

# **ARTIFICIAL CONTROL OF THE ENVIRONMENT FOR FORMATION AND PERFECTION OF MOTOR FUNCTIONS IN SPORT**

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## **Summary**

The basic contradictions in the formation and perfection of movements in the classical schemes of the traditional system of sports training are considered. The basic contradiction is between biomechanical rationality of sports or training exercise which increases and the probability of obtaining desired physiological results which decreases. This leads to the need for differentiation between the purposes of application of each of the means of technical preparation. Since variation of modes of performance of training exercises has a certain target (provision of the basis for enhancement of sports results through increase and summation of training effects), the set of means and methods for this purpose should provide a possibility for persistently crossing the limits of the natural motor modes across the whole set of parameters. Each of the means of technical training according to its target functions can play the role of a means of conjugate training providing simultaneous increase of power or velocity potential supplemented with formation and consolidation of mental images of movements with new properties.

In view of the above mentioned statements, movements of a human being and their perfection are treated not just as a result of interaction with the surrounding environment, but as a specific interaction, when physical properties of this environment are purposefully changed. It means that in such way it is possible to influence purposefully the character of motion through adaptive motor reactions of a human being in the conditions of his/her continuous interaction with the surrounding environment (that can be termed as “an external control system”). The author proves that in the process of management of human motions there is an internal (nerve mechanisms) and

an external system, coordinated functioning of which allows creation of the whole motor activity of a human being.

The limitations of the traditional system of sports preparation can be removed by a combination of the traditional scheme with a specially organized artificial environment. The latter is implemented in the form of biomechanical benches, special training gadgets, exercise machines, sports equipment and tools. In each specific sports exercise they provide energy, power, coordination help to a sportsperson, protecting the locomotor apparatus from overloads, and improving motor activity management.

Several examples demonstrate how it is possible to organize the process of preparation of sportspersons within the framework of methodology of an artificially controlled environment aimed at high and even record sports results.

## **1. Introduction**

Human motion follows the same physical laws governing any material body on the Earth. These are the law of universal gravitation, the Newton's laws, laws of hydrodynamics, fluid mechanics, oscillation and wave dynamics, etc. The motion of a human body, as a rule, is quite complex, since the locomotor apparatus of a human body is a very difficult mechanical system. It consists of more than 200 bones, several hundreds of tendons. The total number of possible movements in joints (so-called, degrees of freedom) exceeds 250, the number of muscles, providing motion, is more than 600. All these components are necessary for provision of purely mechanical displacement of a human body in the surrounding medium.

The action of muscles is a biological process, in which muscular filaments must be activated so that they perform some mechanical work, moving the corresponding parts of a human body. Some energy is necessary for this work. In a human body, energy is the result of biochemical reactions. From a mechanical point of view, a human body is a system, possessing an internal energy source of biological origin. For muscular contractions in corresponding sequence and with a certain force (and, eventually, for required mechanical effect of movement) muscles must be controlled (managed). The human brain and the nervous system (functioning together as a biological system) manage all movements. For the operation of biological control mechanisms of a central nervous system the human brain possesses higher mental functions, such as motivation, cognition, programming, which influence directly the process of formation and execution of neural commands.

The psyche of a human being is qualitatively distinct from the higher nervous activity of animals. It manifests also in motor activities. Only a human being can purposefully do exercises, set a certain purpose of motion, understand its meaning, control and perfect motions, perfect the surrounding medium, special gadgets for increasing the mechanical effect of motor activities. Only a human being is able to perform higher symbolical movements - not only speech, but also drawing, playing musical instruments, dancing, pantomime, etc.

An overwhelming majority of human movements is performed with a certain purpose and they represent voluntary movements. Such motions are a part of motor activities, i.e. they are included in a set of elementary motor acts, directed to achieve a certain purpose. In each motor act there are orienting, executive and control parts. The executive part is mechanical motion itself. But it is always determined by mental and physiological activity of a human brain, providing not only direct control of motions, but also orienting and controlling parts of motor by using systems of internal biological feedback.

From this point of view we understand, that human motion itself is interaction of his/her internal systems with the external environment. Aristotle wrote: “Any moving animal changes its position pressing the underlying surface“. R. Enoka considered motion as a result of interaction of a certain biological system and its external environment through functioning of neuromechanical systems of an organism (we can treat it as an internal control system). I. P. Ratov and G. I. Popov have extended this approach, asserting that human motion and self-perfection in motion must be considered as a result not just of interaction with a certain environment, but specific interaction, when the physical properties of the surrounding environment are purposefully varied. It means that in such way it is possible to influence purposefully the character of motion through adaptive motor reactions of a human body in conditions of its continuous interaction with the environment (that can be named “external management“).

Hence, in motion management there are internal and external systems of management, coordinated functioning of which allows one to create the whole motor act of a human body.

## **2. Contradictions in Formation and Perfection of Movement**

A traditional process of training sportspersons is connected with a gradual attainment of a prescribed level of biomechanical, physiological and power parameters, leading to improvement of sports results. During this training process (training is understood here not only as a process of initial mastering of a certain motion, but also as transition to a higher level of performance of a certain exercise within the framework of motion perfection) some contradictions arise.

