LEARNING FOR SPORT EXERCISES

Yu. K. Gaverdovsky
Russian State University of Physical Culture, Sport, Youth and Tourism, Russia

Keywords: motor action, sport movement biomechanics, motor skill, training methodology and technology, sport didactics.

Contents

Summary

Biomechanical foundations of learning for sport exercises, methodology of training and the basis of sports didactics are considered. Questions of work of the motor apparatus of a sportsperson, principal elements of structure and techniques of main types of sports movements (as the subject of training in sport), key features of the procedure of educational-training work with reference to exercises are discussed. Concepts of "motor ability", "motor skills", connected with them levels of training (sportsmanship) of a sportsperson are considered. Modern means and technologies of training (education), and also the system of didactic principles, adapted specially for sport, are described.

1. Introduction

1.1. Terminology

1.1.1. Concepts of "Learning" and "Training"

In the general pedagogical sense, "learning" is a constructive process of methodologically organized activity with the purpose of acquisition of knowledge and skills. In the sport context, learning is the process mainly directed to formation of motor skills, with simultaneous acquisition of motor abilities, motor feelings and special knowledge, expanding cognitive experience of a student and representing a means of formation of specific and motor skills allied to them. Learning is a difficult dynamic process managed on the basis of existing feedbacks. The main subjects of learning are a teacher, a trainer supervising the process of teaching, and his/her trainee, mutually interacting on a constructive basis. Learning has a purposeful character and is carried out stage by stage, including estimation of the initial level of readiness for concrete work, formation of motor feelings, intermediate motor abilities and complete motor

skills. Educational activity of a teacher (a trainer) is developed on the basis of training methodology, in the framework of which didactic principles, methods, holds, means, forms, techniques of teaching are considered. In the context of interaction between a teacher (a trainer), as the subject of training, and a trainee (a sportsperson), as an object, undergoing changes in the process of teaching, it is necessary to distinguish the terms "teaching (tutoring) " and "study". The first term is a characteristic of forming imperative influence from the side of a teacher, directed to a trainee (a student), the second term is an indicator of active, conscientious attitude of a student (a trainee) to an educational process. Both terms are integral indicators of existence of a biunique organic process of learning.

Training (in its general sense) is a component of perfection of a sportsperson, directed to solution of different problems connected with the improvement of the level of sportsmanship and competitive activity. In the context of learning for exercises, "training" is a process of maintenance at a necessary level (fixation) and perfection of previously mastered and practiced motor skills, including maintenance and perfection of a required competitive level of physical, psychomotor, volitional and other human qualities.

1.1.2. Terms "Motor Action", "Movement", "Exercise"

Motor action is a psychophysiological, biomechanical component of a motor act in its efferent phase, being the defining factor of any movement, making the basis of a motor skill. The direct result of motor movement can represent both physical movement and set fixation of a pose – a position of a body of a sportsperson.

Movement is a physical phenomenon, meaning translational motion (displacement) and (or) rotation of a body of a sportsperson and its links in the given system of coordinates - irrespective of the reason, caused this effect, and able to carry involuntary character (The mentioned definitions of terms "motor action" and "movement" principally differ from the similar terms within the framework of the concept of N. A. Bernstein.).

Exercise is the purposeful form of motor activity of a sportsperson, being the means of development (perfection) of a motor skill or quality, got at many times repeated, systematized solution of a certain motor problem, and also the result of this educational-training work in the form of ability to solve confidently the given motor problem or a set of problems of a certain class demonstrating corresponding forms of motor behavior.

