of training methods in running and a discussion of similar trends in swim training will help in understanding what innovations swimming specialists have introduced into running training.

Development of Training Methods in Running

Up until the 60's, the making of world records was related to some new training method. The outstanding performances of Nurmi in the 20's-30's were achieved thanks to the use of long steady running.

The hero of the 40's was Hegg, world record holder in the 1500m, mile, two mile, and 5000m. His countryman, Holmer, developed a new training method called "fartlek," which was the main training method of Hegg.

In the 50's, world records in running were related to interval training. The first runner to use interval training and achieve world fame was Harbig, who astounded the sports world in 1939 by displaying the then unbelieveable times of 46.0 in the 400m and 1:46.6 in the 800m. Harbig's coach Gerschler later on developed a method that is called the "controlled interval" method. In spite of the fact that this method appeared in Germany before World War II and in spite of the successes of Harbig, it didn't become well known until 1952, when Bartel won the Olympic gold medal in the 1500m. After this, the interval method became popular.

The Multi-Method System of Running Training

At the start of the 60's most running specialists perceived that the time for using only the interval method was past. Said Reindell: "In order to accomplish different objectives, multi-method training is necessary. If one type of training is isolated, we will be unable to elevate the essential biological functions to the proper level." Nekker, in turn, stated: "In order to develop general endurance (including expansion of capillary network) you must do 'endurance work.' This can be done by running long distances, 'fartlek,' and interval training. Many coaches and former world-class runners expressed the opinion that an "optimal complex" of different methods is the trend in modern training."

One of the first to develop a multi-method training system and describe its content at the start of the 60's was Lydiard. Most experts related the success of his runners to the so-called "marathon training," but this was only partially true. Said Lydiard: "In the early years I didn't pay much attention to competition. The greater part of the time was spent trying to find the ideal proportions of fast sprinting, interval running, running at moderate tempo, long endurance running, and tempo (speed) work."

In other words, in addition to "marathon training," Lydiard gave a lot of attention to combining different methods during different periods, months, and weeks. The Lydiard system (or the multi-method system) has been well publicized in running literature. We'll list only a week that Lydiard recommends for 1, 3, and 6 mile runners during the period of road training (second month-second week), so that the reader can see the basic difference between multi-method running training and "integrated" swim training, which will be explained later in the article.

Monday. 2 × 880y at ¼ effort, 1 mi at ½ effort. *Tuesday.* 2 mi at ½ effort. *Wednesday.* 6 × 880y at ½ effort. *Thursday.* 6 mi at ¾ effort. *Friday.* 6 × 220y at ½ effort. *Saturday.* 20 × 220y at ½ effort. *Sunday.* Long-distance jogging.

In the above schedule, Lydiard recommends using one method per workout—one method that affects a certain physical quality (general or special endurance, speed, etc.).

Hence, it can be concluded that the multi-method training system for middle- and long-distance runners uses a combination of *different* training methods in individual periods, months, and weeks, and also use of *one* method only within the confines of an individual training session.

Development of Training Methods in Swimming

In the past, swim training was based on moderate and low intensity work over relatively long distances, even if the swimmer was preparing for the 100m. This method, known as "long training loads," remained popular until the end of the 20's.

During the 30's and 40's the "pyramid" or "locomotive" method gained popularity. It much resembled "fartlek."

In the mid 50's, swimming experts acquainted themselves with run training and the research that was done on interval training. At first, interval work in swimming was elemental, episodic. In many cases it was difficult to overcome the inertia of old methods; many coaches resisted the new tendencies. In training for the 1956 Olympics, the Australians used interval training with success. As a result, they shocked the swimming world with their performances and gave a strong impetus to the development of interval training throughout the world.

The Integrated System of Swim Training

In the early 60's, swimming experts, as their counterparts in track, realized that the time for using only the interval method was past. As earlier, swimmers turned to the runners, who had begun to use multi-method training with great success. This was the last borrowing by swimmers of training methods from runners. By the late 60's swimmers had already set out to develop a new training system, which was called "integrated."

One of the first to use integrated training was Counsilman, who wrote: "By combining different training methods in one session, a swimmer can develop speed in one phase and endurance in another. The basis for the Indiana system of training is integration of the various training methods into a single workout. Just as a mixed diet of proteins, fats, carbohydrates, minerals, and vitamins is essential for good health, so a mixed or integrated program of the various types of training methods is essential for the top conditioning of swimmers." Then Counsilman emphasizes: "No one particular method of training can develop all of the qualities desirable in a swimmer, that is, speed, muscular endurance, cardio-vascular endurance, and so on. The exact proportion of each of these qualities depends primarily upon two factors: the time of season and the distance for which he is training. For this reason the relative amount of each type of training that should be included in an integrated program will also depend upon these two factors."

Counsilman includes a table of integrated training that represents the training of a freestyler. His best performances were: 100y—48.2; 200y—1:45.8; 500y—4:54.4.

In one workout, with a relatively large volume, the swimmer improves all essential physical qualities: general and special endurance, speed, and so on. This schedule provides great variety, and is economical. Also, knowledge of what physical qualities and body systems are effected by a specific method allows the coach and athlete to intelligently vary the training means and be confident that the effect from the exercises used today will be multiplied by the effect from all of the preceding and succeeding workouts.

Summarizing the opinion of swimming experts, it can be noted that integrated training has several advantages: 1) it creates variety in training and intensifies the emotional factor; 2) facilitates fuller development of the athlete's potential capabilities; 3) provides for the maximum degree of conditioning; 4) ensures development of all essential qualities.

Of interest is another aspect of integrated training—many competitions per year. Swimmers competed an average of 30-40 times a year when using the multi-method of training. They compete up to 150 or more times a year when using integrated training. Additionally, most of the world's best swimmers compete over a wide range of distances and show class results. Integrated

training makes "universalists" possible. Among runners, there are still no universalists who can run the 800, 1500, 5000, and 10,000m at world-record levels, as swimmers do.