Transition to increasingly significant results is a steady process of “training – re-training“. It is connected with the fact that demonstration of a certain result requires stabilization of motor skills, and on the other hand, such stabilization hinders improvement of sports results, since for this purpose it is necessary to generate new motor skills. An effective method of achievement of higher results, namely, sports technique, cannot be mastered out of conditions and motor modes, corresponding to these results.

One more contradiction of motion mastering is due to the fact, that the whole daily practice of usage of training methods is built on formation of internal content of motion by means of attempts of the trainee to imitate some etalon external forms of a certain sports exercise demonstrated by a trainer as an example.

At the same time, it is obvious, that external forms of movements are a consequence of changes of their internal content, namely, coordination interaction of muscular groups (intermuscular coordination) of a sportsperson in a specific sports exercise. Not only deep rooted centuries-old practice of training on the basis of imitation, but also practical lack of any methodical means for control over correctness of forming of internal content of movements hindered comprehension of the mentioned contradiction. Problems of a trainee with fast mastering of complex exercises have forced sportspersons and trainers to use training schemes, in which motor tasks are performed through their simplification and division into elementary exercises.

Another contradiction that is also connected with laws of intermuscular coordination is due to the fact that the greatest probability of formation of rational intermuscular coordination appears only in conditions of absence of external hindrances to performance of mastered sports exercises. At the same time it is known that entry-level sportspersons, following their own and trainer's sets, implying increase of effectiveness of movements, raising intensity of performance, increase the probability of influence of hindering phenomena on development of movements, first of all, due to intermuscular mis-coordination, insufficient physiological readiness and a lag in development of physical qualities. Thus, mastering of highly efficient movements is impossible without attainment of a level of activity, at which hindrances are absent, whereas the process of achievement of this level (this mode) leads to appearance of such hindrances.

The last is due to the fact that study of a certain sports exercise begins, as a rule, at relatively low levels of development of specific physical qualities. Therefore, formed motion cannot be efficient enough. Repetitions of exercises form and reinforce motor skills. With skills fixed low efficiency of mastered motion is also reinforced. The resolution of this contradiction on the basis of traditional methodical methods is in regular multistage re-training with application of special means, preventing fixation of wrong skills.

In the process of formation and perfection of movements, one of the most important external indices is reduction of variations of characteristics of movements at the time of increase of power manifestations and at growth of kinetic energy of movements of a human body and its separate parts.

The attainment of regimens of power maximums of muscular work is connected with such typical parameters of sportsmanship in motion, as concentration of efforts in time and convergence of accents of muscular activity, dynamics and kinematics. The features of better and perfect motor skills manifest this way.

Repetition of biomechanically rational and more and more stabilized sports exercises leads to consolidation and fixation of stable motor skills. Stabilization of motor skills, although on the whole a positive phenomenon, carries in itself simultaneously a negative consequence in the form of stabilization of sports results. Among the reasons for this stabilization there are contradictions, appearing not only as a consequence of biomechanical rationality, but also connected with positive in whole adaptive responses to execution of training exercises. In this case it necessary to pay special attention to

laws of adaptation to raising intensity of physical exercises and to their increasing volume, considered as crucial conditions of gaining of higher levels of fitness.

Adaptive responses to increased physical loads mean not only becoming accustomed to serious training modes and withstanding to the forcing down influence of fatigue, but also mark stabilization simplification of all technical components of mastered motor skills with negative influence in the form of stabilization of results.

The undesirable influence of adaptation of an organism of a sportsperson to high training loads becomes evident also in situations, which limit possibilities for subsequent improvement of the level of sportsmanship by permanent repetition of motor modes, characterized by near-maximum and middle intensity. Persistence of motor modes, providing a set of corresponding training volumes and guaranteeing appropriate productivity at a level of average (middle) values and some probability of quite high results, fixes the already created motor skills, limiting with each repetition the possibility of efficient mastering of higher levels of sportsmanship.

The said contradictions do not undermine the role of any of the components of a training process, but in contrast, underline their interrelation and inter-conditionality. In a versatile process not only positive, but also negative dependences of different components can appear. Deviation from straight pedagogic methods in the course of planning of a training process, usage of dialectic methods will promote transition to more advanced positions in sportsmanship management. A principally important feature of this approach is not only to take account of the influence of the mentioned contradictions, but also understanding the fact, that with improved of sports results new contradictions of deeper levels also can appear.

Contradictions between increased biomechanical rationality of sports or training exercise and decreasing probability of obtaining of a desired physiological consequence (result) from performance of this exercise lead to the necessity of differentiation of purposes of application of each of means of technical preparation. Since variation of modes of performance of training exercises has its target (provision of a base for subsequent growth of effectiveness (productivity) through increase and summation of training effects), the set of means and methods for this purpose must provide possibility of lasting ability to go beyond the of limits of natural motor modes on the whole series of parameters. Each of the means of technical preparation (according to own target functions) can play the role of a means of conjugate preparation, providing simultaneously increase of power or velocity potential, supplemented with formation and consolidation of mental images conception of new properties of movements.

