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OPERATIONAL METHODS FOR ASSESSING THE CURRENT FUNCTIONAL STATE OF AN ATHLETE IN THE TRAINING PROCESS

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Purpose: to develop the methodology for an individual assessment of the current functional state when organizing the training process.

Materials and methods: the following methods were used: analysis and generalization of scientific and methodological literature; generalization of the experience of the practical work of the coaching contingent working with the contingent of sports improvement groups in basketball; methods of mathematical modeling and processing of video materials of sports competitions of various levels in basketball; the modernized method of orthostatic test by N. Teslenko - test «sitting-standing".

Results: an individual method for assessing the functional state in the process of conducting the training lesson allows to determine the measure of working capacity and the athlete's readiness to the loads presented. The practically developed method makes it possible to introduce control over the state of developed fatigue in real time, thereby assessing the level of performance and giving objective assessments of individual endurance. In practice, the developed method makes it possible to introduce control over the state of developing fatigue in real time, thereby assessing the level of performance and giving objective assessments of individual

endurance. It should be noted that the modified method of N. Teslenko orthostatic test with the use of modern computer technology makes it possible to transmit the information received at any distance and control the state of the athlete's body without restricting his motor activity.

Conclusions: the developed technique of the modified orthostatic test by N. Teslenko allows early diagnosis of the development of fatigue, which prevents the deterioration of the body and prevents the phenomena of fatigue.

Keywords: fatigue, modified orthostatic test by N. Teslenko, assessment of endurance, optimization of physical activity.

Introduction

Currently, the urgency of the problem of fatigue and recovery after the transferred load is increasing.

The problem of fatigue has been studied for more than two hundred years [9].

Fatigue is a universal phenomenon inherent in all living things: plants, animals and humans. Despite the universality of this phenomenon and its enormous scientific and practical significance, the answer to the question asked is given to a greater extent in a descriptive form that does not reveal the essence of fatigue and its physiological mechanism [3, 12, 19].

The most widely used definition sounds like: fatigue is a temporary decrease in performance caused by work, which is different in nature, volume and intensity. This definition does not reveal the physiological mechanism of fatigue, since a decrease in working capacity can be considered as a consequence of fatigue, and not as fatigue itself [6, 14, 17].

Of the various directions in the study of fatigue, in full accordance with the above definition, the study of working capacity is widely carried out in order to judge the depth of fatigue by its state. Apparatus study fatigue began using myograph on isolated from the body's neuromuscular preparation, as well as through ergograph in humans.

The first ergographs designed by A. Mosso and I.M. Sechenov's works were designed to control the performed physical load of individual motor acts with an accurate assessment of the volume of work performed and its nature in terms of such parameters as its intensity and duration.

Subsequently, this method was extended to various kinds of tetbans, treadmills, bicycle ergographs and other devices that allow taking into account the volume and nature of the physical work performed.

A common feature of the ergographic method for studying the process of fatigue is that only the study of dynamic work is available to them.

Static stresses cannot be expressed in terms of the units used (kg/ m). all the more it is inaccessible for assessing energy costs, the degree of technical activity, or trophic energy costs under various conditions of being in any stress state.

The problem of assessing fatigue was considered by individual scientists as early as the 17th century. With the development of physiology and the appearance of objective research methods, their number has increased significantly. Already in 1925 their number exceeded more than 13 thousand. This problem was paid attention to by G. Helmholtz, E. Dubois-Reymond, A. Mosso, I. Sechenov. Ch. Sherington, A. Ukhtomsky, K. Bykov and a number of other physiologists. However, the abundance of works on this issue has not allowed to date not only to reveal the theoretical foundations of the process itself, but even to work out a single definition. The term "fatigue" is one of the most imprecise in physiology.

S.H. Bartley, E. Chute (1947), V. Rosenblat (1975) in their works give up to 100 different definitions of this state. Moreover, in a number of works the opinion is expressed that this term is unscientific and should be removed from use. Naturally, this state of the issue is determined by its complexity. Fatigue as a process reflects the state of the organism and can be interpreted as the degree of deviation from its functional optimum, that is, the normal state.

The problem of the norm has been studied throughout the history of the development of biology and medicine and also has significant contradictions in assessing the concept of the norm, its interpretation, up to the complete denial of the

concept itself. Naturally, it is difficult to allow interrelated problems to be resolved on the one hand and remain unresolved on the other. However, the variety of approaches to solving common issues made it possible to supplement the understanding of each of them.