Concerning the fact that swimming coaches (as opposed to running coaches) have more modern views on the training of their swimmers, beginning with the children's age groups, Coach Timmons said: "I have the feeling that we running coaches are often quite timid in evaluating the prospects of our athletes, that we are more inclined to talk about what can't be done than what can be done, now or in the future. I think running coaches can learn from swimming coaches. . ."

Ryun refuted the opinion of many running specialists concerning the limited possibilities of teenagers by achieving international fame at age 17-18. At 19 he set outstanding world records in the 880y, mile, and 1500m.

As is evident from the above facts, the training methods of runners and swimmers have much in common. Integrated training facilitated progress in swimmers and also increased the closeness of world-class results, so we thought it possible to make it the basis for preparation of runners. We set out to develop an integrated training system for runners in 1974.

We began with training methods that were used in the training system and started to seek the optimal combination. We tested individual variants of integrated training during different periods, and then fully in the annual cycle.

Today we have achieved some successes. For example, Mazin became national champion in the indoor 3,000m. His best results: 1500m—3:41; 3,000m—7:56; 5000m—13:41; 10,000m—28:59. In 1978 noted distance runners Zatonski and Milhailov joined us. By using integrated training they also bettered their personal results. Other runners have also made significant progress.

As an example of integrated training we present a typical week's training during the competitive period (June):

Monday. AM: easy running 6km (27-28 min), calisthenics, accelerations 10 × 100m (13.5-14 sec). PM: (track): warmup 3-4km, calisthenics 10 min, accelerations 5 × 80m. Running work: 1. 5 × 400m (58-60 sec) alternated with 400m jogging. 2. 3000m in 9:00-9:10. 3. 1000m in 2:33-2:35. 4. 1000m in 3:05-3:10. 5. 400m in 55-56 sec. Easy running.

Tuesday. AM: same as Monday. PM: steady cross-country 20-25km (1:20-1:45).

Wednesday. AM: easy running 6km (26-27 min), calisthenics. PM: (track): warmup 3-4km, calisthenics 10 min, accelerations 5 × 80m. Running work: 1. 400m in 54-55 sec. 2. 5000m in 15:10-15:40. 3. 400m in 56 sec. 4. 1000m in 3:10. 5. 5 × 200m in 30 sec, alternated with 200m jogging. Easy running.

Thursday. AM: easy running 10km (42-44 min). PM: rest.

Friday. AM: same as Monday. PM: warmup 3-4km, calisthenics, accelerations 3 × 100m. Running work (forest-track): 1. 10 × 200m in 32 sec, alternated with 200m jogging. 2. 5000m in 15:30-16:00. 3. 800m in 2:00. Easy running.

Saturday. AM: steady cross-country 20km (1:20). PM: 2000m competition (best result 5:10.5).

Sunday. AM: steady cross-country 15km (1:05). PM: 800m competition.

The training method used was met with skepticism on the part of the athletes. They observed that sometimes their training programs contradicted theoretical knowledge that they acquired as students. Only after they showed good performances over a wide range in distances, from 1000 to 10,000m, were they inspired with confidence.

The training method we developed forces a new look at the preparation of runners, beginning with the teen years, at questions of nurturing physical qualities (speed, general and special endurance, and so on), competitive preparation, and planning.

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An Expert's Commentary

The essence of this system consists of parallel development of essential qualities in one workout. In the authors' opinion, integrated training fosters more "universal" runners and should eventually replace the multi-method system. This system is not new. Similar combinations of distances, with their different effect on the body, have been used in the past. Coaches should note the typical pre-competitive and competitive training cycles presented in the article. These combinations reduce the monotony of training and facilitate higher quality preparation of runners for competition. The authors are correct in increasing the competitive loads of runners. However, the possibilities of runners, in distinction from swimmers, are limited by the characteristics of their musculo-skeletal systems. Incidentally, the unusually large number of competitive starts (meets) in swimming is partially explained by the fact that they include controlled workouts in their calculations.

"MAXIMUM LOADS (IN MIDDLE AND LONG DISTANCE RUNNING)"

P. Shorets

Today's top-class middle- and long-distance runners use increased training loads at separate stages of training. These so-called "shock" (in dosage) or "sharp" (in intensity—speed work) training sessions produce pronounced functional changes in the body. The purpose of this article is to show what maximum loads are used by top-class runners.

In the preparatory period, distance runners usually use high-volume road running or dirt running, and sometimes high-dosage variable running, for maximum training loads.

An example of the volume-type training sessions of a marathoner is running 85 km (25 + 35 + 25 km) in one day. The best Soviet marathoners run 40 km on the road in 2:17-2:20, 35 km—1:55-2:00, and 30 km—1:37-1:40. Moiseev has covered 45 km in 2:28.15.

For middle- and long-distance runners, the optimal tempo distances (on the road) are 15 and 20 km, done in the winter and early spring. In the spring, women use 5 and 10 km distances, which are done significantly faster than 20 and 40 minutes.

Such volume-type workouts are good indicators of the level of general endurance. A high level of "tempo" endurance—which significantly improves aerobic-anaerobic performance capacity—makes it possible to do quality repetition training and perform more consistently in multiple—including multi-stage—competitions.

An important training mode in the prepartory period is tempo road running (high intensity); it fills the "vacuum" that exists between long slow cross country running and high-intensity repetitions. Sportsmen stand up to road running significantly better than running on a limited dirt area or on a stadium track. Road running is preferable to running on dirt because of the more powerful push-off from the hard surface, which makes it possible to maintain high running speed, allowing the athlete to show good results in tempo road running without a large expenditure of nervous energy, thus intensifying the training process.

The best period for testing the level of general endurance is the middle of April, when 15 km (for women, 5 km) runs are held. Later, specialized training for improving special endurance and speed is begun—with gradual adaptation to competitive loads on the primary and secondary distances.

In the competitive period it is important to prudently use maximal anaerobic loads in the forms of repetitions at competition speed or faster. A particular variation of such workouts is a control (test) run. In the past, several have used a control run as the most effective means of "sharp" (speed) training and the best form of "tuning up" for forthcoming competitions.

