VERKHOSHANSKY

SPORT STRENGTH TRAINING METHODOLOGY©

YURI VERKHOSHANSKY

THE BLOCK TRAINING SYSTEM

IN ENDURANCE RUNNING

On the cover

The picture on the left (from www.olympic.org, credit: Getty Images-Tony Duffy)
Moscow, 1 August 1980. Men's athletics: Mirtus YIFTER of Ethiopia brushes shoulders with Aleksandr FEDOTKIN of the Soviet Union on his way to victory in the 5000m at the Games of the XXII Olympiad.

The picture on the right (from www.olympic.org, credit: Getty Images)
Steve OVETT (279) and Sebastian COE (254), both of Great Britain, trail Jurgen STRAUB (338) of East Germany part way through the men's 1500m final at the 1980 Olympic Games in Moscow. OVETT eventually finished third behind COE and STRAUB.

The Block Training System in endurance running

Translated by Lorena Vitiello
Edited by Natalia Verkhoshansky

Published in electronic format by Verkhoshansky.com

Thanks and acknowledgment

The author wishes to thank Mark McLaughlin, Dan Partelly, Mark Bennett and Carlo Buzzichelli for their contribution of review in the early translation process.

A special thank to James Smith, for his precious work of final review.

An acknowledgment to my daughter Natalia for her continuous stimulating scientific conversations to make more clear the content of this book adapting my "old academic Soviet style", at the best that was possible considering my natural reluctance, to the reader's needs.

PREFACE

The photos on the cover of this book were not chosen randomly; they were specifically selected in order to recall events that inspired the research and experimentation that founded the training system presented in this book.

The sport events, to which we refer, are the three well-known final rushes at the Moscow Olympics in 1980: Sebastian Coe's rush in the 1500 meters run (on the right) and Miruts Yifter's rushes in the 5000 e 10000 meters run (on the left).

The most striking rush among these was surely in the final in the 10000 meters.
All of the fans of the legendary Finnish athlete Lasse Viren, who won four gold medals at the previous Olympics, hoped he would win his fifth gold medal at his third consecutive Olympics.

In the final of the 10000 meters- Viren winning the gold seemed to be a distinct possibility: Lasse Viren was always among the first four runners.

In the last lap, when the front runners began increasing their speed, Viren, who in that moment was in second place, moved forward toward the first position. The whole "Luzniki" stadium had put their hands up to applaud the great Viren. All of a sudden, something unbelievable happened: Miruts Yifter, who was running behind Viren, unexpectedly increased his speed and began outdistancing himself from the leading group as if he were an athlete who had just begun a 400 meters competition.

When Yifter crossed the finish line the others were almost 20 meters behind him.
The most striking thing was not so much the fact that Yifter had been able to increase his speed at the end of such a very hard distance; but the way in which he had done it. It seemed as if he had "changed gear".

Thinking this event over, some Soviet scientists, who had made studies of and carried out research into the physiology of endurance sports, couldn't help wondering- what were the characteristics of an athlete's organism that allowed him to accelerate so rapidly over the final distance.

Until then, training methodology in endurance running had been based on maximal oxygen consumption development and on glycolytic capacity development.

The traditional metabolic model of middle-distance and long-distance running foresaw that the athlete had to run by resisting a high level of acidosis at the end of distance.

Nevertheless, Sebastian Coe's final "flights" and especially Miruts Yifter's "gear changes" were so striking that they raised an essential question: how can the athlete execute these final accelerations if his muscles are full of lactic acid?

At the beginning of 1980s, research on the role of the different energetic mechanisms in physical activity showed that when the intensity of prolonged physical activity increases, the change from the aerobic metabolism to the anaerobic one (that is, the crossing of the so-called "anaerobic threshold") is equivalent to a "gear change". It was postulated that this physiological event takes place via the recruitment of the muscle fibres not involved in the aerobic phase of work.

Starting from this hypothesis, it was possible to suppose that in order to win, thanks to a final rush like Yifter's, an athlete had to run the entire distance in the aerobic regime (that is, below the anaerobic threshold) by using only slow muscle fibres such that the working effort does not cause lactate accumulation.

Only at the end of the distance the fast muscle fibres, which previously hadn't been subjected to lactate accumulation, had to be "triggered" and, thus, were able to execute contractions that could assure high-speed running.

Yet, in order to develop this model it was necessary to identify means, methods (exercises), and forms of their temporal organization in the preparatory cycle, different from those used until then in the training methodology of endurance sport disciplines.

The first problem to solve was: how could an athlete increase their running speed at the anaerobic threshold?

The main problem was not so much rooted in how to increase the anaerobic threshold (expressed as a percentage of VO2max); but rather, how to increase the speed at which athlete reaches the anaerobic threshold (in other words, to increase the slow muscle fibres capacity to work in a prolonged regime with higher power).

To solve this problem it was necessary to identify the exercises which could increase the oxidative and contractile capacity in slow muscle fibres.

To increase the oxygen capacity in slow muscle fibres, it was necessary to force them "to breathe more" and to more rapidly *oxidize lactate. In order to accomplish this, a rather well-known training method was used: prolonged running at anaerobic threshold speed and Aerobic Fartlek (by inserting brief accelerations during prolonged running).*

The hardest problem to solve was: how to increase the contractile power of the slow muscle fibres?

In this case, the use of resistance (strength) exercises proved to be beneficial. Yet, the traditionally used strength training methods caused the involvement of fast muscle fibres and the increase in anaerobic glycolysis.

In 1981 Y. Verkhoshansky found a very original way to solve this problem: the enforcement of the CP mechanism of energy production that serves the universal role (as a universal energy transporter) in supplying energy for intensive muscular activity. He conceived the Local Muscular Endurance Method (resistance exercises executed in an interval regime) which assures the increase in both the contractile capacity and the oxidative capacity of muscles involved in endurance running and the decrease of lactate accumulation.

The studies made on the temporal organization of these new means and methods, and their temporal integration with other specific training methods in the preparatory cycle of high-level athletes, showed that another invention made by Y. Verkhoshansky could be useful: the Block Training System (BTS).

In the 50 pages of this book you will learn the theoretical and practical principles upon which the Block Training System for endurance running has been developed, the results of its experimentation, and how has been build the training model with the description of each training means and the training programs used.

However, these principles can also be applied to develop a BTS for other endurance sport disciplines. The author, using the basis of this model, has developed other models for different endurance sport disciplines: rowing, skating and skiing.

More than 20 years have passed since the beginning of the experimentation on this training model; however, it is still a "winning model" as demonstrated by the results of its application in recent years.

One of most successful applications has been developed by Prof. Y. Verkhoshansky and Oreste Perri, Italian Rowing National Team coach (canoe, kayak).

The Italian National team, via the integration of the BTS, won ten Olympic medals (four gold): five in Atlanta 1996, three in Sydney 2000 and two in Athens 2004.

Natalia Verkhoshansky

This book has been written on the basis of previous publications by the author, mainly from:

- "The annual training system for middle distance running"; Y. Verkhoshansky, E.Zaleev - Sport science bulletin journal, 1989, n. 6 pag. 3-8 (in Russian).

- "La preparazione fisica speciale"; Y. Verchoshanskij, CONI Scuola dello Sport, 2001(in Italian).

- "Basi fisiologiche e principi metodologici dell'allenamento nella corsa di resistenza" In: "Le basi scientifiche dell'allenamento in atletica leggera", supplement of nn.1/4 - 2005 "Atletica Studi" magazine, p. 95-150 (in Italian).

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INTRODUCTION

I was inspired to publish this book because I recently observed great interest and debate with respect to the Block Training System (BTS) and, at the same time, a great deal of misunderstanding and misinterpretation of the subject matter.

Previous English publications have only illustrated the basic principles of BTS and I don't think there has been enough explanation to give the reader a sufficient understanding of the material.

In this book the reader will see how the basic principles of BTS have been applied to a concrete training model, the BTS in endurance running.

In order to obtain a more clear understanding of BTS basic concepts, so that they can be applied more effectively in other sport disciplines, the reader can follow a bottom up learning approach: from the concrete model to the principles of BTS.

The reader should be aware, however, that in order to build a successful application of BTS it's very important to have a deep knowledge of the physiological basis of specific sport disciplines:

– knowledge of specific performance structure;
– knowledge of each elements of this structure and the physiological relationship between them;
– knowledge of the more effective training means and methods to improve each elements of specific performance structure.

The aim of this book is to illustrate an application of the Block Training System for Track & Field middle and long distance running (1500 m - 10000 m).

The idea of this system is based on physiological and biochemical research on intense muscular activity; which confirms that the training of Track & Field endurance runners should not only be based on increasing the *maximum oxygen consumption* (VO_2max) and *cardiac output*, but also on improving of the oxidative capacity and the contractile capacity of muscles involved in executing the competition exercise. These improvements ensure also the lowest level of involvement of the glycolytic mechanism in the energy supply process of competitive distance running.

The research of more suitable means for developing both the contractile and oxidative capacity of muscles shows the effectiveness of specific resistance exercises used in an interval regime to develop the Local Muscular Endurance.

The analysis of this research indicates that the Conjugate Sequence temporal organization of training loads with different emphasis in the preparatory cycle (Block Training System) is the most appropriate way to improve the performance of high-level endurance runners.

1. PRELIMINARY SCIENTIFIC REMARKS

1.1. The main mechanisms and limiting factors in improving performance in endurance running

1.1.1. Increase of AT running speed

In Track & Field endurance running the competitive activity is prevailingly carried out through the involvement of slow twitch fibres (19, 30, 40, 45, 54, and 61). Fast twitch fibres are involved in the work after the fatigue of slow twitch fibres (27, 61) or when the intensity of work is increased (36, 39). Fast twitch muscle fibre activation begins when the Anaerobic Threshold (AT) intensity is reached (21, 24, and 53). Therefore, it's possible to deduce that the mobilization of fast twitch fibres leads to an increase in blood lactate concentration.

Endurance training leads to a decrease in lactic acid accumulation during prolonged work (65). When the intensity of work (running speed) gradually increases, high level athletes begin to utilize their anaerobic potential later than low level athletes. In the standard $V0_2$ max treadmill test, executed with a gradual increasing of work intensity, high level long distance runners reach the level of 2-4 mMol/l blood lactate accumulation, at a speed of 5-7.5 m/sec, while the lower level athletes reach this level of blood lactate accumulation at a speed of less than 5 m/sec (65).

As a result, in order to reach the running speed of 7.6-8.0 m/sec, a predictor of good results in long distance running, high level athletes utilize the anaerobic energy system to a lesser extent than low level athletes.

1.1.2. Reconstruction of metabolic specialization of skeletal muscles which leads to a predominance of Aerobic Processes

In the human body, lactate can be eliminated from muscles not only by the liver and the myocardium, but also by the skeletal muscles themselves (by myofibril's mitochondria, via pyruvic acid conversion): in a well-trained organism- muscle plays the most important role in lactate oxygenation (17, 18, 25, and 35).

The decrease in lactate concentration during the muscle work, which can be observed after endurance training, is connected not so much to the decrease in lactate production as it is to the increase in the speed of its elimination (18, 25, 35, 37, and 61).

The decrease in blood lactate accumulation during prolonged work can be related to the improvement in oxidative capacity in most of the motor units involved in the exercise (39, 14, 59, and 62).

Considering that the improvement in oxidative capacity (the increase in the synthesis of mitochondrial protein enzymes) can take place both in slow and fast twitch fibres (16, 64), it's possible to propose that the improvement in endurance capacity is related to the reconstruction of the metabolic specialization of skeletal muscles; which leads to a predominance of the aerobic processes.

In fact, in the skeletal muscles of high-level endurance athletes one will observe very little difference between the level of mitochondrial enzymes in slow twitch fibres and in fast twitch fibres (20, 64). Sometimes it's not even possible to identify the intermediate fibres, those of type IIx, which, probably, are entirely transformed into those of type IIa (20, 45, and 62).

An increase in the energy production of muscles, during the prolonged work, is assured by the growth in the number and in the mass of mitochondria and by the growth in activity of the mitochondrial enzymes (23, 36, 38, 52, and 61).

These two factors are correlated more strongly with the improvements in endurance capacity then they are to the increase in VO_2 max (22, 28, 48, 51, 57, and 59). When, under the influence of endurance training, the endurance capacity is increased three-five-fold, the number of the mitochondria and the oxidative capacity of muscles are increased two-fold, but, at the same time, the VO_2 max level is increased only by 10-14% (23, 29).