1.2. Specificity of Training to an Arbitrary Movement in Sport

In contrast to traditionally verbal ("school") education with its key orientation to acquisition of knowledge, learning for sport exercises, assuming formation of motor skills, is based not only on cognitive abilities of a student, his/her memory, logic thinking, but also on his/her motor, sensomotor, functional abilities. With reference to the above mentioned, the methodology of learning for sport exercises uses the terminological apparatus of not only pedagogy, psychology, but also physiology of muscular and higher nervous activity, physics and biomechanics, and also such disciplines with general pedagogical applications, as system analysis, information

theory, philosophy. Cardinal feature of motor training as a whole is its especially concrete (not abstract, as at conceptual education) orientation to a subject of training, namely action - movement. It gives the chance ("forces") to build perception of new information on the basis of not only mental mechanisms of cognition, but also on sensomotor mechanisms with engagement of sensory apparatus, including sight, hearing, tactile perception, vestibular mechanisms and - first of all – a muscular-motor sense, kinesthesia. This determines choice of methods and means for learning for sport exercises, in the system of which verbal methods dominating in traditional "school" education play important, but, nevertheless, an auxiliary role, whereas methods and means using motor functions are crucial in this case. They include ideomotion (mental actions - movements), quasi-motion (imitating exercises as a metaphor of movement) and directly motor activity - educational exercises - both auxiliary and target.

2. Biomechanical Foundations of Learning for Sport Exercises

2.1. Biomechanics of Movement and Training in Sport

Any motor action and a corresponding movement becoming a subject of training in sport are based on the general substratum, i.e. are created on a uniform natural basis, being in this case a human locomotor apparatus (LMA) with mechanical, anatomic, morphological, physiological, system properties, all inherent to it. Exactly LMA "dictates" to the executor of a concrete exercise corresponding requirements to the best organization of set action - movement, and also limits of possible "determined" in this case by the nature. Motor tasks, typical for this or that kind of exercises, can be specific enough, but any way they must be solved by means of the same, principally general for any healthy person LMA. If this factor is ignored or interpreted incorrectly, it is impossible to develop an efficient training process.

2.2. Motor Apparatus of a Sportsperson

Human motor apparatus represents in movement, a specific machine characterized by exclusive diversity and managed variability of own functions. A human, motor apparatus of which has indefinitely large number of potential abilities of movement, cannot perform coordinated actions without excluding of superfluous degrees of freedom and transforming thereby own motor apparatus into the working machine acting at each concrete moment according to a certain program and capable, at the same time, to readjust itself operatively and expediently depending on the corresponding purpose of action.

2.2.1. Physical Laws of Work of a Motor Apparatus

In the context of learning for sport exercises, it is interesting to consider, first of all, questions of relative mobility of links of the body of a sportsperson, since they are important for understanding of corresponding techniques and mastering of exercises. For this purpose specialists use terminology of technical mechanics, two main terms of which – a kinematic pair and a kinematic chain, kinematic pair (k.p.) is the simplest structural element of human LMA, in which relative motion takes place. These are two links (forearm-upper arm, hip-shin, etc.) or two fixed, as whole, sets of links (arm-trunk,

trunk-legs) with a common joint. Kinematic chain (k.c.) is a consecutively connected series of relatively mobile k.p. (an arm, a leg or a trunk of a sportsperson). Depending on bonds applied to a human body, it is possible to distinguish three main types of k.c., important for understanding of a concrete technique of sports movement. It is a free k.c. (at support-free movements), open k.c. (with fixation of one its end in such positions, as standing (on legs, arms), hanging, and also at motion of a free extremity – swinging, performed by an arm, a leg, etc.) and closed k.c. (positions with both ends fixed, for example when a human stands on his/her arms and legs simultaneously). From the point of view of motion management the most important case - open k.c., since in this case there is possibility of interaction with a support (energy exchange) with simultaneous active actions, performed by highly mobile peripheral links. Degrees of freedom of links of open k.c. depend on the position of a link relative to a support. Potentially, peripheral links of k.c. are the most mobile and full of maximum energy (for example, an the arm of a thrower at throwing). At the same time, the more the number of degrees of freedom of a certain link, the higher is the risk of a motor mistake. One of the sides of kinematics of the LMA is connected with mobility in joints, which depends on a series of specific factors. One of them has a principally morphological character: spherical joints (humeral, coxofemoral) allow three-dimensional link rotation, but hinge joints (elbow joint) have only one degree of freedom. The amplitude of movement in joints depends both on joint morphology (with limits, determined by bone structure of a joint) and elasticity of soft tissues, surrounding a joint (joint capsule, adjoining muscular-ligamentous apparatus). The latter can change in the course of training and is a subject of special training for improvement of flexibility and mobility in joints. One of the aspects of kinematics of the LMA of a sportsperson is also axial interrelation of movements in joints of the pectoral arch. For example, simultaneous combination of movements for extension of elbow with arm supination (or flexion of elbow with simultaneous pronation) allows one to perform rotary motions in the pectoral arch without restrictions regarding the angle of rotation, which provides a partial load mode (soft mode) of joint operation. The opposite combination of movements (extension with pronation, flexion with supination) causes forced, maximum deformation of soft tissues of an upper arm, leading to traumas. At the same time, exactly such operating mode can be used for development of mobility in joints.