Most Intense Training Sessions
of Middle, Long, and Ultralong Distance Runners

Distance	Athlete	Dose	Intensity
Middle	P. Snell	10 × 440m	Average 59.5
	E. Arzhanov	1000 + 600 + 400 + 200m	2.22.4: 1.25.0: 53.0: 23.8
	I. Ivanov	400 + 300 + 200 + 100m	51.0: 38.0: 23.0: 11.2
		3 × 600m	Average 1.24.3
		1000 + 800 + 600 + 300m	2.35.0: 1.59.0: 1.25.0: 38.0
	M. Zhelobovski	4 × 600m	Average 1.25.0
		6 × 300m	38.5-39.0
	S. Kruchek	2 × 500m	1.03.0: 1.05.0
	N. Andreev	3 × 200m	Average 23.16
		6 × 400m	Average 54.6
	V. Poryukin	3 × 200m	Average 22.8
	M. Ulvmov	3 × 1000m	Average 2.31.0
	A. Sergeev	2000m	5.10.0
	V. Ponomarev	600 + 400m	1.19.3: 52.0
	N. Sabaite	2 × 400m	56.5: 56.3
Long	L. Viren	30 × 200m	Average 27.7
	A. Konov	4 × 1000m	Average 2.39.7
	L. Ivanov	3000 + 2 × 400 + 6 × 200m	8.02.4: 58.0: 29.0-27.6
		2000 + 1000 + 2 × 400m	5.18.0: 2.36.8: Average 60.0
	V. Kudinski	2000 + 1000 + 400 + 200m	5.15.0: 2.37.0: 58.0: 24.0
	A. Kuryan	800 + 3 × 200m	1.53.0: 26.0: 25.0: 28.0
	V. Shashmyrin	5 × 1000m	Average 2.38.2
		800 + 2000 + 5 × 400m	2.20.0: 5.14.8: Average 63.0
	M. Zhelobovski	3000 + 2000 + 1000m	8.06.0: 5.23.0: 2.32.0
	A. Velichko	5000m c/n	15.25.0
		10 × 400 + 800 + 200m	Average 65.0: 1.59.0: 25.5
	R. Bitte	2000m c/n	5.35.0
	I. Grigas	2000m c/n	5.35.2
	L. Bragina	5000m	15.56.0
Ultra-long	K. Vorobyev	40 × 200m	Average 29.7
	S. Popov	50 × 200m	Average 30.3
		40 × 400m	Average 65.0-67.0
	A. Konov	10 × 1000m	Average 2.50.0
	V. Volkov	10 × 1000m	Average 2.46.7
	Y. Popov	30 × 1000m	Average 3.12.0
	V. Velikorodnyh	60 × 200m	Average 33.0
	A. Anisimov	15 × 1000m	Average 2.55.0
	D. Bugaev	17 × 3000m	Average 9.20.0
	V. Moiseev	6 × 1000m	Average 2.49.0
	V. Tsyrenov	5 × 1200m	Average 3.25.0
	L. Moiseev	3000m	8.02.2
		45 km	2:28.15.0

One runner executed 11 "test runs," which he alternated with 20 starts in competition. This indicates the high "specific gravity" of test running in the training process. All runs were of very high intensity. A control run was usually conducted 4-6 days before competition. Competitions were systematically alternated with control (test) runs.

A survey of leading Soviet runners and their coaches showed that they use maximal loads in the form of "sharp" repetitions. Depending on the stage of pre-competition preparation, such loads are used in the form of variable, repetition, and control running at maximum intensity. The accompanying table shows that runners frequently use a "staircase" construction of repetitions, modeling the nature of running competition (Kudinski, Arzhanov, Ivanov, Zhelobovski, Ponomarev).

Regular use of "sharp" workouts facilitates improvement of special endurance and is a source of immediate information on the runner's current condition. We tried *a new test* (for 1500m runners) which consists of running *400 + 800 + 300m within 6 min.* of rest (with calculation of pulse recovery in 5 min.). Such a combination of segments to a certain degree imitates competition running—a fast start, competition speed in the middle of the distance, and a "sharp" finish. The total time of the three segments (which total 1500m) can be correlated with competitive results. Specifically, for Class I-ranked athletes *this test (total time of the segments) is better than the competitive result by about 10 sec.,* for Master of Sport candidates—*about 7-8 sec.* The number and length of segments, running speed, duration and nature of rest between segments—all depend on the experience and condition of the athlete, the period of precompetition preparation, the purpose of training session, and so on.

It is necessary to point out such varieties as running in "different" conditions—uphill, on sand, up a sandy hill, with "burdens" (i.e., with a tow rope, with a weight belt, or ankle weights), against the wind, in water, and jump-like running uphill. Such work, accenting power, is usually conducted in early spring, including at medium-high altitude conditions (March, April). Soviet and foreign runners use competitions as an effective means of training, as a way of gradually adapting to competitive running intensity.

CLASSIFICATION AND CALCULATION OF LOADS IN MIDDLE-DISTANCE RUNNING

A. Korobov & E. Shirkovets

In order to carry out sports training effectively, the coach must have complete information on the functional state of the athlete and how he does his training work. This is possible only when there is objective control of the reactions of the body systems to different training means and correct calculation of the training loads. Then it is possible to reveal the real reasons for an increase or decrease in results, to compare data on loads used in different years, and to outline prospects for improving training methods.

At first sight, everything is simple. However, analysis of the diaries of even the strongest Soviet runners showed that they, as a rule, unsystematically and incompletely record the *conditions* and how the physical exercises were performed. The number of kilometers run is recorded without the *time.* Total running time is recorded without the *speed.* Information is not always given on the content and duration of *recuperative* rest periods between intervals run. Indices of the *functional state of the athlete before, during* and *after workouts* are virtually absent.

A number of pressing questions arise in this connection. On which components of training should attention be centered? *Into which intensity zones should specialized running work be divided*? Finally, *which forms of workout plans, load calculations, and sports diaries are best for use in practice*? In order to answer these questions, research was conducted in the problem laboratory of the Lenin Institute of Physical Culture.