The increase in the oxidative capacity of the muscles allows for a reduction in the contribution of energy from anaerobic glycolysis during the work, thus reducing lactate production (18, 28, 38, 42, 51, 58, 60, and 62). Pyruvic acid (pyruvate) and fatty acids are utilized as a substrate for oxygenation, rather than lactate, enabling glycogen to be used in a more economical way (23, 24, 38, 39, and 58).

1.2. Improving performance in endurance running

1.2.1. High volume of prolonged running before the start of interval training

The power, or the speed, by which an athlete can reach the Anaerobic Threshold (the maximal intensity of load which doesn't produce a considerable lactate accumulation), is considered as a more significant indicator of endurance capacity than VO2 max (25, 33, 47, and 49). Prolonged activities carried out at this level of intensity represent an effective method to develop endurance capacity (31, 35, 51, 57, and 63).

The prolonged running, carried out at the speed at which athlete reaches the Anaerobic Threshold, is considered an effective training method to increase the oxidative capacity in slow twitch fibres (24, 33, 47, 49, 51, 57, and 63). Interval training, in which the work intervals are carried out at an intensity that reaches or slightly surpass the level of VO2 max, is an effective training method to increase the oxidative capacity of fast twitch fibres (30, 36, 39, 51, and 56). If interval running is used after a period of time in which only prolonged running has been carried out, its effectiveness to develop the aerobic capacity in fast twitch fibres increases (30, 56, and 62).

A high volume of prolonged work is an essential element of endurance training; not only because it leads to a gradual increase in the volume of the cardiac ventricular cavity, but also because it assures the formation of particular peripheral vascular reactions linked to the optimal distribution of blood flow during the work. These reactions assure the supply of a greater quantity of oxygen to the muscles involved in the work.

The peripheral vascular reactions are local (differentiated), very stable and they show the characteristic of organism adaptation to the prolonged work in a more precise way than the traditional indicators (heart rate and heart systolic throw) (1, 10, 13).

It's important that the formation of these peripheral vascular reactions precedes the higher intensity training (1, 8, 15, 18, 30, and 34). The premature intensification of endurance training leads to a temporary improvement in sport result but, at the same time, it leads to the over tension of cardiovascular system and this can create the conditions which lead to the cardiac dystrophy (1,8, 13, and 30) and can interfere with the normal development of the training process.

1.2.2. Improvement of Local Muscular Endurance

During endurance training, metabolic and morphologic changes in muscles are clearly local. For example, it has been proven that the muscle myoglobin levels increase only in the muscles involved in the work (38, 55) and that the mitochondrial adaptive changes take place only in the muscle fibres which are involved in the contractions (32, 35, 39, 61). It is therefore very important to ensure that the exercises used to develop endurance include the same movements as the competition exercise.

The degree of increase in muscle oxidative capacity, and in the number of mitochondria, depends predominantly on the total volume of the muscle's contractile activity (39). This volume can be increased in two different ways: by an increase in the number of muscular contractions per unit time, or by an increase in the capacity to maintain a steady level of contraction frequency (26, 29, and 34).

The number of muscular contractions per unit time can be increased by using specific resistance exercises aimed at the improvement of the so called Local Muscular Endurance (3, 4, 5, 6, and 9).

Local Muscular Endurance improvement through the use of resistance exercises in an interval regime is based on the enforcement of the CP mechanism of energy production. The CP system serves the universal role (as the universal energy transporter) in supplying energy for intensive muscular activity (66-69).

The enforcement of this CP mechanism allows an increase in the intensity level of muscular work executed without great blood lactate accumulation (5).

1.2.3. Principle of "Antiglycolytic" finality

Physiological and biochemical research on intense muscular activity highlighted that endurance is limited by the following:

- Hypoxia in skeletal muscles
- Maximum oxygen consumption (VO2max)
- Cardiac output
- Capacity of muscles to draw out a higher percentage of oxygen from of arterial blood and to oxidize lactate.

In other words, the limitation and the development of endurance depends not so much on the capacity of heart to pump blood, but rather on the adaptation capacity of skeletal muscles themselves to the specific work regime (56,62).

Aforementioned scientific remarks show that, from a physiological point of view, the principle on which endurance improvement is based can be defined as the principle of "antiglycolytic" finality.

In order to realize this principle the construction and the organization of training loads, during the whole preparation process, should be done with the aim to minimize the involvement of the glycolytic mechanism in the energy supply process during competition distance running.

This means that an essential element of endurance training is the athlete's preliminary preparation that precedes the intensive execution of specific exercises. This preliminary preparation should include a sequence of preventive actions aimed to assure the:

1) increase in cardiac cavity volume;
2) formation of specific reactions of peripheral blood vessels in the muscles involved in the work (blood circulation improvement);
3) improvement of the contractile capacity of involved muscles;
4) improvement of the oxidative capacity of slow twitch fibres.

Only after this sequence of preventive actions is conducted it's possible to begin the work aimed to:

- increase myocardium power;
- improve the buffer systems of the organism;
- improve the oxidative capacity in fast twitch fibres;

All of these factors are directed towards the increase of the maximal average speed needed to cover the competition distance.

2. PRELIMINARY METHODOLOGICAL REMARKS

2.1. The Block Training System

The Block Training System was pioneered at the end of 1970's (before the Moscow Olympic Games) in order to provide an innovative model for the training of high level athletes in the speed-strength disciplines of Track & Field.

In this historical period, in the East European sport training methodology, the improvement of sport performance was associated with an increase in the total volume of training loads. At the end of the 1970s the total volume of training loads carried out by high level East European athletes reached the supportive limits of human capacity.

In one of the scientific laboratories of the Moscow Central State Institute of Physical Culture and Sport (the Interdisciplinary Laboratory of the researchers who worked on the problem of the Optimization of the training process), a research project was initiated in order to identify the most suitable training models that could assure the improvement of sport results without increasing the total volume of training loads.

One innovative idea consisted of directing the training load volume of one training stage primarily towards only one training objective (a "concentration of the load). This created a "persistent/focused" training stimulus that influenced the most important factor of increasing sport performance.

The first experiment explored the Long Lasting Training Effect (LLTE) of concentrated training loads directed towards the increase of maximal strength. It was shown that in order to realize the LLTE, specific to obtaining the highest improvement of the speed-strength sport performance, the concentrated strength load should be followed by explosive strength training loads and work to improve the technical execution of the competition exercise.

As a result of the series of experiments, an innovative model of the preparation cycle of training, in the speed-strength sport disciplines, was discovered based upon the *Conjugate-Sequence* temporal organization of different emphasis loads (2).

In the 1980s, this training model, named by coaches "Block Training System", was successfully approved and soon became the dominant training model used in the training of high level Soviet athletes in the great Olympic strength-speed sport disciplines. Ironically, during this same period in time, no one used the "Block Training" model in the preparation training of the cyclic (endurance) sport disciplines.

The Block Training System is based on the following three principles:

The Principle of Concentration of training loads having the same primary emphasis in different training stages (Blocks); for example, “Block A”, “Block B” and “Block C” of Figure 1. The application of this principle ensures the possibility of yielding the deepest training influence on each of the organism’s different physiological systems involved in the specific competition activity [1].

The Principle of Superimposition of concentrated training loads consists of the consecutive superimposition of training effects yielded by more specific and more intensive loads on the training effects (the adaptation traces) of previous loads (less specific and less intensive), which prepare the organism to obtain the most significant final cumulative effect.

The concentrated training load of each previous block creates the morphological-functional basis to obtain the most effective result yielded from the concentration of the training loads of subsequent blocks. The subsequent blocks loads, in addition to realizing their specific directives, assures the realization of the training effect of previous block loads at a higher level of the athletes’ work capacity.

This principle also implies that each training block is not completely separated from the preceding and following blocks. In the training process, every type of subsequent block’s loads must be introduced in such a way that gradually replaces the previous block’s loads.

The Principle of Priority of the Special Strength Preparation implies a temporal placement of resistance exercises in the first stage of the Block Training System plan.

The Principle of Priority of the Special Strength Preparation has a crucial significance because the Block training model is based upon the use of LLTE of the strength loads that facilitate and emphasize the training effect of the subsequent training loads.
Also, the name Block Training System is historically related to the Priority Principle. The first article, dedicated to LLTE, featured the graphics that illustrated the training stage of concentrated strength loads. This was presented as the quadrate figure that symbolized the “monolithic unit” that was later re-named “block” by the author.

[1] The word “concentration” does not have to be interpreted as an increase of the general training loads “density” but as the “localization” of training loads with same emphasis in a determined period of time (Block). Each of the different loads emphasis has a primary *physiological* directive that doesn’t correspond to the general forms of “physical abilities”.
(Editor’s note)

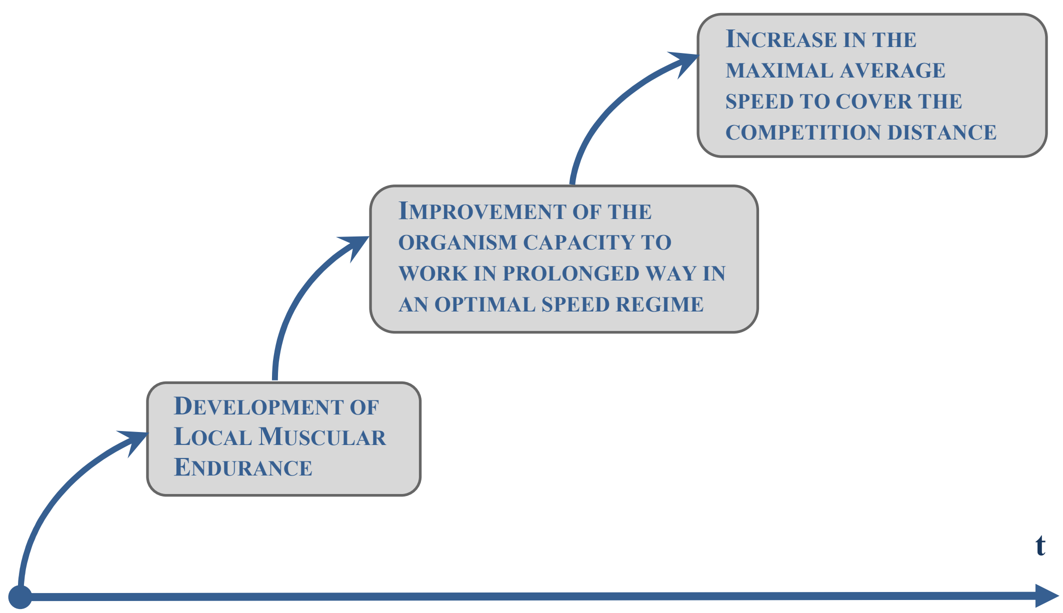
2.2. Building a Block Training System for endurance running

The methodological approach to develop an effective training system for endurance running should be based on the strategy to create favourable conditions that gradually increase the maximal average running speed needed to cover the competition distance, via the:

- development of Local Muscular Endurance (LME) that consists in the related improvement (through the use of special methods of resistance training) in the oxidative capacity and contractile capacity of muscles mainly involved in the execution of the competition exercise;
- gradual improvement in the functions of the athlete's cardiovascular system, which is assured by the use of running exercises with a gradual increase of intensity.

This methodological approach implies that the improvement of sport results in Track & Field middle and long distance running should be based upon the *Conjugate Sequence* temporal organization of different emphasis loads in the preparation cycle (Block Training System).

The combined analysis of the BTS principles and the physiological research data leads to the definition of the general strategic lines needed to develop the plan of the preparation cycle; which can be conceptually summarized in its temporal evolution as follows:



The planning of the training preparation period (whose duration, depending on the competition calendar for the different endurance training disciplines, could be half-year or one year) should begin with the Special Strength Training (SST) planning.

The planning of SST must include the following phases:

- to assign the main goal of SST (for endurance sport disciplines, it must be LME increasing);
- to select the SST means and methods (for endurance sport disciplines: the *system* of training means that assures the increase in LME);
- to calculate the appropriate work volumes for each training mean (that must be based on the training load volumes reached in the preceding preparation period of training).

Only after these steps, it's possible to proceed with the planning of other training components (in endurance sport disciplines: running loads with different training emphasis).

3. THE BLOCK TRAINING SYSTEM MODEL

3.1. Conceptual model

The conceptual model of the Block Training System in endurance running is represented in Figures 1 and 2. This BTS can be applied for a one year preparation cycle (the usual cycle for Track & Field long-distance running disciplines) or, in the case of the athlete participating in winter competitions, for a half year cycle, but, in this case, it must be repeated twice over the course of the year.