Geometry of mass of a human body, as a separate section of sports biomechanics, includes information about relative mass (moment of inertia) of corresponding links of a human body, their distribution within the framework of the system and about mass-inertial properties of the body of a sportsperson as a whole. Relative masses of links of a human body are important as factors, which can significantly influence a technique of sports exercises, requirements to special physical training and special features of training to corresponding exercises. The important mass-geometrical factor - arrangement of local and general centers of mass (centers of mass (gravity) of corresponding links and the general center of gravity – g.c.g.). The center of mass of links of a human is relatively constant morphological indicator, connected with constitution of a concrete human body and, consequently, with techniques of corresponding exercises. Relative and absolute position of g.c.g. of a human body is the integral indicator, significantly changing, depending on the working pose of a sportsperson and displacements of the whole body in space. The analysis of relative and absolute positions and displacements of g.c.g. of a body of a sportsperson is an

important section of sports biomechanics. For the kinds of sports, connected mainly with rotary motions of a human body, the other mass-geometrical indicator is crucial - the moment of inertia of links of a human body and, in particular, the moment of inertia of the whole body. The magnitude of the latter significantly differs both for different axes of a human body and, especially, for various poses of a body of a sportsperson on a support and in flight. Change of a pose and, as consequence, the moment of inertia relative to a corresponding axis of rotation is one of the key mechanisms of management of rotations of the body of a sportsperson. One more aspect of geometry of mass of the body is connected with constitution of a sportsperson. This is, in particular, one of the criteria of selection and orientation in sport. Depending on height-weight and constitution indicators of people, specialists recommend different kinds of sport and different specializations for them within the framework of the chosen kind of sport. There is general classification, according to which sports specialists distinguish dolichomorphic, brachymorphic and mesomorphic types of constitution. It significantly determines individual features of techniques of exercises in sport. The constitution question in sport has also a gender aspect: a technique of exercises can have distinctions in connection with gender features of constitution.

Dynamic interactions in k.c. are one of the most important factors of a technique of sports exercises. Single reaction interactions in k.p. are the simplest, they cause differently directed rotation of elements of a pair, brightly demonstrated at support-free movements. Understanding of interconnection and interconditionality of motion in k.p., caused by reaction, is very important for training; a sportsperson must understand that "isolated" movements and actions (in this matter) do not exist. More complex character is typical for cyclic, swinging movements in k.p., at appearance of which laws of isochronous and resonant movement work. Interactions in k.c. are the most sophisticated, when they represent biodynamic phenomena similar to a "running transverse wave", they significantly determine the technique of an exercise and are in the basis of "self-organization" of movements.

2.2.2. Physiological Laws of Work of Human Motor Apparatus

2.2.2.1. Motor Reflexes

For understanding of sports-applied aspects of human motor activity within the framework of the theory of reflexes, the most important are those reflexes, which define special features of muscular work of a sportsperson. These are, first of all, unconditional motor reflexes of the spinal cord, including reflexes of muscles stretching, cutaneous bending reflexes for displacement from an irritant, pushing-off reflexes, rhythmic, pose reflexes. The spinal cord causes also interaction of centers of muscles-antagonists (including reciprocal innervation, rationally regulating simultaneous work of muscles-agonists and antagonists), and at locomotion - more complex unbending and stepping reflexes (description of conditional reflexes in this case is omitted).