The first stage involved collection, processing and interpretation of information on the training loads. From this, *a way to classify loads was worked out which* made it possible to more clearly systematize the many methods *according to their training effect.*

Most effective was identification of the following main parameters, which reflect the training of highly qualified middle-distance runners (*Table 1*).

Preparatory work includes running in morning exercises and in warm-up, as well as in general developmental exercises (GDE). Its purpose is to prepare the body for the forthcoming training (morning workout) and for execution of the main loads. The volume of preparatory work per year in leading runners is *more than two thousand kilometers.*

The *compensatory zone* combines *running in the rest intervals between segments,* including restorative running. The latter is employed as independent training means after intensive work. The load in this zone is rehabilitative and is an integral part of the total preparation.

TABLE 1

Type of Load	Day of Month	Unit of Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Monthly Total Km.
Preparatory work	Morning run	km																	6														6
	Run in warm-up	km	2								1	1				4		2		4			3		2		3						22
	General developmental exercises	min		10	20																												
Compensatory zone	Running in periods																																30 min
	Between segments	km																															
	Run in warm-up	km	1									1						3		1			1		2		1						10
	Restorative running	km				6											6	6						6	6	6							36
Aerobic zone	Long-distance running at rate below TAM	km													10						20						20						50
	Run at TAM level	km		8	8		8	10		8		2				10			14				12	12			18	22	14		12	10	168
Mixed zone	Aerobic-anaerobic regime	km										1					11					12			8	16							48
	Anaerobic-aerobic regime	km									4	2						6															12
Anaerobic zone	Glycolytic regime	km																															
	Alactate regime	km														0.3		0.3		1			1.2				0.7						3.5
Total running volume		km	3	18	28	6	8	10		8	5	7			10	14.3	17	17.3	20	6	20	12	17.2	18	18	22	40.7	22	14		12	10	385.5
Jump exercises / General Physical preparation		No. / hours	60			40						30			90 / 60	160		90		90		30	250				250						966 / 3 hrs 10 min
Number of training sessions																																	
Competitive activity	Total number of competitive distance starts																																
	Including: No. of starts at other distances																																
	Including: No. of cross-country starts																																

The work regimes have been identified in the *aerobic zone.* The first is the long-distance run with effort below the *threshold of anaerobic metabolism* (TAM) and the second is the TAM level run. Long runs usually complete the weekly training cycle. They promote improved capillarization of the muscles, improved exchange processes and removal of waste products from the muscle tissues. Running at the TAM level is an effective means of perfecting aerobic capabilities, improving efficiency and economy.

The *mixed zone* is divided into aerobic-anaerobic and anaerobic-aerobic regimens, depending on the primary participation of various sources of energy supply during execution of the training work.

Usually this zone corresponds to exercises lying in the intensity range from TAM to the critical rate. They are characterized by blood lactate concentrations from 36 to 110 mg%. As it turns out, a load causing a lactic acid accumulation of 40 and 100 mg%, for example, belongs in the same zone. However, special studies have shown that work performed at the lower (30-70 mg%) and upper (70-110 mg%) limits of this zone have different training effects. Thus, the first regimen is directed mainly to development of the cardiovascular system (in particular, stroke volume and aerobic effectiveness). The second promotes an increase in the critical rate at which the limit level of oxygen consumption is achieved. From a physiological standpoint, such work is universal since is simultaneously acts on the aerobic capacity (ability for prolonged upkeep of maximum oxygen consumption) and on anaerobic productivity.

The *anaerobic zone is* subdivided into glycolytic and alactate regimens. Training with a glycolytic emphasis (various forms of interval training) is necessary for improvement of the lactate mechanism of energy formation, which is prevalent during a competitive middle-distance run.

Work in the alactate regimen (running short segments with maximum speed and long rest periods between repetitions) leads to accumulation of intramuscular energy substrates and facilitates development of speed qualities. The total running volume involves all of the specialized work carried out in all of the zones indicated above.

Jumping exercises include multiple jumps from leg to leg, on both legs, jumps from various heights (depth jumping) with a subsequent jump upward, jumps over 6-10 objects, and so on. These exercises serve as an effective means of developing maximum strength of the main muscles of the runner and strengthening the ligaments, tendons and joints.

General physical preperation (GPP) involves use of supplementary means (team games, swimming, etc.) for training various

muscle groups. The number of training sessions depends on the adaptational capabilities of the body, his qualifications and trainedness at a given stage of training and weather conditions.

Analysis of competitive activity (total number of starts and results in the main and other distances and in cross-country races) aids in controlling the effectiveness of training at various stages.

In distributing specialized work, taking into consideration the main physiological effect, the coach should be guided by the objective criteria presented in Table 2. Note that lactate and acid-base equilibrium supplement each other and reflect the degree of participation of the anaerobic sources of energy supply.

The recommended classification assumes not only calculation but also planning of loads with respect to the structural units of the yearly cycle (weeks, months, stages and periods). It has created a basis for transition to time (having biological substantiation) criteria for evaluation of specialized work. In essence, improvement in each body function is directly related to the sum of the training effects on it. A quantitative characteristic of these effects is the *time* of work in the zones enumerated. Calculating training methods according to *time* allows the coach to make the training ojective. Comparative analyses of the load over a number

TABLE 2

Classification of Basic Means of Training According to Physiological Effects (Exemplary Parameters)

Type of Load	Physiological Parameter	Heart rate b/min	Lactate mg %	pH	BE,mekv
Preparatory work (morning run & run in warm-up)		110-140	Up to 25	7.42-7.38	0+ -3
Compensatory zone (restorative running)		110-140	Up to 25	7.42-7.38	0+ -3
Aerobic zone	Long-distance running below TAM rate	140-150	20-30	7.40-7.35	-3+ -5
	TAM level running	150-160	30-36	7.35-7.30	-5+ -8
Mixed zone	Aerobic-anaerobic regime	160-175	36-37	7.30-7.25	-8+ -10
	Anaerobic-aerobic regime	175-190	70-110	7.25-7.20	-10+ -15
Anaerobic zone	Glygolytic regime	Maximum	110	Below 7.20	-15+ -30
	Alactate regime	Maximum	30-60	7.35-7.25	-4+ -8

of years both in the same and in different athletes can also be done.