Figure 1 (I) illustrates a schematic of the global conceptual model of BTS in endurance running:

1) The model of the training loads system, "A", "B" and "C", which have a Conjugate - Sequence temporal organization. "A", "B" and "C" symbolize the blocks of the concentrated training loads with different training emphasis, (the curves symbolize the effect of the training load on the organism but not its relative volume).
2) The trend of top speed (maximal average speed) to cover competition distance and the trend of the athlete's functional condition parameters:
   - the dynamics of maximum average running speed over the competition distance (V);
   - the highest level of maximum average running speed over the competition distance reached during the previous stage of training (Vo);
   - the increasing in maximum average running speed over the competition distance (ΔV) planned for the current stage;
   - the dynamics of essential functional parameters (f) which characterize the athlete's specific work capacity (the most important physiological power parameters, as verified by the standard physiological test procedures used in the laboratory or in the field);
   - the maximal value of functional parameters, reached during the previous training cycle (fo);
   - the planned increase in functional parameters (Δf).

Figure 1 (II) illustrates a schematic of the conjugate-sequence organization model of training loads influence on the different components of the cardiovascular and neuromuscular systems.

In III of Figures 1 and 2, the schematic illustrates the conjugate-sequence system of running exercises organized in coherence with the principle of the superimposition of loads with different training emphasis.

Block A – the directive of Block A may be considered as "the stage of functional-energetic training". It's aimed at the activation of adaptation and morphological-functional transformation processes; that are necessary to obtain the subsequent intensification of organism work in the specific speed regime.
In this period, resistance exercises are carried out whose aim is to increase explosive strength and improve Local Muscular Endurance. At the end of block A, this type of training load is gradually replaced by Long-Distance Uphill Running (or Long-Distance Bounced Uphill Running, see § 3.2).

The running exercises (bouncy running and continuous prolonged running) must be executed with a moderate intensity.

During this stage, the prolonged running must be performed with a gradual increase in intensity and, subsequently, it must be replaced by Aerobic Fartlek.

Block B – the directive of Block B may be considered as "the stage of running intensification". It is aimed at the gradual increase in the power output of the specific competition regime.
The Long-distance Uphill Running of previous block is replaced, gradually, by the Short-distance *bouncy* and *bounding* running; these are mainly used to improve explosive strength and reactive ability.

The Aerobic Fartlek is replaced by specific running exercises carried out with a gradual increase in the:

1) Speed execution, up to the maximal level;
2) Running distance at competition speed.

Block C – the directive of Block C may be considered as "the stage of competition training". Block C includes the final part of the organism's adaptation cycle. This Block assures the attainment of the maximal level of work power in the specific speed regime, under the influence of competition loads. In Block C the work is primarily focused on distance running and on pre-competition training.

The synthesis of all training elements, that characterize each Block, is exposed in Table 1.

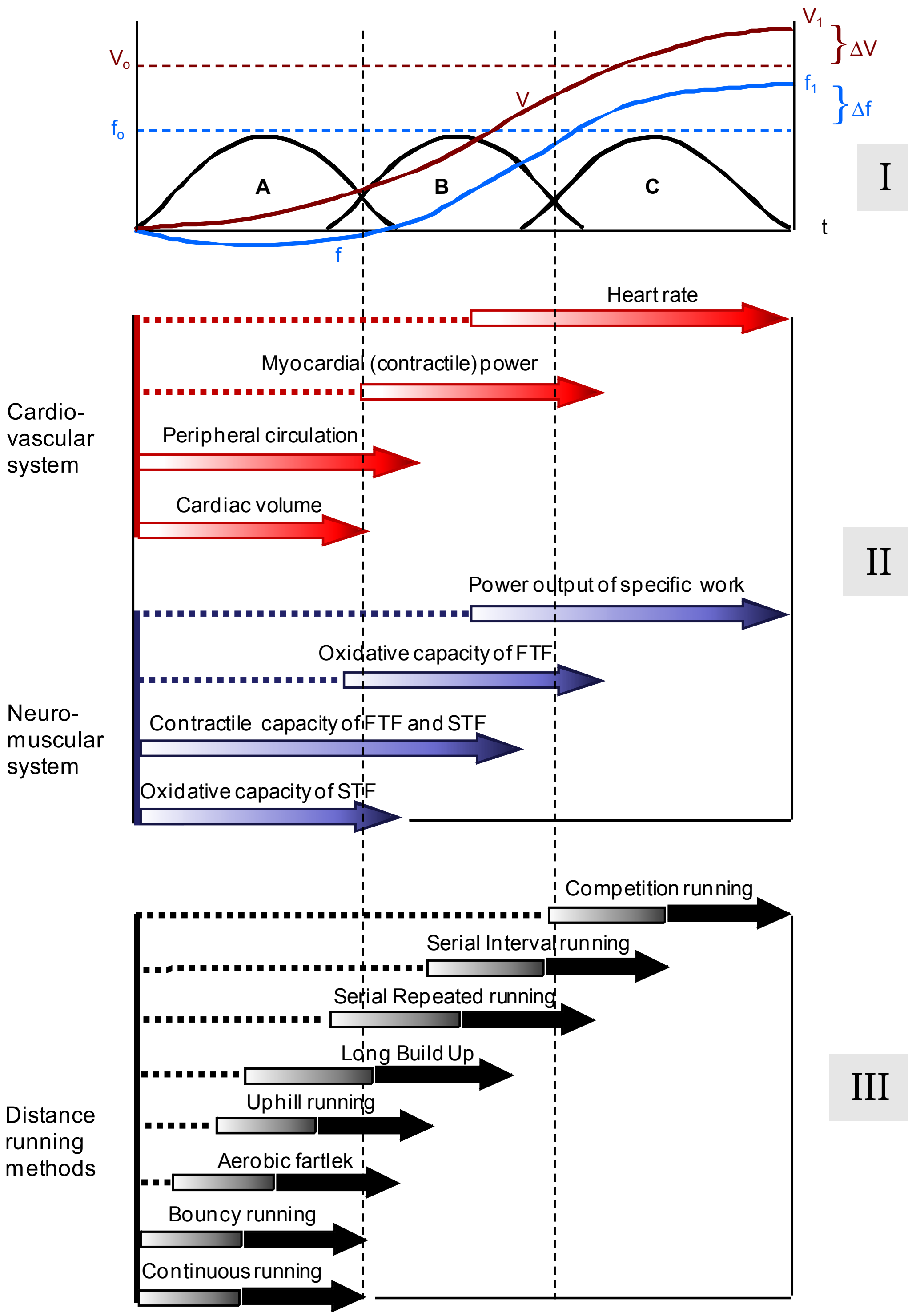


Figure 1 *- General model of BTS in middle distance running and long distance running: the organizational model of training actions on the cardiovascular and neuromuscular systems of the athlete's organism.*

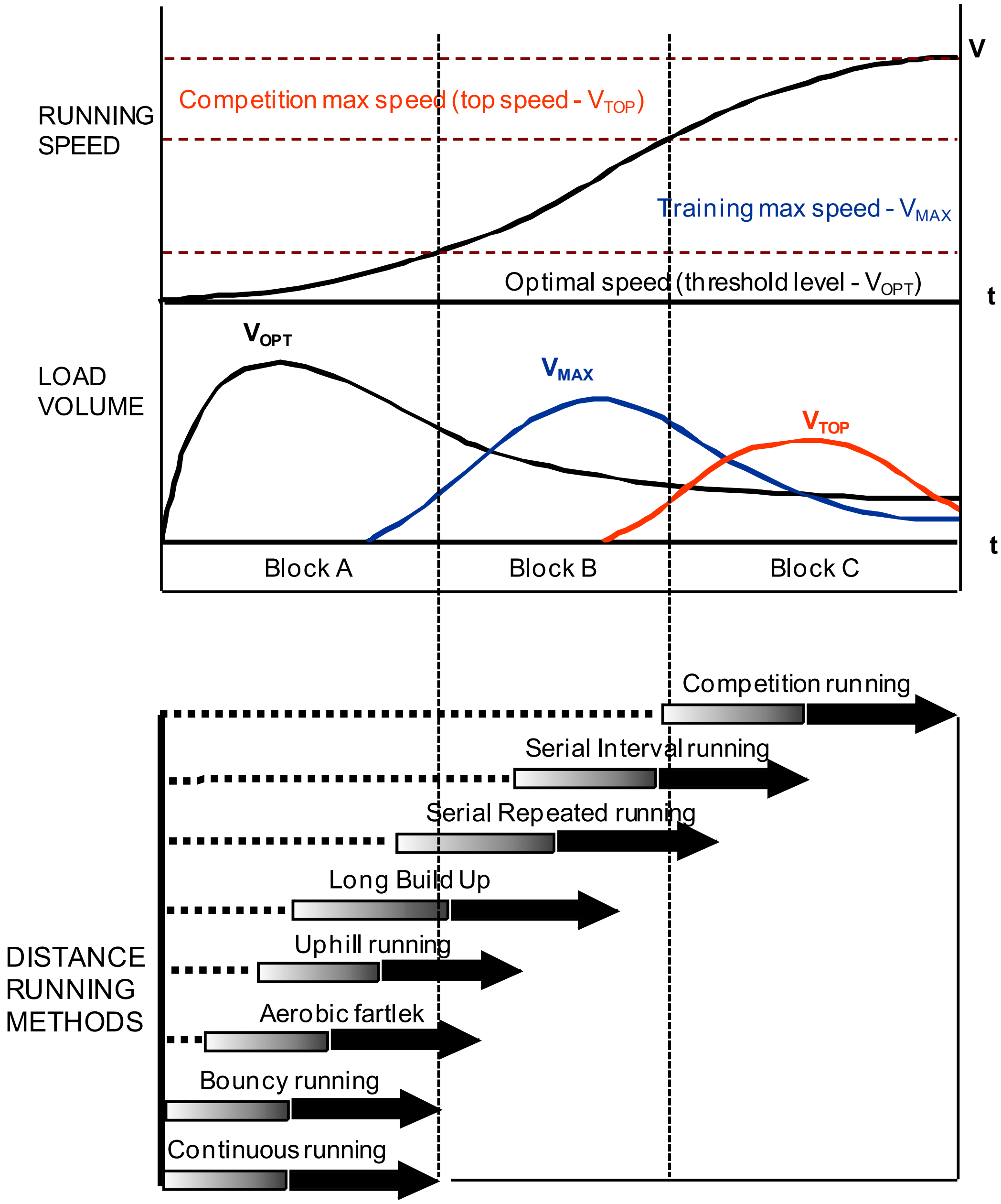


Figure 2 *- General model of BTS in middle distance running and long distance running: the system of distance running training means, organized in relation to the principle of superimposition of loads with different training aims.*

	Block A	Block B	Block C
General Aim	Initiation of adaptation and morphological-functional transformation processes that are necessary to obtain the subsequent intensification of the organism's work in the specific speed regime.	Gradual increase in the organism's work power output in the specific regime of movement under conditions similar to those of a competition.	The final part of organism's adaptation cycle aimed to obtain the maximal level of work power in the specific speed regime, under the influence of competition loads.
Aim at the cardiovascular system level	Increase in the cardiac cavities volume and formation of peripheral vascular reactions.	Increase in the cardiac capacity resulting from the increase in the myocardium contraction power.	Increase in the cardiac capacity resulting from the increase in the frequency of cardiac contractions.
Aim at the neuro-muscular system level	Increase in the muscles contractile capacity and improvement of the oxidative capacity in slow twitch fibres.	Increase in the muscles contractile capacity and contextual increase in oxidative capacity in fast twitch fibres	Increase in the work power of muscular system in the specific regime.
Training contents	Running at the aerobic threshold level. Running speed gradually increases as the aerobic threshold increases. Specific resistance exercises aimed at the increase in explosive strength and in the improvement in local muscular endurance.	Running exercises with gradual increase in speed up to the maximal level and an increase in the running distance, carried out at the competition speed. Exercises aimed at the increase in explosive strength and in the improvement of the reactive capacity in the leg muscles.	Distance running exercises and competition training.
Training Means & Methods	- Resistance exercises (LME) - Uniform running - Bouncy running - Aerobic fartlek - Uphill running - Long build-ups	- 100-120 m progressive build-ups with gradual increase in the maximal speed tract. - Aerobic fartlek - Bounces and Bounding uphill running	- Serial Repeated running - Serial Interval running - Competition (or control) running

***Table 1** - The aims, methods and means of Blocks A, B and C.*

3.2. Running Exercises and their introduction sequence

The system of running loads is composed of means and methods organized in a temporal sequence as described below (see Figure 2):

1) *Uniform prolonged running* - consists of continuous running at a steady speed corresponding to that of the athlete's anaerobic threshold (AT). The execution of this exercise needs to be done with special attention directed towards correct breathing and optimal stride length (i.e., during the running, the upward push off the ground should be rather reactive). At the beginning of Block A, the speed of the uniform prolonged running corresponds to the level of the 1°- 2° intensity zone (from 60% to 70% of VO2 max). Subsequently, during Block A, the running speed is gradually increased up to the 2° intensity zone level (70% -80% of VO2 max) that corresponds to the level of the "ventilatory" Anaerobic Threshold (Wasserman et al 1973). At the end of the Block A, the uniform prolonged running must be gradually replaced by Aerobic fartlek.