Myotatic reflex is a reflex of tension of muscles, manifesting in the form of muscle excitation in response to its tension. It plays a cardinally important role at performance of many arbitrary, including sports (especially with strong power) movements, since only stretched muscle develops, with other things being equal, the greatest power. The

effects, caused by the myotatic reflex, cause such major laws of work of muscles, as interrelation "length-stress" (the more strongly, up to an optimum, the muscle is stretched, the greater power it develops), "speed-force" (the faster a muscle is stretched, the more is developed force; the faster is muscle contraction, the lower is force, developed by it), and also different operating modes of a muscular apparatus.

Tonic neck reflex is a physiological phenomenon, causing interrelation between movements (position) of the head relative to the trunk and the tone of muscles of the trunk and hands. In traditional physiology (school of R. Magnus) it is considered as a phenomenon, which in norm is typical only for animals and babies, but adults (except for pathology) can easily suppress it and thus, in this age it is considered as insignificant. However, long-term practice of sport and special researches demonstrate rather significant role of a tonic neck reflex in management of motor actions of a sportsperson and their influence on muscular force and coordination of movements. Concrete action of a tonic neck reflex manifests in the form of dependence, at which movement (or the fixed position) of the head after neck bending (forward motion), unbending (backward motion) or side bending stimulates activity of the corresponding (similar) muscles of the trunk and especially muscles of the shoulder girdle. At performance and, in particular, at mastering of sports exercises effects of a tonic neck reflex can render significant, and often even crucial influence on coordination of motor actions, and so they are widely used as one of the means of formation of motor skills and technical perfection of a concrete motion.

2.2.2.2. Operating Modes of a Muscular Apparatus

Work of a muscular apparatus is determined by a series of biomechanical factors and parameters. They are the following: speed and degree of excitation of a muscle; as consequence – the level of its tension/relaxation; working length of a muscle; the direction and speed of change of length of the muscle; and also magnitude of external reaction, of the load, applied to a concrete link, moved by a muscle. Depending on the parametrical ratio of the mentioned characteristics, one more important parameter is changed - the force, developed by a muscle. For analysis of a technique of sports exercises corresponding laws (following from the above mentioned) are very important. These are the following dependencies: loading-force, length-stress, speed-force. For analysis of a technique of sports exercises it is also reasonable to apply the concept of operating modes of a muscular apparatus. This concept is connected, first of all, with cumulative action of two general factors, determining the working state of a muscle. This is the degree of tension/relaxation and working length of a muscle, including the character of its tension-contraction (Terms "tension-contraction" in this case mean exclusively change of the working length of the muscle, i.e. elongation and shortening, accordingly. In this context the term "contraction" means exclusively approach of bearing ends of a kinematic pair and is not connected by any way with the degree of tension of a muscle.). Four most typical modes can be distinguished. These are: a stopping mode (stretching, the muscle is more and more excited and develops significant force), an overcoming mode (straining, the muscle is reduced), a ballistic mode (reducing under its own inertia, the muscle gradually relaxes), a conceding mode (continuing to relax, the muscle is extended). Alternation of these modes at swinging work in a kinematic pair has a cyclic character, providing the most efficient work of

muscles in an auxotonic mode. The isometric mode (the muscle strains or relaxes, without change of its working length) also can be distinguished.