Up to now, coaches and athletes only set the distance and the speed to cover it. This method does not have a rational basis, since running speed depends greatly on external conditions and the functional state of the athlete at the time in question.

The proposed system for recording loads, of course, cannot solve the entire problem, since even identical physical exercises cause different body changes in different athletes. Nevertheless, the classification system facilitates optimization of training. The major differences between it and previous variants are that it covers numerous training methods; takes into account the specifics of middle-distance running; and makes it possible to convert to automated processing of current information on a computer.

ON THE TRACK WITH NADEZHDA OLIZARENKO

V. Kryazhev, V. Mansvetov, & U. Turin

Great success was achieved by Nadezhda Olizarenko at the Moscow Olympics. This sportswoman, who from outside appearances is hardly distinguishable, (height 165 cm, weight 55 kg) was able to not only win 2 medals (gold in the 800m and bronze in the 1500m) but set a phenomenal world record for the 800m—1:53.42. The essential characteristics of this world record holder is that she possesses a rare combination of speed (400m in 50.9 sec) with a high level of functional capabilities. (In various periods of training Nadezhda was tested and found to have a maximum O_2 uptake of from 55 to 77 ml/kg min.) Another outstanding feature of this sportswoman is the high running economy; i.e., the ability to achieve and maintain a given speed with minimum energy expenditure. This ability is, obviously, tied in with perfected running technique.

The cinematogram shows her run in the 800m finals taken at the 650m mark. Analysis of the external picture of her movement shows the characteristic features of an effective and economical run; push-off under a relatively sharp angle (frames 1 & 8), energetic forward carry of the swing leg (frames 6-7), early braking of the thigh (frames 2-3), active "pawing" in placing the foot on the track (frames 3-4) and synchronized work of the arms and legs.

The economy of the technique is substantiated by calculations and laboratory research. In Table 1 are the running stride parameters, recorded at the 350m and 750m segments in the Olympic finals where Nadezhda ran with approximately the same speed. Characteristic for Nadezhda are the low flight times and the amount of vertical oscillation of the body which is indicative of the relatively low external mechanical work in a vertical direction. It follows to note the difference in running technique in the middle and at the end of the distance (Table 1). She tries to maintain stride frequency (tempo).

At this time the flight decreases and support time remains practically unchanged. The amount of vertical oscillation re-

Table 1
Running Technique of N. Olizarenko at the 350m and 750m Distances in 80m Finals at the XXII Olympic Games

Distance	Running Speed (m/sec)	Stride Length (cm)	Tempo Strides/ sec	Flight Time (sec)	Support Time (sec)	Coefficient of Activeness	Vertical Oscillation (cm)
350	7.0	189	3.7	0.130	0.140	1.07	7
750	7.0	178	3.9	0.135	0.120	0.88	7

mains practically the same as in the middle of the distance. However, the corresponding components upon which these oscillations depend—flight (take-off) over the track and "sitting" in the phase of amortization (shock absorption and preparation for the push-off)—change. At the finish the amount of flight decreases, which indicates decreased flight time and "sitting" increases, which shows in the greater angle of flexion in the support leg.

A drop in running speed, a decrease in stride length and frequency (Figure 1) at the finish and changes in other biomechanical parameters signify the appearance of the phase of uncompensated fatigue (according to V. S. Farfel). However, because of a high level of specialized endurance, the sportswoman maintains speed at a sufficiently high level.

An important factor of an economical run is the decreased energy expenditure coming from foot placement on the track. It can be judged according to the amount of drop in horizontal movement speed in the phase of amortization. In practice, such measurement is made with an accelerometer (a device which measures acceleration) which is fastened to the waist of the athlete. Results of laboratory studies attest to the relatively lower loss of speed in the amortization phase by Olizarenko in comparison of other runners (Table 2).

Table 2
Running Stride of N. Olizarenko in Comparison to The Mean Data of the Runners on the USSR Team (When Running on a Treadmill with a Speed of 4m/sec)

	Stride Length (cm)	Tempo (Strides sec)	Support Time (sec)	Flight Time (sec)	CG Acceleration	
					T. Horiz	Vert.
Olizarenko	154	3.24	0.199	0.109	2.5	2.7
Team Group	152	3.25	0.172	0.134	3.2	3.4