2) *Bouncy running or Bouncy Extensive Tempo,* is a repetition running executed with shorter strides with the forward impulse coming mainly from the articulation of the foot and ankle (see § 3.2.1.)

3) *Aerobic fartlek* - consists of prolonged uniform running at the intensity of the athlete's Aerobic Threshold (blood lactate 2 mMol/l), with short distance speed accelerations (see § 3.2.2)

4) *Uphill running* - carried out with an accentuated push and an active forward swinging movement of the recovery leg (see § 3.2.3).

5) *Long Build Ups* - consists of 100-120m runs performed with a smooth increase in speed up to the point where it is kept constant by inertia while holding technical form. (see § 3.2.4).

6) *Serial Repeated running* - consists of distance running exercises carried out at high speeds that are repeated and interspaced with complete recoveries. The length of the runs is determined by the length of the competition distance. At the beginning, the running speed is sub-maximal, then (at the end of the stage B) it becomes maximal. The recovery period between the repetitions should assure the full re-establishment of the organisms work capacity, enough for a good-quality performance in the subsequent exercise.

7) *Serial Interval running* - consists of repeated distance runs carried out at an optimal speed separated by incomplete recoveries. It represents the traditional well-known method of training for endurance in every running sport discipline.

8) *Competition (or control) running* - performed at the competition distance and, now and then, at longer or shorter distances than the competition distance.

According to the sequence previously illustrated, it's possible to assert that the main idea of the training system consists of the gradual increase in intensity of the organism's work regime.

This increase begins with training means aimed to develop Local Muscular Endurance (block A) and then it continues with the training means aimed at decreasing the time needed to cover the competition distance (block B) and, finally with the competition loads (block C).

When resistance exercises are replaced by running exercises (from Block A to Block B), their role changes: from training means aimed to increase the intensity of the organism's work regime to training means aimed at supporting the level of the muscles contractile capacity.

What should be perfected in Block B is not so much the competition exercise speed but rather the capacity of the athlete's organism to develop and to maintain the power in the specific (of competition exercise) work regime. By the completion of this phase, the basic energy systems of the athlete must be sufficiently prepared to carry out the competition distance at the maximum level of the specific power regime (block C).

The speed of the distance running work (the running exercises carried out on the racetrack) should be gradually increased in such a way that it does not excessively fatigue the organism. This is why the speed at which the running exercises are carried out on the racetrack should be strictly controlled and, in every training block, they should correspond to three work power levels (Figure 2):

- *Optimal level* (V_{OPT}) - corresponds to the level of the uniform running work in block A;
- *Maximal level* (V_{MAX}) - corresponds to the level reached by the athlete in block B, when he is able to carry out the distance running without his organism excessive fatigue;
- *Record maximal level* (V_{TOP}) - corresponds to the level reached by the athlete in block C, before the main competitions.

3.2.1. Bouncy Running

Bouncy running or Bouncy Extensive Tempo is running exercise executed with shorter strides with the forward impulse coming mainly from foot work.

Different from the standard runs, this variation requires a more accentuated vertical push and a bouncy overall action. The oscillatory movement of the recovery leg is minimized and the whole action is very relaxed. In fact, the athlete's relaxation is paramount for the correct execution of said exercise, in particular the relaxation of the upper body combined with the intense work of the muscles of the feet.

Upon initiating this type of training, *Bouncy Extensive Tempo* must be carried out on tracks with a soft surface. Two repetitions of 200m and two repetitions of 400m should be performed in the first training session. Three repetitions of 200m and two repetitions of 400m should be performed in the following training session.

Throughout the remainder of these workouts, during the Block A, the exercise must be executed with a gradual increase in the power output of the push offs using one of the following training variants:

- 2-3 repetitions of the distances ranging from 100-150m to 300 m;
- 4-5 repetitions of 200 m with complete recoveries(repetitive method);
- 2-3 series of 2-3 repetitions of 100-150 m (serial-repetitive method). During the rest intervals the runner must perform 2-3 Long Build Ups ranging from 60-80 m.

Relaxation exercises and relaxation movements must be carried out during the rest intervals separating all working efforts for each of the training variants presented above.

It Block B, the *Bouncy running* will be carried out as the Uphill running exercise (see § 3.2.3) using the following training variants:

- 2-3 repetitions of exercises with the middle level of power output, carried out over the distance of 200-300 m separated by complete rest intervals (repetitive method);
- 2-3 series of 2-3 repetitions with the high level of power output, carried out over the distance of 150-200 m, separated by complete recovery intervals between the repetitions and 10-12 minutes rest between each series (serial-repetitive method).

3.2.2. Aerobic Fartlek

Aerobic fartlek is the training method that assures the increase of the anaerobic threshold (AT).

Aerobic fartlek consists of prolonged uniform running (5-8 km) at the intensity of the athlete's aerobic threshold (blood lactate 2 mM/lt), during which time short running accelerations are executed (8-10 sec) with the speed increasing up to maximal level.

The most appropriate fartlek prescription for long distance runners is 10-15 km running with 8-10 sec. accelerations. Longer accelerations can also be used: 100-200 m for middle-distance runners and 300-400 m for long distance runners, at 10-12 min intervals during the running time.

The contribution of the anaerobic mechanism to the energy supply, during the acceleration phases, should not be higher than the level of 4-5 mMol/l blood lactate. The speed reached during the acceleration intervals, their duration, and the number of repetitions is gradually increased from one training session to another. The intervals between the accelerations is maintained and regulated on the basis of the athlete's condition.

It's possible to suggest the optimal volume of threshold level loads. This "optimum", expressed as percentage of global volume of running work, increases according to the increase in the athlete's preparation level.

For long distance runners, the following five levels, of the optimal volume of running loads carried out at AT speed level, are suggested:

	AT running speed (m/s)	**"Optimum" of AT speed loads (%)**
1° level	3.6 - 3.9	15
2° level	4.0 - 4.3	15 - 20
3° level	4.4 - 4.7	20 - 25
4° level	4.8 - 5.1	25 - 30
5° level	5.2 - 5.5	30 - 35

Practical experience shows that, usually, the greatest increase in AT level is assured by the use of 30% volume of AT running loads (until 40%, in the case of high level runners). There are also opinions that suggest, for high level long distance runners, the use of 40-65% AT loads with 45-60 min runs with a cardiac frequency of 170-180 beat/min.

3.2.3. Uphill Running

Uphill running, if correctly applied, is an effective mean for improving several factors of endurance capacity: local muscular endurance, aerobic capacity, and anaerobic lactacid and alactacid capacities.

Unfortunately, the information present in the literature, regarding the degree of the uphill slope, the uphill running distance, the number of repetitions, and the recovery breaks, is contradictory and could be different in relation to an experimental specification in different sport disciplines.

Nevertheless, it's possible to offer advice for Track & Field middle and long distance runners.

Choosing the right uphill track slope is of paramount importance, not just for the extent of the training effect, but also for the degree of specificity of this exercise.

Performing the training exercise on a steeper slope causes a technical change (such as an increase in stride frequency and a decrease in stride length) which lessens the transference to the competition exercise.

Figure 3 presents the results of research that illustrates the change of technique and energetic cost of treadmill running when the slope incline is increased

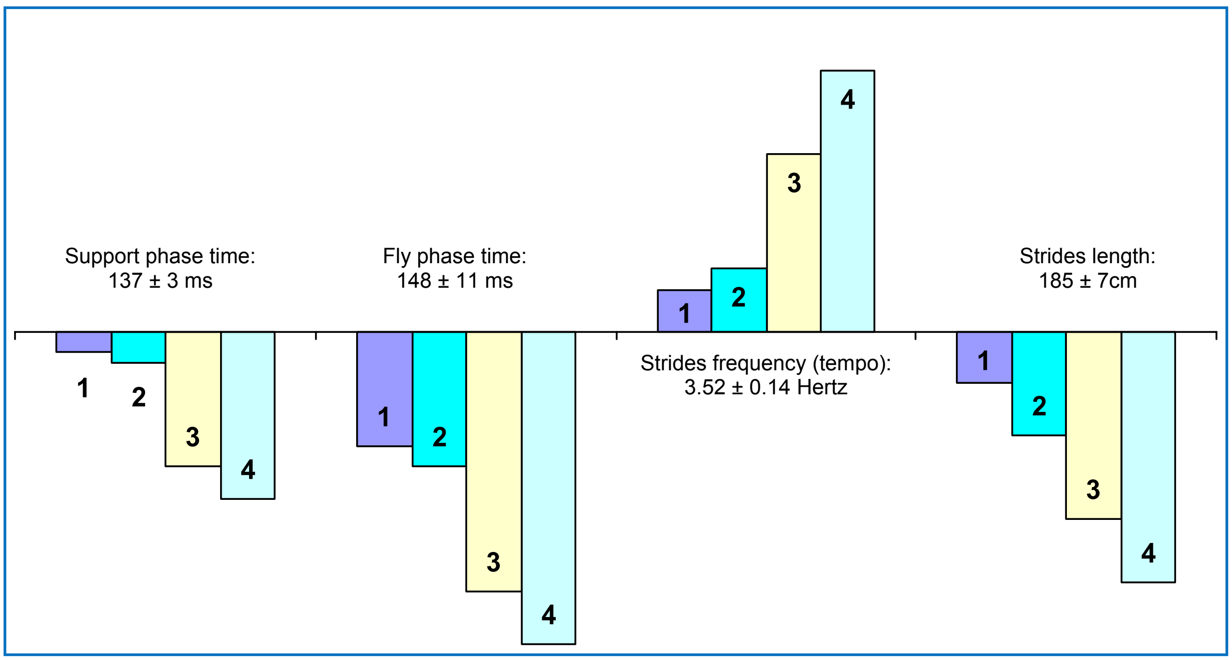


Figure 3 – *Changing of steps parameters in the treadmill running with a speed of 6.5 m/sec (V.L.Mohnov, 1983).*

1. *Treadmill belt inclination 4%*
2. *Treadmill belt inclination 6%*
3. *Treadmill belt inclination 8%*
4. *Treadmill belt inclination 10%*

In the graphic we can see: a decrease in the foot support phase time and flight phase time, a decrease in stride length and an increase in stride the frequency.

Moreover, in this research, one will notice: a decrease of the vertical and horizontal body acceleration during the pushing phase, and an increase in 23% of the energetic cost of running when measured by the oxygen consumption.

It's obvious that the athlete is forced to use more energy to move the centre of mass to a higher level. In order to overcome this difficulty he unconsciously changes running technique, decreases the stride length and increases stride frequency. For this reason, he prefers to be conservative in the pushing phase; increasing the total energy cost of the locomotion; resulting in a complete change in the uphill running training effect. The result is hard and inefficient work.

As stride length is one of most important running parameters, uphill sprinting must be performed with the correct method of exercise execution, not at the maximal running speed, but with maximal pushing power of the leg. This must be accentuated and accompanied with an energetic swing of the recovery leg. So, hill sprints and runs must be executed with a low frequency and with an optimal stride length.

The right choice of hill length is a crucial factor for determining the training effect of this exercise:

1) *Short distance (40-60 m) uphill running exercises* assure the improvement of maximum anaerobic power and of explosive strength. These exercises must be executed at maximum speed. Nevertheless, as it has been outlined before, the unintentional changes in technical form that often occurs in performing said exercise at maximum speed may make it less specific. Thus, it is advisable to perform Bounding Uphill Runs instead, which are performed with an active propulsive movement of the foot plant as well as an active recovery of the swinging leg.