Despite the fact that neither in 1961 at the symposium on the problem of fatigue and recovery of working capacity during muscular activity, nor in 1969 at the symposium in Kyoto there was no consensus on the interpretation of the physiology of fatigue and work capacity, nevertheless, the results of many years of research allowed a significant at least to reveal a number of features of this phenomenon (Rosenblat, 1973).

Such a big difference in opinions and conclusions about the mechanism of fatigue was explained by the fact that various authors used in their studies various objects from isolated organs and tissues to the whole organism, using a wide variety of operating modes.

As a result of these works, it was possible to establish certain ideas about the general biological basis of fatigue, as a certain state of the body relative to its norm. The introduction of the concept of a norm required the definition of its semantic content, since the level of temporary decrease in working capacity relative to its normal manifestation is a quantitative expression of the functional state of the working organ and the organism as a whole.

The set of conditions most favorable to the equilibrium state of this process can be accepted as the norm. The possibility of positive or negative deviations under these conditions requires certain reserve potentials from the body. The greater this potential, the wider the zone of fluctuations in environmental conditions available for a given organism. In practice, it is important to know how it is possible to increase this potential reserve for expanding the zone where the organism or its systems are located and how it is possible, without expanding the zone of oscillations, to ensure movements to another area, in favorable conditions of existence, while maintaining the previous potential capabilities [10, 22, 26].

It should be noted that in this direction, the processes that determine the normal state of the organism or its individual organ have been studied in depth, pictures of age-related changes have been established, ideas about how and in what exactly these changes occur.

Connection of research with scientific programs, plans, topics: This work was carried out in accordance with the topic of the Consolidated plan of research work in the field of physical culture and sports for 2011-2015. on topic 2.6 “Theoretical and methodological foundations of improving the training process and competitive activity in the structure of long-term training of athletes (state registration number 0111U001168).

Purpose of the research: to develop a method for individual assessment of the current functional state in the organization of the training process.

Research objectives:

1. To analyze the types of existing control of the functional state of athletes in situational sports.

2. Determine the non-specific (universal) reactions of the body to external environmental factors and the mechanisms of their control.

3. To establish the structure of the non-specific (universal) reaction of the body.

4. To determine the mechanism of action of the body's nonspecific reaction to the state of the organization of the training process.

Material and methods

In solving the set tasks, the following methods were used: analysis and generalization of the experience of practical work of the coaching contingent, working with the contingent of sports improvement groups in basketball; methods of mathematical modeling and processing of video materials of sports competitions of various levels in basketball; modified method of orthostatic test N. Teslenko - “sitting-standing”.

Results of the research

Currently intensively developed remote methods assessing the functional state of an athlete during running of both training and competitive process. It is based on the analysis of video materials of controlled motor activity with subsequent processing of the kinematics of displacements of the centers of mass of both individual biokinematic links and the general center of mass of the whole body [11, 21]. Regarding these methods, which require a rather complex and expensive video recording technique and the corresponding program processing of the evaluated motor actions, for the subsequent assessment of the measure of fatigue, the method under consideration uses a nonspecific (universal) reaction, which acts as a frequency characteristic of heart contraction or heart rate.

The advantage of this method is that the frequency response reflects the general state of the body, regardless of kinematic or static physical activity, or mental experiences, or in a state of deep sleep, then the ongoing trophic processes reflect the dynamics of the ongoing metabolism.

This method was developed on the basis of a survey of tens of thousands of students of the Faculty of Physical Education of the H.Skovoroda Kharkiv National Pedagogical University. Frying pans, associate professor of the Department of Anatomy and Physiology N. Teslenko. The developed method is based on statistical processing of changes in the frequency response of heart contractions during the orthostatic test "sitting-standing". In the observed reaction of the heart rate (HR), there were changes in frequency, in which the pulse while standing was less than the pulse while sitting; the pulse while standing was equal to the pulse while sitting, the pulse while standing was higher than the pulse while sitting. The data of the initial state were subject to static processing (the characteristic heart rate at rest, observed at the time of the survey, which varied in the surveyed array of students in the range from 39 beats per minute to 120 beats per minute).