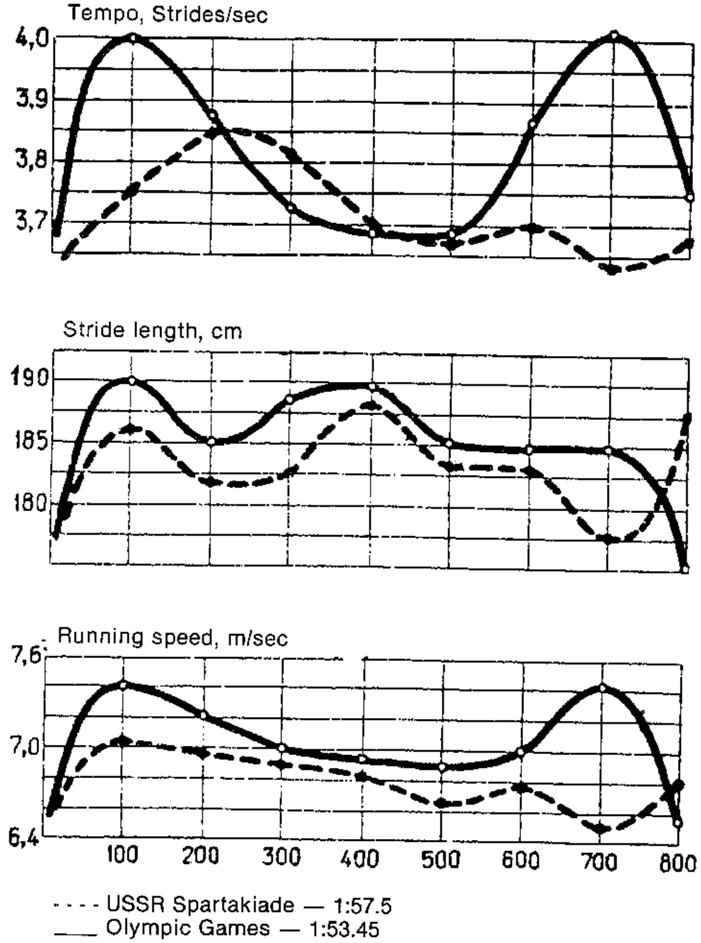

Figure 1

It is interesting to do a comparative analysis of the basic running parameters of Nadezhda at the VII Sportakiad of the USSR, where she won a silver medal and at the XXII Olympic Games. From the data presented in Figure 1, it can be seen that she achieved a greater speed in running the distance at the Olympics mainly because of increased frequency, which is especially characteristic for the beginning and end of the run. Thus, this once again supports the fact that increased speed is more favorably realized by an increase in stride frequency together with a slower increase in stride length.

Without doubt, running technique does not appear as the only component of economy. Nonetheless, the run of N. Olizarenko appears as a clear example that because of effective technique it is possible to achieve a drop in energy expenditure and to more effectively use one's own functional capabilities.

SPECIAL EXERCISES AND HURDLER ABILITY

Z. Struchkova & V. Chernobai

Based on published sources and practical experience, Soviet and foreign authors have now suggested more than 200 specialized exercises for hurdlers of differing abilities. From our studies of 58 athletes (whose abilities ranged from novice to expert) we have culled *eleven* special exercises from the larger group. These eleven exercises have been shown to increase substantially the hurdler's mean running speed and stride frequency. There was also good correlation between these exercises and improvement in race results while maintaining the rhythmic structure of the 100m hurdles.

The comparative values of the eleven exercises selected for athletes with different abilities are indicated by their place in the following list.

Exercise 1: Run the hurdles with the distance between hurdles *reduced to 8.25m.* The average speed of the high ranked hurdlers increased up to the fourth hurdle (up to the sixth in the 100m hurdles). For lower ranked hurdlers the average speed increased up to the third or fourth hurdle (up to the first or second hurdle in the 100m hurdles).

Exercise 2: Run the hurdles with the *height reduced to 76.2cm* and the distance between hurdles reduced to *8.25m.* In the lower ranked runners a clearcut rhythm is observed in the kinematic indicators, and their average speed increases up to the fourth to sixth hurdle (just as with the high ranked hurdlers in the 100m hurdles).

Exercise 3: Run the hurdles using *five strides* with the hurdles placed *11.50-12.00m apart.* The top hurdlers increased their mean speed and stride frequency (by 4.7% and 7.6%, respectively) and increased their speed on the last step prior to clearing the hurdle. The support times were reduced to 0.108 sec. After the initial acceleration stride frequency increased markedly. In the 100 meter hurdles maximum stride frequency was observed at the beginning and end of the run.

Exercise 4: Run hurdles in which the distance *between* hurdles is reduced *10 cm* in succession (from *8.50m to 8.10m*). While the Master and Master of Sport candidates increased their stride lengths, their average speed and stride frequency also increased by 2%, and the times improved by 2.8%.

Exercise 5: Running with the hurdles at *different* heights (*76.2cm and 84cm*). This helped reduce the amount of time in support and helped increase flight time where the hurdles were at regulation height. Where the hurdles were lower, the flight of the running strides was reduced.

Exercise 6: Run alongside the hurdles. Competitive results improved 2.2%. Average speed and stride frequency increased by

1.4% and 3.3% respectively, and stride times were reduced by 2%. Stride length changed very litte.

Exercise 7: Run while pretending there is a hurdle every three strides. The kinematic parameters for Class I athletes did not show any significant change, indicating that they had developed good running habits. Their times improved by 12.8% and stride frequency increased by 8.9%. The speed in the imitation hurdle steps increased significantly (16.9%) because length of the steps decreased and flight time decreased.

Exercise 8: Run with the hurdles *tipped 2°* at those places where the average speed is the lowest (after the third hurdle). This exercise helps to intensify all kinematic factors and maintains high average speed over most of the distance. The average speed increased 4.7% and running tempo by 4.9%. The loss in speed while going over the hurdles dropped by 3.3%. The overall times improved by 2.2%.

Exercise 9: Run the hurdles *while being pulled.* Race results improved by 2.7%. Average speed and stride frequency increased by 2.6% and 2.7%, respectively. Support time and stride time decreased by 10.9% and 2.4%, and flight time increased by 8.6%. Speed of clearing the hurdles increased by 4.9%, and stride length increased by 3.8%.

Exercise 10: Run the hurdles with the distance between the *third and fourth hurdles changed to 8.25m.* The results for Class I and II runners improved by 3.8%. Their average speed increased by 2.4% while the stride frequency increased by 4%. Speed was increased more and kept at a high level longer in those spots where it drops when running the 100 meter hurdle race.

Exercise 11: Run the hurdles with the distance between the *third and fourth hurdles increased to 11.50-12m.* In these portions of the 100 meter hurdles where the speed dropped, an increase of 2.7% and 3.5% was observed. The time indices and flight time dropped by 6.3% and 10.9%.

Table 1

Skill Level	Exercise No. in order of importance
Novice	3, 2, 1
Class III	1, 2, 3, 8, 6, 11
Class II	3, 11, 8, 10, 2, 1, 6
Class I	7, 8, 11, 9, 10, 3, 6, 1, 5
Candidates and Masters of Support	8, 3, 4, 1

The technique training exercises studied here were divided into groups appropriate to different classes (ranks) of athletes (see Table 1). The exercises are listed in order of importance to each group. Individual groups of exercises are recommended for specific problems in running technique (Table 2).