2) *Middle-length distance (150-300 m) uphill running exercises* assure an increase in the power of glycolytic anaerobic energy production mechanism and the power of the CP energy production mechanism, but with a scarce influence on increasing aerobic capacity.

3) *Long distance (> 400 m) uphill running* exercises assure the maintenance of a high level of aerobic capacity and an efficient (with less energy waste) functioning of cardiovascular and cardio-respiratory systems.

Middle and long distance uphill running should be carried out at a speed of about 55-60% of the competition speed. In a training session it should be carried out as follows:

- 10 × 150 m, by middle distance runners
- 10 × 400 m, by long distance runners.

In order to develop the muscles capacity to recover mechanical energy we again suggest the use of *Bounding uphill runs* over the distance of 200-800 m on a low degree slope.

The middle and long distance uphill running can be repeated 5 times in a training session.

The athlete's activity during recovery intervals after each exercise repetition consists of:

- returning to the starting point, with light running;
- 2-3 repetitions of light running (50% of the maximum) over a distance from 100 m to 400 m on a flat track.

For the same aim, uphill *bouncy running* (see § 3.2.1) can be used on a low degree slope (2-3 × 200 m) instead of *bounding running*.

We remind the reader that the necessary technique to perform bouncy running requires a more accentuated vertical push and a bouncy overall action, the oscillatory movement of the recovery leg is minimized and the whole action is very relaxed.

3.2.4. Long Build Ups

Long build-ups are 100-120 m runs performed with a smooth increase in speed up to a point in which speed is kept constant by inertia while holding technical form.

This exercise can be divided into two phases:

- first part of the run, where maximum or sub-maximum speed is reached gradually and then held for an increasing distance, that corresponds to the improvement in the athlete's ability to perform said exercise;
- second part of the run, where the speed reached is kept constant while holding technical form, stride length, and overall relaxation.

The exercise must be performed with a gradual increase in running speed, up to the maximum, for every repetition during every training session. Rest intervals must ensure complete physiological recovery before the next repetition is performed.

Long Build Ups represent an effective training mean to ensure the (gradual) planned adaptation of the organism to the high speed regimen of cyclic sports. The main idea of such training method is the gradual increase of speed up to the maximum and its maintenance for a determined period without undue movement stiffness: the length of the maximum speed distance, that is initially 3-6 strides long, must be gradually increased to 6-9 strides. In the final phase of the exercise execution, the intensity of the stride push must be gradually decreased and, at the same time, the stride frequency, as well as the technical form, must be maintained and controlled up to the end.

3.3. Resistance exercises used to develop Local Muscular Endurance

The resistances exercises are concentrated into block A. Their aim, as already mentioned, is not only directed towards the development of strength but also to ensure an intensification of the organism's work regime in order to improve the local muscular endurance (LME) of the muscle groups specific to the competition exercise.

3.3.1. Description of resistance training means

The training means used to develop local muscular endurance are listed below (Figure 4):

– Barbell Half Squat Jumps, consist of vertical jumps initiated from a semi-squat position with barbell on shoulders.
– Scissor-lunge Jumps consist of vertical jumps initiated from a position with one's legs split wide apart in the sagittal plane (with or without changing the lunge position during the flight phase).
– Vertical Jumps from a semi-squat position holding a Russian Kettlebell.
– Resistance exercises for the hip flexor muscles, carried out on special strength equipment.

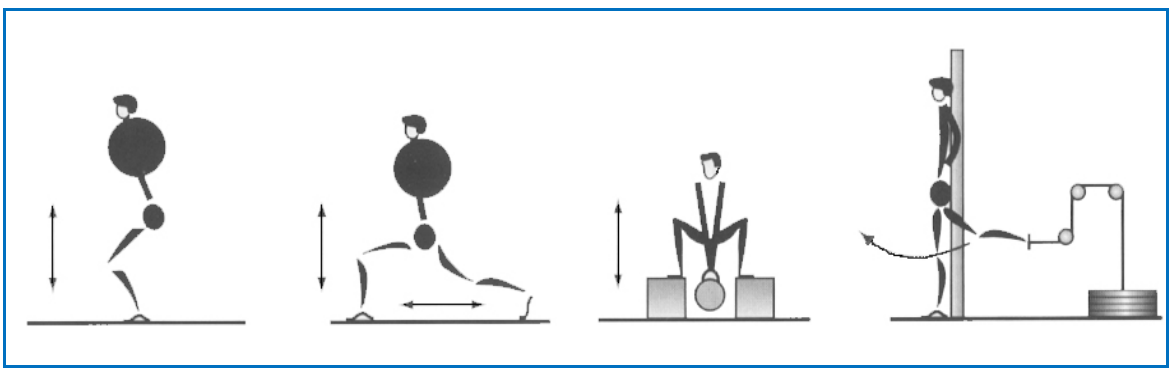


Figure 4 *– Exercises to develop local muscular endurance in lower limbs muscles*

The forward movement of the thigh (last drawing in Figure 4) is carried out from a starting position in which the angle of the coxo-femoral joint is equal to 210°. Force production is accentuated in the early region of the movement trajectory. The overload weight is individually chosen. The movement frequency is equal to 8-10 movements in 10 sec.: 10 movements with on leg and then 10 movements with the other leg (the belt on the ankle is quickly changed with the help of a partner). 2-3 series are carried out in a training session; each one including 6-8 repetitions for both legs.

The recovery interval between each series is 8-10 min. After each repetition, the overload should touch the support during which time instantaneous muscular relaxation must occur.

During the rest intervals between the series, in addition to the relaxation movements, the same exercises may be carried out: 2 repetitions, of 15-20 sec, of the preceding main exercises without overload, at a lower frequency, at a moderate speed.

One may also carry out light bounces or *bounding running* to cover a distance of 30-50 m (2-3 repetitions) or long build ups (60-80 m) of sub-maximal intensity (2-3 repetitions).

3.3.2. Methods of performing resistance exercise

In order to develop Local Muscular Endurance it's possible to use the interval method and the interval-serial method. Regarding the use of either method, two parameters must be regulated: the power output and the temporal regime of exercise.

The power output level depends on the magnitude of resistance and on the movement speed. The temporal regime depends on the movement frequency, on the number of repetitions in a set, and on the length of the recovery interval between the sets and series.

The magnitude of resistance and the speed of movement are responsible for the training influence of this exercise on the main control mechanisms of movements. The temporal regime of this exercise is responsible for its training influence on the energy supplying systems of the muscle work (increasing in their power and in their capacity).

The following variants, of the interval method to develop Local Muscular Endurance, have been verified in experiments:

1st variant - [(WORK 10", RECOVERY 60") x 8-12] x 2-3 (RECOVERY 6-8')

2nd variant - [(WORK 10", RECOVERY 30") x 8-12] x 2-3 (RECOVERY 8-10')

3th variant - [(WORK 10", RECOVERY 10") x 8-12] x 2-4 (RECOVERY 10-15')

4th variant - [(WORK 20-30", RECOVERY 60") x 8-10] x 2-3 (RECOVERY 10-12')

5th variant - [(WORK 20-30", RECOVERY 30") x 6-8] x 2-3 (RECOVERY 10-15')

The first three variants, in which the work interval lasts 10 sec., assure the development of the CP power mechanism (maximal anaerobic power), while the fourth and the fifth variants assure the development of the CP-anaerobic mechanism capacity with moderate stimulation of the glycolytic anaerobic mechanism.

All the five variants influence the increase in power and in capacity of the aerobic mechanism and, at the same time, the improvement of the aerobic effectiveness (the speed of the aerobic function increasing) that plays an important role in the recovery processes during and after the work.

During the use of each one of these variants, intensity needs to be gradually increased in two ways:

- *by increasing the weight and maintaining the movement frequency;*
- *or by increasing the movement frequency and maintaining the same weight*

The results of experimental research, on the optimal regimes of the serial-interval method of LME resistance training, allows us to suggest the use of two versions of the five variants presented above:

1st version

- Sets with short duration (10 sec circa) are carried out.
- Each set includes the repetitions of one of the exercises presented in Figure 4.
- Each repetition must be executed with maximal intensity (maximal power output).
- The frequency of repetitions is one jump per second (or one thigh movement per second).
- At the beginning of the training period each set includes 5-6 repetitions of exercise.
- During the training period, this number must be gradually increased up to 10-12 repetitions.
- The recovery intervals between each set have different durations: 10, 30 and 60 sec.
- At the beginning, when the number of repetitions is 5-6, the recovery interval is 60 sec.
- Afterwards, as the number of repetitions is increased up to 10-12, the recovery interval is decreased: first to 30 sec. and then to 10 sec.
- Each training session must include 2-3 series separated by 8-10 min recovery intervals.

2nd version

- Sets with duration of 20-30 sec are carried out.
- Each set includes the repetitions of one of the exercises presented in Figure 4.
- Each repetition must be executed with a sub-maximal intensity (sub-maximal power output).
- The repetition frequency is one movement per second.
- The number of sets in each series varies from 4-6 to 10.
- The recovery intervals, between sets, last 30-60 sec (see § 3.3.4).

- At the beginning of training period, the number of sets, in each series, is 4-6 and the recovery interval between sets lasts 60 sec.. Afterwards, the recovery interval is decreased to 30 sec., while the number of sets in each series is increased to 10.
- Each training session must include 2-3 series separated by 10-15 min recovery intervals.

3.3.3. Selecting the overload weight and the role of muscle relaxation

The main methodological problem of using the LME interval training method is connected to the choice of the overload weight. Experience has shown that the optimal overload weight is specific to every individual; therefore it's difficult to give general recommendations.

Overload weight depends on: the level of athletes' preparation, individual percentage of slow and fast twitch fibres in the muscles; the volume of the muscle groups involved in the work; the athlete's functional condition; the characteristics and volume of previous loads; and the environment temperature as well as other factors.

Among these factors, what plays an important role is the athlete's capacity to relax the muscles or, at least, to reduce the load on muscles during the execution of the resistance exercises.

The importance of muscle relaxation during the resistance exercises is illustrated in Fig. 5.
The graphics show the trend of blood lactate accumulation during the execution of two exercises with the same overload weight and with the same frequency of repetitions (tempo): Barbell Squats and Barbell Half Squat Jumps. In the case of Barbell Half Squat Jumps, the level of lactate concentration is much lower because the athlete's muscles can be relaxed during the flight phase.

All of the considerations listed above lead to the following conclusion: the overload weight must be chosen individually and empirically so that the athlete will be able to carry out 10-12 repetitions of overload exercise, with a frequency of one repetition per second, free of clear symptoms of fatigue and without a decrease in power output.