### **3. Variation of Motor Modes**

Training exercises, as purposeful processes of interaction with an external power environment, are oriented by their internal essence to overcome hardening at repetitions, processes of adaptive ordering of stabilization processes. The last from the above mentioned, in spite of obvious biological expediency (adaptive responses of a human organism arise as a method of establishment of stable interrelations of functional systems of an organism with an environment), perform the function of factors, limiting

non-equilibrium relations of a human organism with the surrounding environment, at which spillover of functions of systems of a human organism beyond the natural frameworks is quite possible.

Since the mentioned spillover (beyond the limits of stable conditions of interrelation with external force medium) represents itself the sole possible way of mastering of higher functional and biomechanical levels of motor activity, variation of modes of performance of training exercises plays a crucial role. M. Bychvarov (Bulgaria) underlined the necessity of introduction of certain “redundancy of diversity” of influence of exercises for prevention of conservative stabilization in these exercises. This statement has something in common with a famous principle of cybernetics: only diversity gives rise to diversity.

Usually modes of performance of training exercises are varied, mainly, by changing self-sets and target tasks. Variation is achieved by emphasis on certain phases of motion (amplitude and frequency characteristics), and introduction of additional self-tasks for certain groups of muscles (their relaxation and tension). Among methodical means specialists also consider special methods of variation, based on usage of primary sound and light signals as guides for orientation of a sportsperson in the surrounding space during motion (for self-control). All these means allow creation of a reference basis for motor activity.

Variation of modes of performance of exercises is brought about by special exercises, with additional weight (of different mass) and with different modifications of resisting forces. For creation of hard conditions in the course of trainings in ancient times athletes ran on sand, later they ran on shallow waters and snow. A special mode of running is on tracks with sawdust (currently rarely used).

One example of variation of modes of interaction of a sportsperson with the running track surface is by using artificial racetracks, treadmills with special coating with different physical and mechanical properties, as means of perfection of sports training. The next stage is application of artificial coatings with characteristics, changed according to target functions of trainings.

This trend exists in the usage of exercise machines and tools with variable, rationally managed properties. Using such equipment with variable properties, it is possible to change the character of performed exercises raising quality of training influence of these exercises on the organism of a sportsperson in more rational limits. For example, there are pneumatic exercise machines, which, depending on air pressure in cylinders, can provide different elastic properties to the surface.

While discussing methods of stabilization and variability of skills, it is important to note to note that in the case of common usage of competitive sports equipment, only technical stabilization of certain skills is provided, whereas increase of training effects can be assured only by introducing variation of modes of motion, or additional special exercises, or by varying external conditions for performing exercises (sports equipment with varying characteristics).

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### **Bibliography**

Enoka Roger M. (1988). *Neuromechanical basis of kinesiology*. Champaign, IL: Human Kinetics, 336 p. [The problem of consideration of motion as a result of interaction of a biological system and its environment through functioning of neuromechanical systems of a human organism (also called “internal management”) is discussed].

Popov G.I. (2009). *Biomechanics*. 4<sup>th</sup> ed. Moscow: Akademiya. [Expediency of consideration of motion of a human being, especially in applied tasks as a result of not just plane interaction with a surrounding environment, but such interaction, when physical properties of external medium are purposefully varied, is proved. On the basis of such approach, the author suggests to influence purposefully a character of motion through adaptive motor reactions (responses) of a human being in conditions of continuous interaction with the environment (it can be named “external management”). (In Russian).

Ratov I.P. (1984). Methodology of the conception of “artificial controlling environment” and perspectives of its practical realization in the process of training of athletes. *Methodological problems of perfection of the system of sport training of qualified athletes: Proceedings of VNIIFK*, Moscow. Pp. 127–145. [Foundations of a concept of an artificial control environment (ACE)]. (In Russian).

Ratov I.P., Popov G.I., Loginov A.A., Shmonin B.V. (2007). *Biomechanical technologies of athletes' training*. Moscow: Fizkultura i sport. [Authors consider questions of preparation of sportspersons in different kinds of sports on the basis of usage of biomechanical training means with the basic task - attainment of record levels of sportsmanship in training exercises beyond of boundaries of current motor abilities of sportspersons]. (In Russian).

### **Biographical Sketch**

**Grigory Ivanovich Popov**, Doctor of Pedagogical Sciences, Professor, graduated from the Physical Faculty of the Lomonosov Moscow State University.

His scientific interests lie in the area of management of motion and sports biomechanics. The basic scientific and technical works of G. I. Popov pertain to a field of biomechanical laws of formation and perfection of motor skills of a human being on the basis of technical means of an artificial control of the environment. He took part in the development of a series of training benches (special exercise machines); technical gadgets - elastic recuperators of energy; a theory of wave processes of transmission of energy in motion of multilink biomechanical systems; a method of time transforms at modeling and prediction of parameters of a technique of sports exercises, etc.

He authored 308 scientific and scientific and methodological publications, including scientific articles, textbooks, educational and methodological manuals, and 25 patents and inventor's certificates, industrial samples and useful models in the area of technical means of training.

He is a full member of the Russian Academy of Natural Sciences, the honorary academician of the Belarus Engineering Academy.