Table 2

Task	Exercise No. in order of importance
Decrease support time	4, 3, 9, 6, 5
Decrease stride time	9, 6, 7
Increase stride frequency	3
Increase speed on the last step before the hurdle	3, 9, 7
Increase speed of clearing the hurdle	7, 8, 9, 6, 1, 3
Increase average speed (at places where it is low)	8, 10, 11, 2

"MORE ATTENTION TO SPEED (HURDLING)"

I. Salchenko

Filming, combined with electromyography, allows one to determine which muscles participate in execution of a sports movement, at what moment in the movement one or other muscles are included and how long they are active. Finally, this combined method allows one to characterize the relative strength of muscles in various phases of the movement. According to muscle biocurrents, one can evaluate the regularities that form the basis of neuro-muscular coordination of movement.

Presented below is some experimental material regarding the effect of running speed on neuro-muscular coordination during hurdling. Also studied were coordination relationships in several specialized exercises that are used by hurdlers.

In Figure 1 are two hurdling attempts. The time spent in running prior to the take-off in the first case (A) is 0.08 seconds more than in the second case (B), i.e., going over the hurdle occurred at greater speed in the second case. Analysis of the electromyogram corresponding to frames 8-11 shows that the duration of increased bioelectric activity and amplitude of the biocurent of the rectus femoris, biceps femoris, and gastrocnemius muscles of the take-off leg are significantly greater when the hurdle is attacked at lower speed. In attacking the hurdle with greater running speed the sportswoman expends less effort and the take-off is accomplished more rapidly. Excessive muscle loading—as measured by both time and effort in the push-off leg in low running speed will cause greater fatigue, which in turn, brings about a drop in speed. In this manner, a vicious circle is formed, the links of which are running with insufficiently high speed before hitting the hurdles, and strained, non-economical clearing of the hurdle. Clearing 10 hurdles in competition causes premature fatigue, a drop in speed, and leads to poorer results. Analysis of the given data shows that sufficiently high running speed up to the hurdles facilitates rapid clearing with optimal muscular effort. Hence, hurdling instruction and training should be accomplished with sufficiently high running speed.

There is a whole "arsenal" of specialized exercises for improving hurdling technique. Unfortunately, these exercises are often selected on the basis of their outward similarity to the fundamental competitive act. In our opinion, one of the important indications of an exercise's suitability is its coordinative similarity (taking into consideration the bioelectric muscular activity) to the main exercise [skill].

Utilization of specialized exercises serves a definite purpose, which consists in improving the technique of the entire, or at least some part of the competitive movement [act]. However, the positive effect may be so small as to not justify the time spent on

using a specialized exercise and on improving neuro-muscular coordination of new movements. Besides this, the coordination used in some specialized exercises may be considerably different from the coordination used in competitive exercises. We will illustrate this with an example from one of the specialized exercises presented in Figure 2. Runners not in good command of hurdling technique (Figure 2, B) are observed to have drawn out, prolonged periods of high muscular activity. The maximum bioelectric activity of the rectus femoris during the push-off (frame 3) coincides with high activity of its antagonist—the biceps femoris. The simultaneous activity of the agonist-antagonist muscles is characteristic for constrained, tense movements, in which the "result" of the joint movements is determined by the superiority of one antagonist muscle's contractile strength over another.

In figure 2, A is the performance of the same exercise by another sportswoman, who has used it for a long time in training.

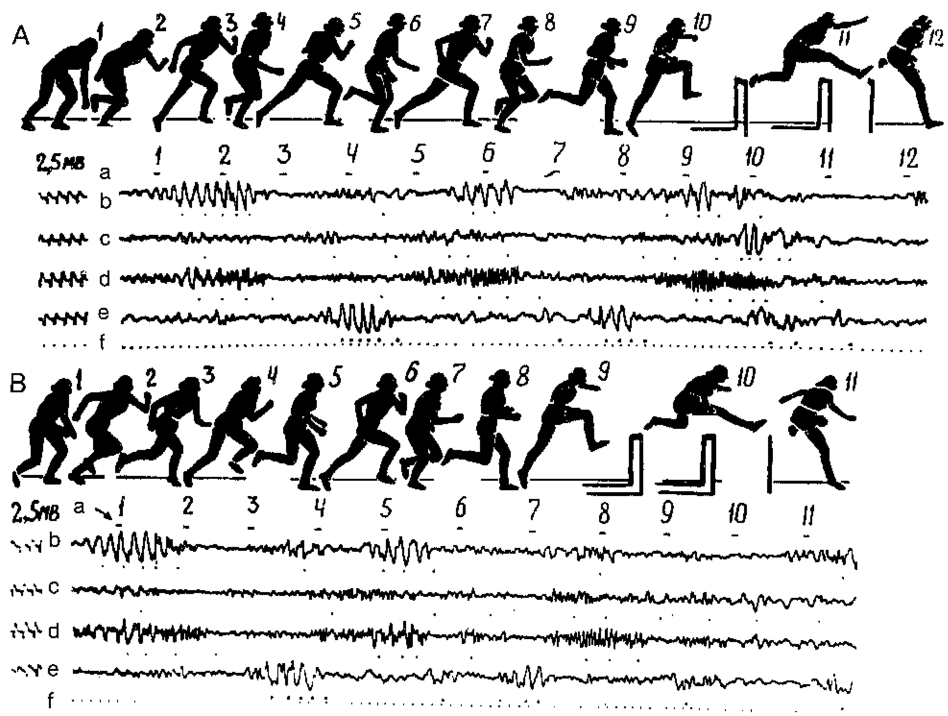

Figure 1. Cinematograms and electromyograms of attacking a hurdle: A—at a lower running speed, B—at a greater speed. Key: a—synchronization marks; b—EMG of the rectus femoris; c—EMG of the biceps femoris; d—EMG of the gastrocnemius muscle of the take-off leg; e—EMG of the rectus femoris of the swing leg; and f—marks indicating 0.02 sec.