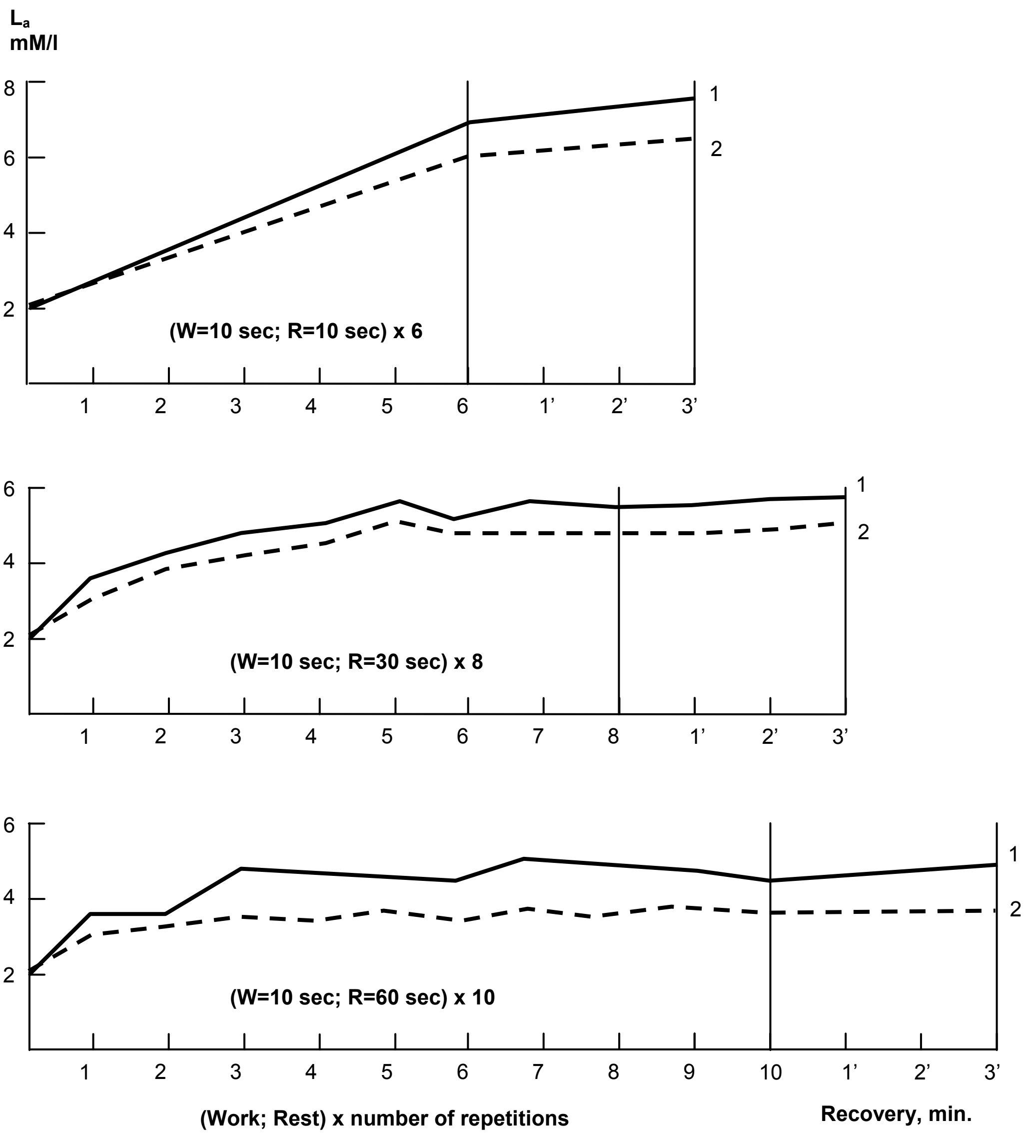


Figure 5 *- Blood lactate concentration, during:*

(1) Barbell Squats,

(2) Half Squat Jumps with a barbell on e shoulders, carried out with the interval method.

The overload weight is 40 kg.

3.3.4. Relationship between overload weight and length of recovery intervals.

The training effect of the LME interval method depends on the overload weight and on the length of the recovery intervals. Figure 6 illustrates the trend of blood lactate concentration during the interval resistance exercises performed with different overload weights (30, 40, 50 and 60 kg) and with recovery intervals of different lengths (10, 30, 60 sec.)

It's possible to observe an increase in blood lactate concentration both when the overload weight increases and when the length of the recovery interval decreases.

When the length of the recovery intervals are 10 sec., blood lactate concentration increases until the end of the work. When the length of recovery intervals are 30 sec. blood lactate concentration increases up to 5-6 sets in a series and, afterwards, it remains the same. When the length of recovery intervals are 60 sec., blood lactate concentration increases up to 5-7 sets.

The shorter the length of the recovery intervals between sets- the higher the increase in blood lactate concentration after the completion of work.

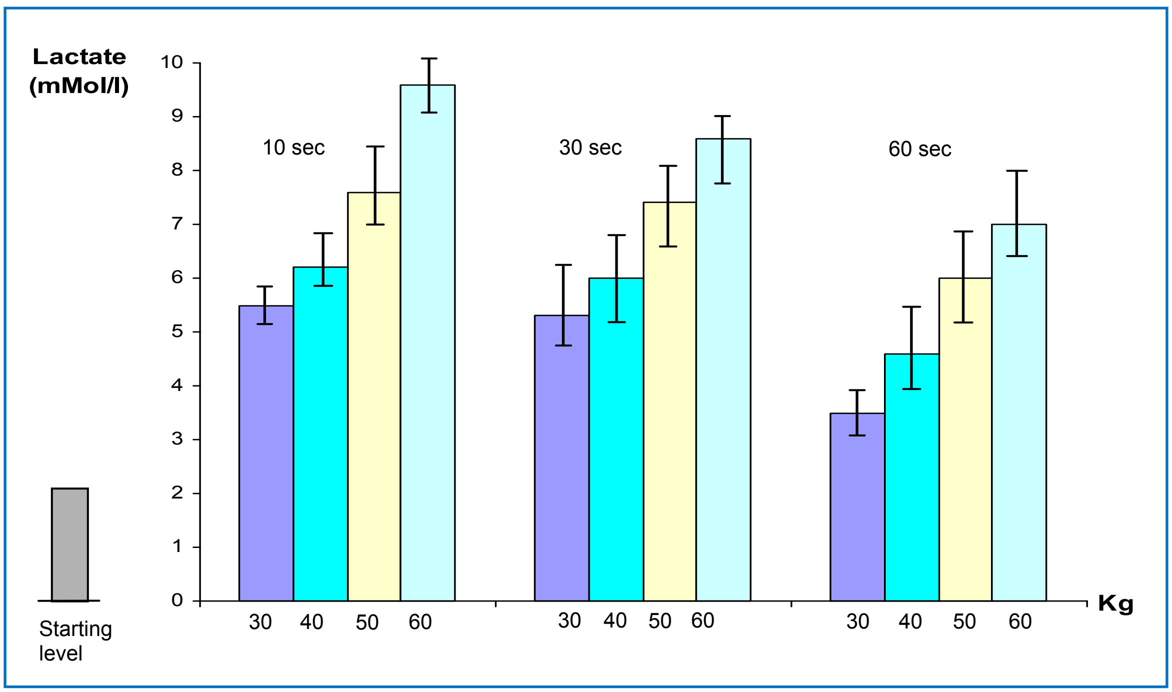


Figure 6 *- Change in blood lactate concentration during exercise with overloads of 30, 40, 50 and 60 kg in the regime at intervals with recovery breaks of different length (10, 30, 60 sec.)*

4. THE EXPERIMENTAL TEST OF MODEL

The training system model presented here was tested for the first time with middle distance runners of medium-high qualification (9) and subsequently with middle and long distance runners of the Soviet National Team (Kulichenko, 1986). The data of the two experiments was comparable and both studies led to the same conclusion.

Since the first experiment was widely exploratory, the data obtained was more significant and more specific than that of the second experiment; this is why we have chosen to illustrate the results of the first experiment.

4.1. Organization of the experiment and the Training Program

The experiment lasted three years and, in each training year, two preparation cycles were scheduled.

The experimental group included 8 middle distance runners, who followed the previously described training program, with only one difference: instead of uphill running, they executed alternating jumps (ten-fold and five-fold) using the serial-repetition method.

The control group consisted of 10 athletes of the same athletic level as the athletes of the experimental group. The control group carried out a training program based on a traditional model.

The main differences between the training programs of the two groups were:

- the distribution of loads with different training emphasis during the preparatory cycle: the experimental group followed a conjugate sequence; while the control group followed a concurrent plan;
- the method of resistance exercise: the experimental group used the LME method, the control group used only general, non specific resistance training;
- the volume of resistance loads: the experimental groups program scheduled a higher volume of resistance and jump exercises and a lower volume of distance running loads in comparison to the control group (Table 2).

Training Means/Period	First year		Second year		Third year	
	Experimental group	Control group	Experimental group	Control group	Experimental group	Control group
Running (km)	2140	3690	2106	3980	1976	4610
Resistance exer-cises (tons)	212	7	226	8.6	272	8.2
Bounces (km)	36.8	21.2	38.4	24.6	47,3	26.6

Table 2 *– Total volume of loads carried out by athletes of experimental and control groups during the experiment*

During the three years of the experiment, the experimental group gradually decreased the total volume of running loads and gradually increased the total volume of SST loads.

Moreover, the total volume of running exercises for the experimental group, executed at an intensity under AT level (with the cardiac frequency under 140 beat/min), was decreased, but the total volume of the running loads executed at the AT intensity (with the cardiac frequency of 140-170 beat/min) was increased. During the third year, the percentage of the total volume of running loads executed at an intensity under the AT level and at the AT level was 30% and 50% respectively in the experimental group, while the ratio was 50% and 30% for the control group.

The special strength training program included basically two variants of exercises with the barbell on the shoulders.

- Squat jumps in place with the feet shoulder-width apart;
- Scissor-lunge jumps.

The load used was 35-45% of maximum in the barbell squat. This weight is used so that the athlete can execute one set of 10 movements with sub-maximal efforts and repeat 6-10 sets without considerable fatigue.

The strength training was carried out two times a week and the dosage was increased as follows:

- 8 x 10 = 8 sets of 10 movements which equates to one series. The number of series is indicated in parentheses.

This special strength training program was elaborated for two "blocks."

The first of them, lasting eight weeks, took place in December-January, and the second block lasted six weeks and took place in March-April.

Even though the second block is executed on the basis of the morpho-functional changes that took place as a result of doing the first block program, the muscle function regime in the second block is more intense.

Program for the First Block

1st day	Squat jumps	6 x 8 (2) Rest interval between sets, 60 sec. between series, 8-10 min.
3rd day	Squat jumps	8 x 10 (2) Rest interval between sets, 60 sec., between series, 8-10 min.
4th day	Scissor-lunge jumps	8 x 10 (3) Rest interval between sets, 60 sec., between series, 8-10 min.
5th day	Squat jumps	10 x 10 (2) Rest interval between sets, 60 sec., between series, 8-10 min
6th day	Scissor-lunge jumps	6 x 8 (2) Rest interval between sets, 30 sec. between series, 8-10 min
7th day	Squat jumps	6 x 8 (3) Rest interval between sets, 30 sec., between series, 8-10 min.
8th day	Scissor-lunge jumps	10 x 10 (3) Rest interval between sets, 60 sec., between series, 10-12 min.
9th day	Squat jumps	8 x 10 (2) Rest interval between sets, 30 sec., between series, 8-10 min
10th day	Scissor-lunge jumps	6 x 8 (2) Rest interval between sets, 30 sec., between series, 8-10 min.
11th day	Squat jumps	8 x 8 (3) Rest interval between sets, 10 sec., between series, 10-12 min.

12th day	Scissor-lunge jumps	10 x 10 (3) Rest interval between sets, 30 sec., between series, 10-12 min.
13th day	Squat jumps	8 x 10 (3) Rest interval between sets, 10 sec., between series, 10-12 min.
14th day	Scissor-lunge jumps	10 x 10 (3) Rest interval between sets, 10 sec., between series, 10-12 min.
15th day	Squat jumps	10 x 10 (4) Rest interval between sets, 10 sec., between series 12-14 min.
16th day	Scissor-lunge jumps	10 x 10 (4) Rest interval between sets, 10 sec., between series 12-14 min.

Program for the Second Block

1st day	Squat jumps	8 x 10 (2) Rest interval between sets, 60 sec., between series, 8-10 min.
2nd day	Scissor-lunge jumps	10 x 10 (3) Rest interval between sets, 60 sec., between series, 8-10 min.
3rd day	Squat jumps	10 x 10 (2) Rest interval between sets, 30 sec., between series, 8-10 min.
4th day	Scissor-lunge jumps	10 x 10 (3) Rest interval between sets, 60 sec., between series, 8-10 min
5th day	Squat jumps	10 x 10 (3) Rest interval between sets, 30 sec., between series, 8-10 min.
6th day	Scissor-lunge jumps	8 x 10 (2) Rest interval between sets, 10 sec., between series, 10-12 min.
7th day	Squat jumps	10 x 10 (4) Rest interval between sets, 30 sec., between series, 8-10 min.

8th day	Scissor-lunge jumps	10 x 10 (3) Rest interval between sets, 10 sec., between series, 10-12 min.
9th day	Squat jumps	10 x 10 (4) Rest interval between sets, 30 sec., between series, 8-10 min.
10th day	Scissor-lunge jumps	10 x 10 (4) Rest interval between sets, 10 sec., between series, 10-12 min.
11th day	Squat jumps	10 x 10 (4) Rest interval between sets, 10 sec., between series, 10-12 min.
12th day	Scissor-lunge jumps	10 x 10 (4) Rest interval between sets, 10 sec., between series 10-12 min.

Besides these exercises with the barbell, runners effectively used special exercises for the development of explosive strength and local muscular endurance of the hip flexors (hip joint flexion).

- These movements were executed with an emphasis on placing the effort at the beginning of the working amplitude [range of motion].
- The weight is selected individually so that it is possible to execute the exercise at the rate of 6-8 repetitions in 10 seconds.
- Ten movements are done with one leg and then the other.
- The optimal amount in one series is 5-6 sets on each leg (by turns).
- In total, there are 2-3 series with a rest of 8-10 minutes in between.
- Between repetitions, the weight should return to a support position in order to achieve instant relaxation of the muscles.
- The rate of executing movements was increased by small degrees.