2.2.2.3. Movements Management

The concept of movement management is reduced basically to the concept of ring neuromuscular processes on the basis of sensor corrections. According to this theory, the process of movement "is launched" when a sportsperson forms initial motor ideas and when corresponding to them efferent signal of direct communication is generated; actually this is the beginning of the motor act. The efferent impulse causes excitation of the muscular apparatus, creating some primary effect in the form of effort and movement (change of state of the system). This result of physical activity is a subject of further reception, i.e. estimation from the side of sensor systems, functionally corresponding to resulting action-movement. Information about results of reception arrives in the form of an afferent feedback signal into apparatuses of comparison of the central nervous system, where analysis and synthesis of the information takes place (programmed movement is compared with actual results of movement). After that action continues according to the primary program, or is corrected in "on-line" mode. This mechanism is known as management of motor actions on the basis of sensor corrections. On the whole controllability of movement is determined by the ratio "speed of analysis/synthesis of sensor information to speed of action-movement"; the higher the first and the lower the second, the more controllable is this movement. The higher is qualification of a sportsperson and the lower is speed of motor action, the higher is available accuracy of movement, and vice versa. Super fast actions-movements, such as pushing-off, basically cannot be operatively controlled (cannot be corrected "on-line") and are perfected only in the course of a long time educational-training process.

2.3. Technique of Sports Exercises as the Subject of Study

2.3.1. The Term "Technique of Sports Exercises"

In its broad sense, "technique of sports exercises" is a method of solution of motor tasks, irrespective of results. The specific meaning of this term is a set of purposeful managing actions chosen for solution of a motor problem and causing ordered programmed movement of the body of a sportsperson (its links) or stabilization of a required pose-position in space-time. The main question in this matter: which precise method from principally possible ways of solution of motor tasks is used in each specific case - is a question, concerning a technique of the given exercise. Technique of performance of sports exercises is one of the key terms of the theory and methodology of sport, defining the basic subject of technical training of a sportsperson. It must be considered in various aspects. The power aspect is connected with choice of ways of performance of exercises, allowing one expediently to create energetically optimum actions-movements (maximum powerful at maintenance of efficient actions controllability, moreover, all actions must be power-saving). The coordination aspect touches the question of structural complexity, controllability of movement and, as consequence, its convenience for mastering and execution. The aesthetic aspect appeals to beauty of movement, irrespective of its power, accuracy, etc. The rational aspect forces to take into account possibility of obtaining of the best result at an optimum ratio

of power of movement, its structural complexity and controllability, appeal, etc. Among important aspects the following are important: morphological aspect (modification of a technique, depending on a gender and mass-geometrical data, constitution of a trainee), a variation-adaptive aspect, connected with reaction to changes of motor, psychomotor, etc. abilities of a trainee. Construction of a technique of performance of sports exercises according to its different aspects is connected with resolution of certain contradictions. For example, requirements to appeal (aestheticism) of a movement often contradict rational biomechanical solutions. Value of "supreme (standard)" technique of champions is also relative enough and always must correspond to a real constitution and state of a concrete sportsperson. In historical retrospective review "standard" technique of sports exercises is also extremely variable.

2.3.2. Elements of a Technique of Typical Motor Actions

There is relatively small number of basic forms of sports exercises, techniques, motor actions with a principal physical basis typical for each of them, revealing of which is the key moment of analysis of a technique of performance of exercises with reference to their mastering. First of all, this is definition of a mechanism of power supply or transformation of previously received energy, as an implementer of the program of movement.

-

-

-

Bibliography

Ashmarin B.A. (1979). Peculiarities of learning in physical education. In: *Theory and methods of physical education.* Moscow: Prosveshchenie (In Russian). [The basic features of motor training in comparison with verbal training (with reference to sport) are considered.]

Back J. (1959). *On sane methods in programming. Automatic teaching*. – New York, Wiley. [The main principles of programmed learning are presented.]

Belinovich V.V. (1958). *Learning in physical education*. Moscow: FiS (In Russian). [The most general foundations of education in the area of physical learning, including its methodology and organizational-methodical forms.]

Bernstein N.A. (1991). *About legerity and its development*. Moscow: FiS (In Russian). [Popular presentation of the concept of N. A. Bernstein about multilevel design of movement.]

Bespal'ko V.P. (1970). *Programmed learning (didactic bases)*. Moscow: Vysshaya shkola (In Russian). [The description of programmed learning as an onto-didactic technique of managed training, its main principles and methods.]