We see perfection of technique, which expresses itself in increased precision of neuro-muscular coordination. Increased biocurrent in the rectus femoris during the push-off (frame 5) corresponds to a substantial drop in the biocurrent of its antagonist—the biceps femoris. The biocurrents in other muscles are concentrated in groups, which indicates well-timed loading and relaxation of the muscles. However, this mastered movement is not similar in coordination to the competitive movement presented in Figure 1, B. On the other hand, as far as coordination of neuro-muscular activity is concerned, it is very reminiscent of the tense—and slower speed movement illustrated by part (A) of the same tracing. Learning the elements of hurdling technique should occur in the presence of sufficiently high running speed, and specialized exercises should have coordination commonality with the basic competitive movements.

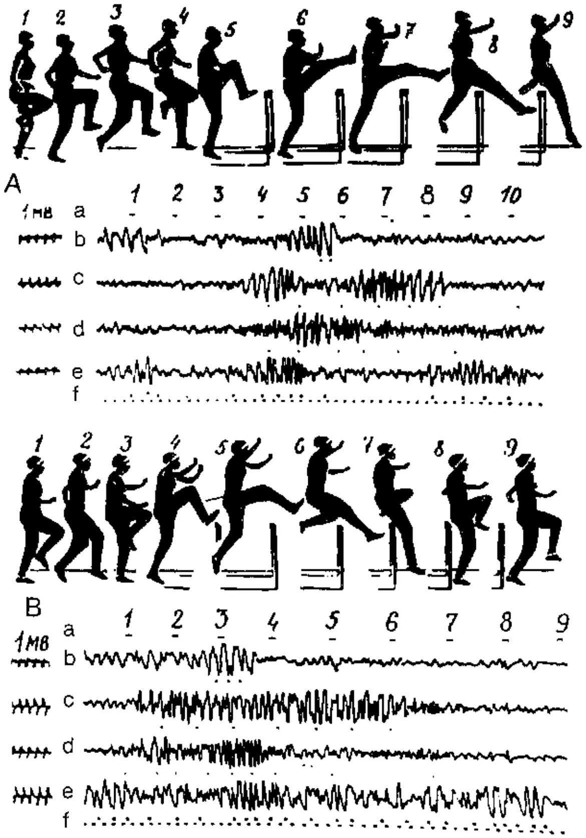

Figure 2. Cinematograms and electromyograms of a specialized exercise: A—a sportswoman who has mastered the exercise, and B—a sportswoman, trained in "flat" running and not having performed the exercise previously. Key is the same as in Figure 1.

"110-METER HURDLING STYLES"

V. Balakhnichev

Stylistic differences in hurdling technique arise mainly in the barrier-crossing phase, which consists of: the push-off, the advance toward the barrier (these two phases make up the "attack"), crossing the barrier, and the descent.

The time (t) required for the swing leg's movement in the "attack" phase (from the push-off to the point of crossing the barrier) is a function of: horizontal velocity of the athlete's center of gravity (c.g.): (V); distance from the push-off point to the barrier (S); leg length (ι) and push-off leg angle at the time the leg leaves the ground (a).

An approximate analytic relationship between time of the swing leg advancing toward the barrier and the above parameters can be obtained as follows:

$$t = \frac{S - \iota\ (\cos a + 1)}{V}$$

This value characterizes the amount of external resistance, which is higher the less the *t* (time). Tall hurdlers with long legs have less time for swing leg movement, i.e., they experience greater external resistance than shorter hurdlers. The longer the legs, the longer the running stride.

Because of a longer stride, tall hurdlers "attack" the barrier from a lower position and experience greater external resistance (time is less). Center of gravity velocity has an analogous effect on increasing external resistance.

Tall and fast hurdlers execute swing leg movement extremely actively, which is aided by relatively great trunk lean in the attack phase. The swing leg is bent at the knee at the moment of crossing the barrier. Specialists call this style the swing style typified by Calhani, Zibeki and Moshnash-Vili.

Hurdlers with optimal morphological-functional qualities (height-speed) execute a less accented, more controlled swing leg movement. The swing leg is completely straight when the foot crosses the barrier. Trunk lean is closer to a running position than for those who use the swing style. The swing leg movement looks like a natural continuation of the preceding running stride. This style is called the running style typified by Ottozi, Drue and Pereverzev.

Shorter, but highly functional, hurdlers experience less external resistance than those using the preceding styles. They have more time, therefore they execute the swing leg movement completely up to the barrier—their swing leg is straightened and fixed in this position.

Because their point of push-off is relatively further from the barrier, they accent the push-off. Their trunk lean is slightly different from running and the toe of the swing leg is up (dorsi flexed). This style is called the push-off style typified by Dillard and Coleman.

We isolated the stylistic groups from analysis of 40 high-class hurdlers. Results are in Table 1.

Table 1

Height	100-Meter Time		
	10.4 and Faster	10.5	11.0 and Slower
187 and Taller	Swing	Swing	Running
186 and 177	Running	Running	—
176 and Shorter	Push-off	Push-off	—

Table 2 shows exercises that can be recommended for the corresponding stylistic groups.

Table 2

Swing Style	Running Style	Push-off Style
1. Crossing barriers (going over the hurdles) with an approach run longer than the starting (22 meters) run, with standard spacing of the barriers. 2. Crossing closely spaced, low barriers. 3. Exercises with hurdles on the side, for the swing leg. 4. It is not advisable to use low barriers with standard spacing.	1. Crossing lower-than-normal hurdles with standard spacing. 2. Flat running with imitation of crossing barriers. 3. Crossing hurdles with an approach run longer than the starting, with spacing 20 cm longer than is standard.	1. Long jumps with imitation of crossing hurdles in the approach run. 2. Crossing a hurdle with 5-6 approach strides. 3. Running hurdles with increased spacing. 4. Crossing hurdles with an approach run longer than the starting, with spacing 30-40 cm more than the standard.

Style, as the "personal" part of sports technique, is hard to relearn. Hence, when teaching hurdling technique, one must envision possible changes in morpho-functional qualities (height-speed) as a result of the training process, in order to ascertain what style the athlete will use.

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