The exercises for the hip flexors were included in the training two times a week in order that the work for the leg extensors and for the hip flexors could be executed on different days.

4.2. Control test procedures and parameters

Control tests were conducted three times a year and included:

- Local Muscular Endurance test (LME test), which consisted of Barbell Half Squat Jumps execution (8 series of 10 seconds of work and 30 seconds of recovery) with the recording of blood lactate concentration during the exercise execution and in the third minute of recovery after the work;

– Maximal speed to cover a distance of 20 m, without starting phase (VMAX running) ;
– Running speed at the Anaerobic Threshold (VAT running), with the recording of stride length, frequency and stride support phase time;
– The index of maximal force displayed in the maximal explosive Leg Press movement with an overload equal to the bodyweight of athlete (FMAX)2.
– Ten-fold long jumps and 30m sprints were tested every month.

The work load volume was recorded during every training session and, on the basis of the data, calculations were made for the volumes of every type of load carried out each month.

4.3. Results of the experiment

4.3.1. Results related to the parameters of running and their correlations with test results.

1) It has been highlighted that a sound correlation exists between V_{AT} running and the results in 800m runs (r = 0.617), 1500m runs (r = 0.686) and 3000m runs (r = 0.756). This suggested that V_{AT} represents the informative parameter of the specific functional level for middle and long distance runners.

2) Stride length at V_{AT} running is soundly correlated to the stride length at V_{MAX} running (r = 0.756). Both parameters are soundly correlated to the value of F_{MAX}: the stride length at V_{AT} running is r = 0.828 and the stride length at V_{MAX} running is r = 0.695.

3) The stride length at V_{AT} running is negatively correlated to the level of blood lactate accumulation during the LME test execution (r = - 0.693). This negative correlation confirms the validity of LME test to evaluate athlete's specific functional level and, indirectly, to evaluate the validity of the "Antiglycolytic" principle.

4.3.2. Results related to the influence of training loads on running parameters and on control test parameters.

The analysis of the correlations between the increase in the control group running parameters and the increase in the strength parameters, during three years, the analysis of the correlations between the increasing parameters, in all tests, and the volumes of different training loads carried out by the athletes, lead to the following conclusions:

[2] For the "Force - Time" curve registration, it has been used the Universal Dynamometric Stand (UDS -3). *(Editor's note)*

1) The increase in the parameters of running at V_{MAX} and the increase in the parameters of running at V_{AT} are soundly correlated to the increase in F_{MAX}, with the following values of “r”:
   - r = 0.828, for the increase in stride length at V_{AT} running;
   - r = 0.695, for the increase in stride length at V_{MAX} running;
   - r = 0.688, for the increase in strides support time at V_{AT} running;
   - r = 0.686, for the increase in stride flight time at V_{MAX} running.

2) The increase in stride length at V_{MAX} running is soundly correlated to the volume of two types of work carried out by athlete: resistance exercises (r = 0.597) and jump exercises (r = 0.760).

3) The increase in F_{MAX} is soundly correlated to the total volume of resistance work carried out by athlete (r = 0.718).

The results illustrating the increase in the jumping tests are shown in Table 3 and Figure 7.

Bounces	**Group**	**Initial results (m)**	**Final results (m)**
Ten fold jump	A	24.76 ± 2.01	32.64
	B	24.86 ± 1.22	25.94
Triple jump	A	7.31 ± 0.28	9.21
	B	8.22 ± 0.56	7.65

Table 3 *- The results of jumping test of experimental (A) and control (B) groups.*

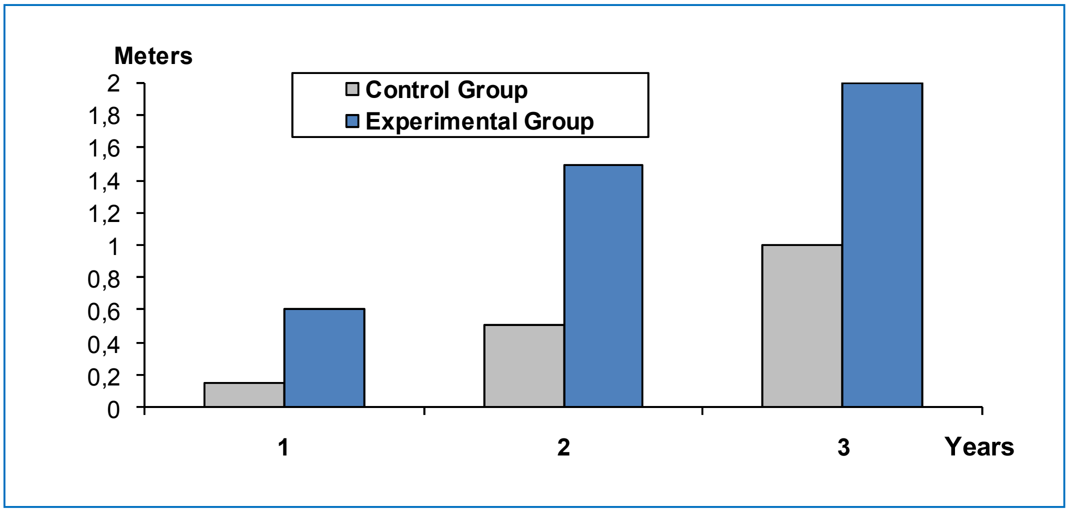


Figure 7 *- The increase in the 10 fold leg to leg bounce obtained during three years by the athletes of experimental and control groups.*

4.3.3. Results related to the parameters of the LME Test and to their evolution under the influence of interval resistance work

The results of the LME test obtained during the three years by experimental (A) and control (B) groups are presented in Figure 8 and Figure 9.

During the first year, the method of interval resistance training was not fully elaborated. As consequence, the athletes of experimental group participated in the preliminary research with the use of resistance exercises to develop the LME (see § 3.3) and performed jumping exercises (leg to leg bounces).

For this reason, at the end of the first year, great differences were not observed in the LME test results between the experimental and control groups.

During the second and third year, the experimental group started to use interval resistance exercises in the optimal way. Consequently, during the execution of the LME test, the blood lactate concentration decreased and, at the end of the third year, it didn't exceed the Anaerobic Threshold level (4 mMol/l).

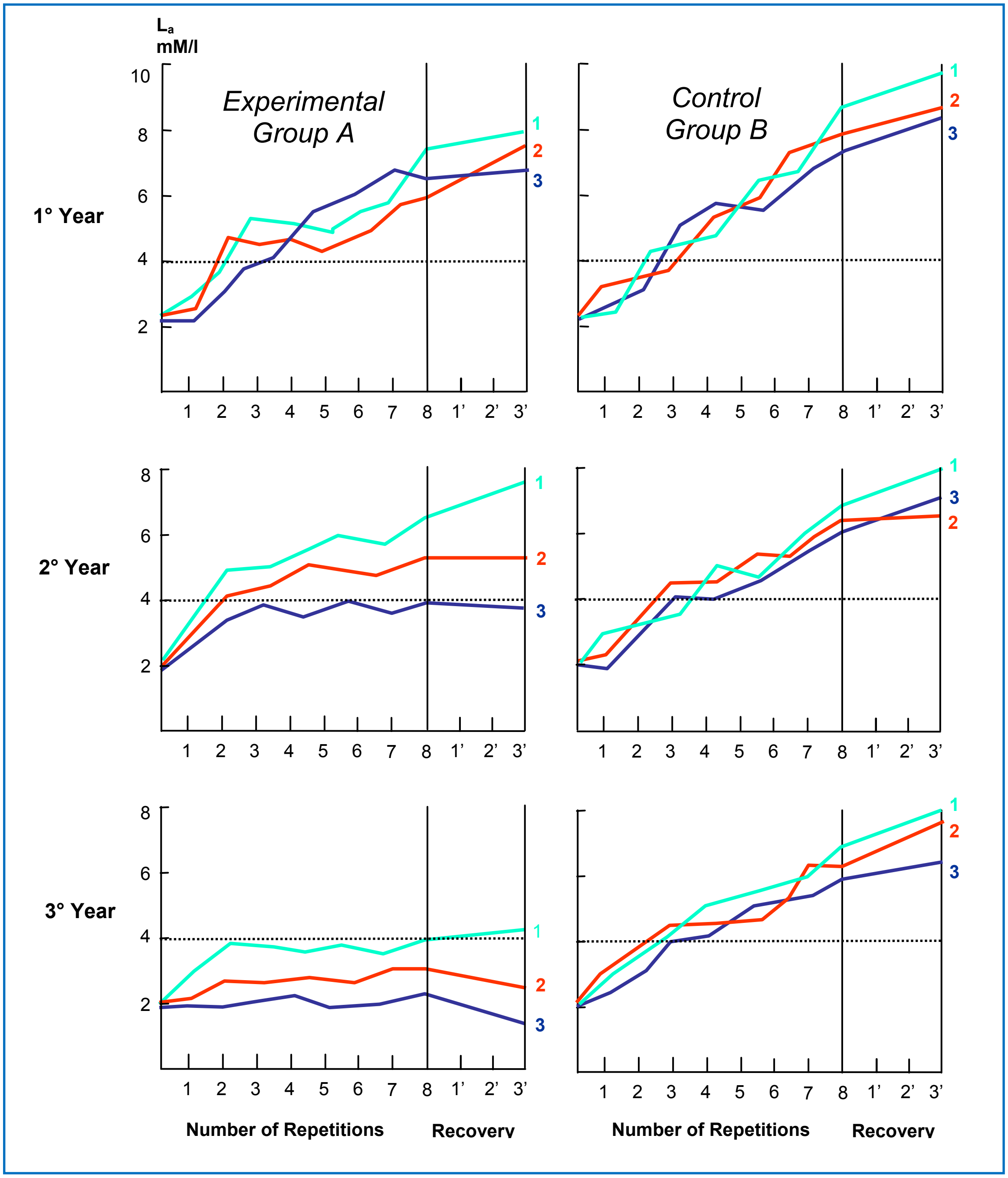


Figure 8 *- The changing of the blood lactate concentration during the execution of the control LME test in October (1), January (2) and July (3) of each of three years of experiment in the experimental (A) and control (B) groups.*