Bogen M.M. (1985). *Learning for motor actions*. Moscow: FiS (In Russian). [Experience of consideration of learning in sport on the basis of the psychological-pedagogical concept of P. Ya. Galperin.]

Crowder N.A. (1965). *On the differences between linear and intrinsic programming*. Phi Delta Kappa. [The analysis of specificity of linear and branched programmed learning.]

Didaktische prinzipen. Studpunkte, Diskussionsprobleme, Lasnyvschuge. (Leitung V. Drevs). (1976). Berlin, Volk und Wissen Velkseigener Verlag. [A discussion concerning didactic principles.]

Donskoi D.D. (1960). *Biomechanics of physical exercises*. Moscow: FiS (In Russian). [The first textbook on biomechanics for special universities with description of physical and physiological foundations of arrangement of sports exercises.]

Gaverdovsky Yu.K. (2007). *Learning for sport exercises. Biomechanics. Methodology. Didactics*. Moscow: FiS (In Russian). [Biomechanical foundations of training in sport are considered in detail.]

Gaverdovsky Yu.K., Zaglada V.E. (1976). Programmed learning: its sense, principles, possibilities. - In: *Gymnastics*, issue 1. Moscow: FiS (In Russian). [One of the first publications, devoted to programmed training to complex and original movements in sport.]

Galperin P. Ya. (1965). *Main results of the investigations on the problem «Formation of mental actions and notions»*. Moscow (In Russian). [The author's presentation of the concept of "systematic - stage-by-stage" mastering of actions.]

Hochmuth G. (1967). *Biomechanik sportlicher Bewegungen*. Berlin: Sportverlag. [A monograph on problems of sports biomechanics.]

Ivanitsky M.F. (1938). *Movements of human body*. Moscow: FiS (In Russian). [A pioneering work on dynamic anatomy of a human.]

Klingberg Lothar (1984). *Unterrichtsprozess und didaktische Fragestellung*. Berlin: Volk und Wissen Volkseigener Verlag. [Philosophical and methodological foundations of the theory of learning.]

Landa L.N. (1966). *Algorithmization in learning*. Moscow: Prosveshchenie (In Russian). [The problem and elements of methodology of learning on the basis of algorithms of various degree of "rigidity" are considered.]

Maznichenko V.D. (1959). *Motor skills in gymnastics*. Moscow: FiS (In Russian). [The general physiological characteristic of the term "motor skill" and its analysis by example of learning in artistic gymnastics is given.]

Nazarov V.T. (1973). *Fixed bar exercises*. Moscow: FiS (In Russian). [The author's concept of modeling and programming of sports movements with use of mathematically formalized programs of "place", "orientation" and "pose" is presented.]

Okoń W. (1966). *Proces nauczania*. Warszawa. [The discursive work concerning the basic problems of a process of education (knowledge acquisition).]

Pohlmann R. (1977). *Der motorische Lernprozesse*. – Theor. u. Pr. der K.K., Berlin, 25, H. 2. [A paper about the problem of formalization of the process of learning in sport.]

Thorndike E.L. (1931). *Human learning*. New York: Appleton-Century-Crofts. [The classical monograph with description of some laws of learning connected with the reflex theory.]

Zatsiorsky V.M. (1966). *Physical characteristics of a sportsman*. Moscow: FiS (In Russian). [On the basis of wide analysis of the world literature, the basic physical qualities of a sportsperson (force, speed qualities, endurance, etc.) are considered.]

Biographic Sketch

Gaverdovsky Yury Konstantinovich is Doctor of Pedagogical Sciences, professor of the Russian State University of Physical Culture, Sport, Youth and Tourism, Academician of the International Academy of Information under the United Nations Organization. He specializes in sports biomechanics, techniques of sport exercises, theory and methodology of learning, programmed learning. In 1962-1985, he worked as a scientific adviser for national teams of the USSR and the Russian Federation in artistic gymnastics. He is the author of more than 250 publications, including some textbooks and monographs.