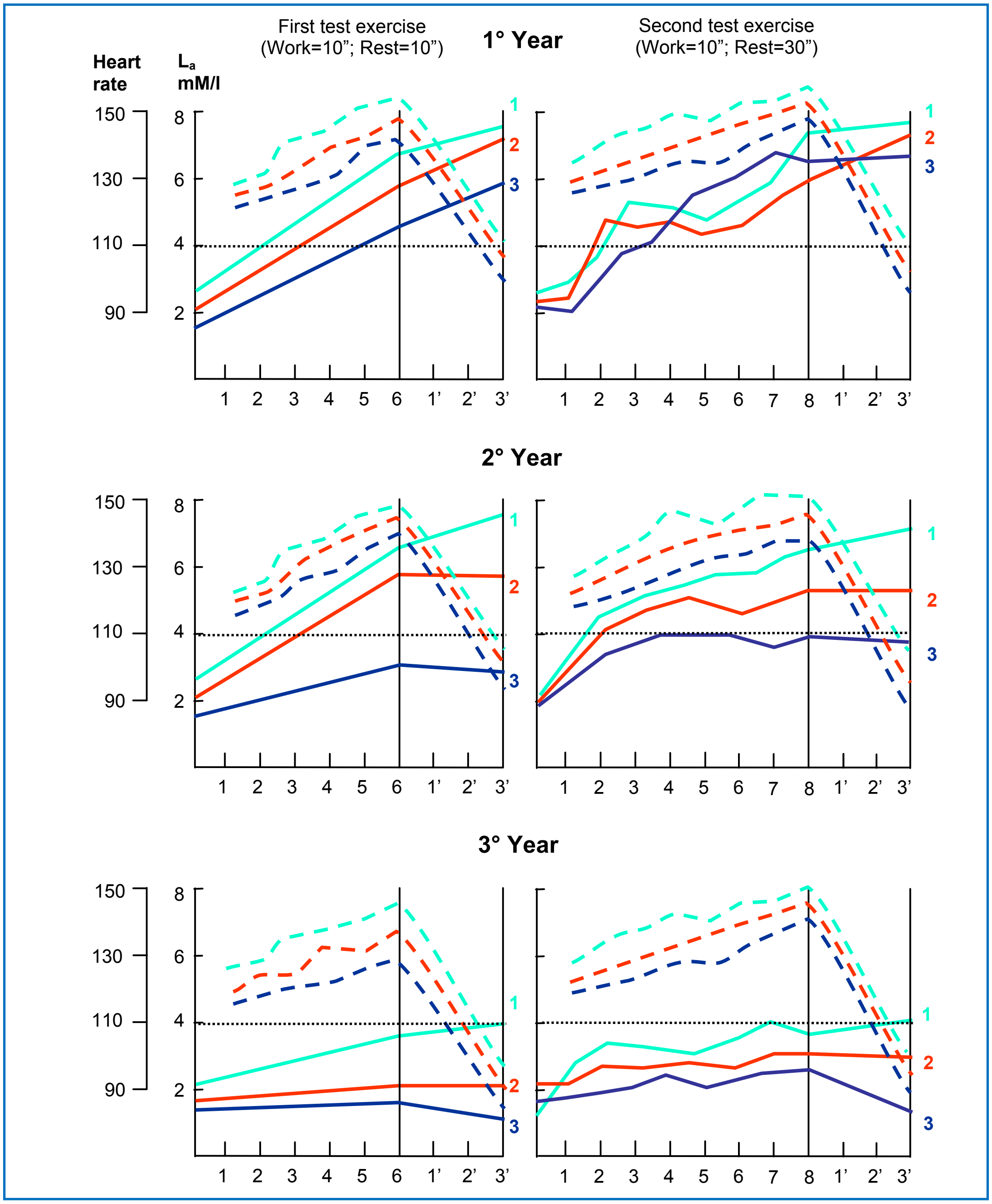


Figure 9 – *Variation of blood lactate concentration and of heart rate during the execution of two variants of LME test by athletes of the experimental group during the three years. The first test exercise is the Barbell Half Squat Jumps executed in the regime of 10 sec work -10 sec rest (left). The second test exercise is the Barbell Half Squat Jumps executed in the regime of 10 sec work – 30 sec rest (right). The tests were made in October (1), in January (2) and in June (3).*

The results of the experimental group show that:

- In the second and third year, the standard work of the LME test yielded a blood lactate concentration much lower than the first year. In the third year, blood lactate concentration was lower than the blood lactate concentration at the AT level. While, in the first year, lactate increased until the end of the LME test. In the third year, this accumulation was noted only during the first three repetitions of the LME test exercises and then it remained the same.
- During the three stages (October, January and June) of the first year, it was not possible to notice differences in the concentration and in the dynamics of the blood lactate level during the LME test. In the second and in the third year, it was not possible to notice a considerable decrease in the blood lactate concentration between one stage and the others.
- The tendency of blood lactate concentration to decrease in the third minute of recovery is a symptom of the considerable increase in muscles oxidative capacity; which was observed in the second and especially in the third year.

At the end of the experiment we noticed a decrease in the value of blood lactate after the LME test, which showed a sound correlation with the total volume of the interval resistance work ($r = 0,637$).

4.3.4. General results of the experiment

At the end of the experiment, the athletes of the experimental group that carried out a total year's volume of distance running work (3000-3500 m), that was 2 times lower than control group (6000-7000 m), showed results, in the running of 800 m, 1500 m and 3000 m, that were considerably better than the athletes of the control group (Table 4).

			1° year		2° year		3° year		
Distance	**Group**	**Results before experiment**	$\bar{X}_1$	Δ_1	$\bar{X}_2$	Δ_2	$\bar{X}_3$	Δ_3	$\sum\Delta$
400 m	A	52.08 ± 0.91	51.17 ± 0.86	0.91	50.40 ± 0.81	0.77	49.60 ± 0.72	0.80	2.48
	B	51.86 ± 0.30	51.12 ± 0.43	0.74	51.16 ±1.07	- 0.04	50.64 ± 0.89	0.52	1.22
800 m	A	1.56.37 ± 3.60	1.54.83 ± 1.57	1.54	1.54.12 ± 1.60	0.71	1.53.05 ± 1.35	1.07	3.32
	B	1.54.86 ± 3.80	1.54.36 ± 2.44	0.50	1.54.27 ± 2.93	0.09	1.54.16 ± 2.82	0.11	0.70
1500 m	A	4.00.17 ± 3.57	3.58.55 ± 2.44	1.62	3.57.64 ± 3.11	0.91	3.56.52 ± 2.96	1.12	3.65
	B	4.00.51 ± 4.80	4.00.14 ± 4.86	0.37	4.01.50 ± 6.84	-1.36	3.59.68 ± 5.97	1.82	0.83
3000 m	A	9.12.24 ± 12.50	9.03.68 ± 5.87	8.56	8.56.18 ± 8.12	7.50	8.44.30 ± 7.93	11.88	27.94
	B	9.06.74 ± 16.12	9.00.30 ± 9.64	6.69	8.56.40 ± 11.42	`3.90	8.51.93 ± 14.97	4.47	15.87

Table 4 - *The sport results in the distance running of the experimental (A) and control (B) groups.*

In the experimental group, the development, during the three years of the Local Muscular Endurance training through the use of specialized resistance exercises, assured an increase in:

– stride length at V_{MAX} running, equal to 2.9%;
– stride length at V_{AT} running, equal to 5.8%.

In the control group, that used a traditional methodology, these increases were lower: 1.7% and 2.8% respectively (Table 5).

Parameters of running	Groups	at V_{MAX}	at V_{AT}
Stride lengths	A	2.9 %	5.8 %
	B	1.7 %	2.8 %
Tempo	A	1.7 %	0.7 %
	B	2.5 %	-

***Table 5 -** The changing of strides length and tempo of running in the experimental (A) and control (B) groups.*

The 3-years dynamics of all control parameters, average value of 4 athletes of experimental group, is showed in Figure 10.

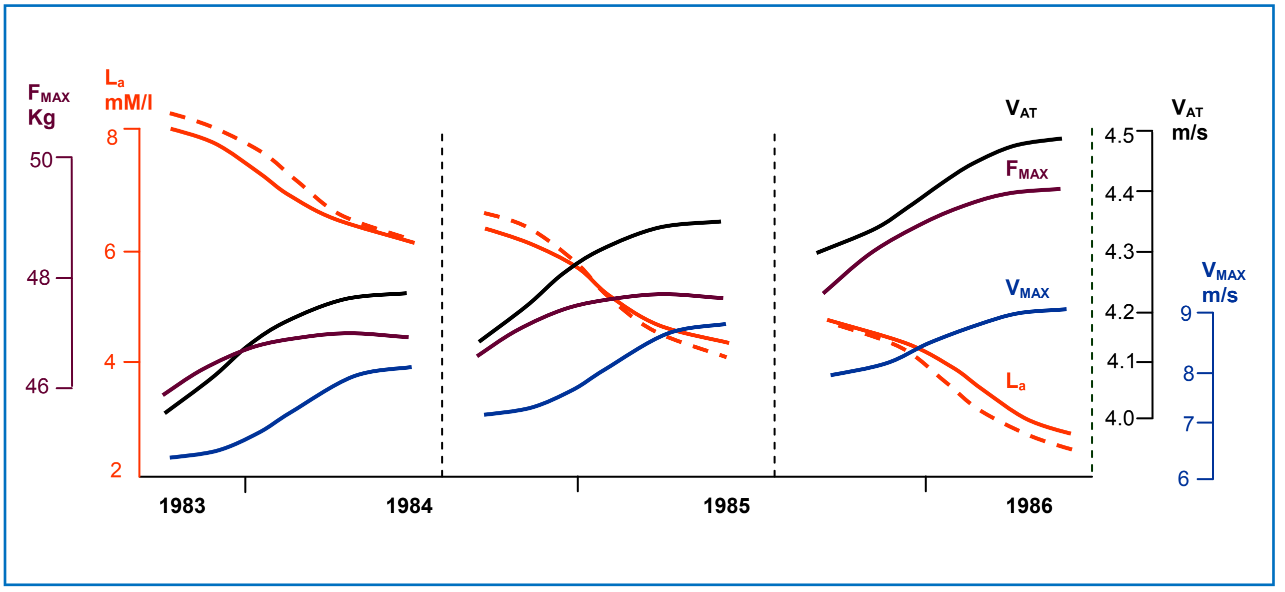


***Figure 10 -** The tendency of the control parameters dynamics (4 athletes of the experimental group):*
*– **V_{AT}**, the running speed at the Anaerobic Threshold level*
*– **F_{MAX}**, the index of maximal force displayed in the maximal explosive Leg Press movement with the overload equal to the bodyweight of athlete*
*– **V_{MAX}**, maximal speed to cover the distance of 20 m*
*– **La**, blood HLA concentration during the Local Muscular Endurance test execution*

CONCLUSIONS

Research and practical experience have confirmed the high effectiveness of the Block Training System, with interval resistance training, for middle and long distance runners.

1. From experience we may deduce that if the athlete carries out only track race training, even if it favours the perfection of the function of the organism's vegetative (autonomic) nervous system, the track race training alone is not able to trigger an adequate training stimulus to increase the muscles' oxidative and contractile capacity.

   Therefore, if the athlete's training is carried out only with track race training means, it can cause an imbalance between the muscular and autonomic nervous systems; which doesn't assure the improvement in the specific work capacity.

   In order to eliminate the risk of this imbalance, the training process should be aimed at finding a solution to two correlated issues:
   - to ensure a higher effectiveness of cardiovascular system (the capacity to provide oxygen to working muscles);
   - to increase, effectively, the capacity of muscular tissue to use and extract oxygen provided by the cardiovascular system.

   Research and experience have confirmed that both issues can be solved by the use of the Block Training System which integrates specialized methods of resistance training. The use of these methods, among other things, can replace many kilometres of distance running, assuring a decrease in the total volume of training loads.

2. In the Block Training System, the conjugate-sequence of load organization solves some methodological issues which, for high level athletes, are very important. In the BTS, the phases of work aimed at increasing the organisms functional capacity (the power of the physiological systems that are directly linked to competition results) and the phase of work aimed at increasing the maximal average speed of the competition distance running (competition running speed), are placed in different training stages. The special strength loads are concentrated in block A. The work aimed at increasing the maximal average speed of competition distance running is concentrated in block B.

   In this way, the work aimed at increasing the competition running speed is not limited by the athlete's organism's functional capacity. At the same time, the loads aimed at increasing the athlete's functional capacity don't interfere with the work aimed at increasing the competition running speed.

3. In the Block Training System, the concentration of strength loads in block A, which assures the increase in training stimuli, could lead to a decrease in athlete's specific work capacity.
   This decrease is due to the strong training effect on the athlete's organism. For high level athletes, this strong training effect is necessary to trigger the adaptation process. At the same time, this decrease creates unfavourable conditions to the training work aimed at increasing the competition running speed. For this reason, the concentrated strength loads and loads aimed at increasing the competition running speed should take place in different training stages.

   Nevertheless, the decrease of the athlete's specific work capacity is temporary. After the conclusion of Block A, one will observe a gradual and stable increase in athlete's specific work capacity till a level that is higher than the initial level in Block A.

   In other words, resistance exercises must precede the concentrated work directed towards increasing the competition running speed. The Long Lasting Training Effect (LLTE) of concentrated strength loads assures the increase of these loads effectiveness in Blocks B and C. In fact, resistance exercises prepare the organism for the high intensity work and assure that this work is carried out under favourable conditions (when organism is at a high level of work capacity).

4. It's important to point out that in the Block Training System model described here, the preparation and competition periods do not have the same meaning as in the traditional methodological approach; which prescribes the subdivision of the training process into two parts only formally connected: the preparation period with a high volume of training loads and the competition period with the participation in competitions.

   The proposed system is a new form of training organization in which there is an organic and interdependent connection between the training and competition activity; which assures a steady development of the adaptation process. In other words, the stage of the so called "immediate preparation" for competition and the competitions are included in the "uninterrupted" process of adaptation to the specific work regime. It consists of the maximum intensification of the organism's work regime in the final phase of the adaptation cycle (block C), which leads the athlete to that level, of specific work capacity, at which the main aims of preparation can be reached.

5. Another innovation in this Block Training System model is a non-traditional training stage (block B), which plays an important role. In block B, the contribution of specific work in training process is increased, thus is assured a gradual transition from the special physical preparation, to the specific speed work and to the participation in competitions.

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Edited by *Natalia Verkhoshansky, PhD*