The examination involved students of various ages, sex, sports qualifications, and various sports. When performing a standard orthostatic test, a standard test of ergometric motor activity was carried out in parallel, which consisted of three five-

second filling of points on a sheet of paper, applied at the maximum possible speed. The ergometric test was performed both in a sitting position in the mode 3 times for 5 seconds, and in a standing position after measuring the heart rate for a ten-second interval, subsequently recalculating the number of beats per minute [4].

Based on the statistical processing of ergometric data, a scale for assessing the state of the surveyed respondents was compiled, which was converted into index points, compared with the frequency characteristics of the heart rate recorded according to the readings of the heart rate in a calm state before the orthostatic test and immediately after it was performed, on the basis of which the scale was compiled the frequency response of the respondents' heart rate according to the results of the test.

Thus, the developed table of the index assessment of the qualitative state of the cardiovascular system of students when performing the orthostatic test "sitting-standing" (Table 1) includes three dimensions: an index assessment of the state of working capacity or a measure of fatigue (applicate axis Z); the scale of changes in the pulse increment after the test (ordinate axis Y); the scale of the observed heart rate of respondents in a calm state before performing the orthostatic test (abscissa axis X), Fig. 1.

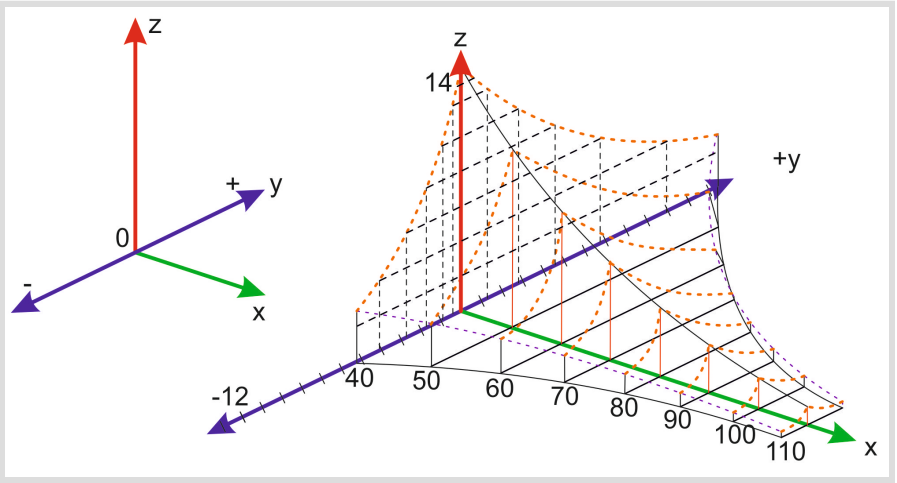

Table 1

Index assessment of the qualitative state of the cardiovascular system of students during the orthostatic test «sitting-standing"

Pulse (HR) in a sitting position beats/min	Heart rate difference (HR)																			
	Less in a standing position than in sitting						=	More in standing position than in sitting												
	-11-12	-9-10	-7-8	5-6	3-4	-1-2	0	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28
39-41	11	11,5	12	12,5	13	13,5	14	13,5	13	12,5	12	11,5	11	10,5	10	9,5	9	8,5	8	7,5	7
42-44	10,5	11	11,5	12	12,5	13	13,5	13	12,5	12	11,5	11	10,5	10	9,5	9	8,5	8	7,5	7	6,5
45-47	10	10,5	11	11,5	12	12,5	13	12,5	12	11,5	11	10,5	10	9,5	9	8,5	8	7,5	7	6,5	6
48-50	9,5	10	10,5	11	11,5	12	12,5	12	11,5	11	10,5	10	9,5	9	8,5	8	7,5	7	6,5	6	5,5
51-53	9	9,5	10	10,5	11	11,5	12	11,5	11	10,5	10	9,5	9	8,5	8	7,5	7	6,5	6	5,5	5
54-56	8,5	9	9,5	10	10,5	11	11,5	11	10,5	10	9,5	9	8,5	8	7,5	7	6,5	6	5,5	5	4,5
57-59	8	8,5	9	9,5	10	10,5	11	10,5	10	9,5	9	8,5	8	7,5	7	6,5	6	5,5	5	4,5	4
60-62	7,5	8	8,5	9	9,5	10	10,5	10	9,5	9	8,5	8	7,5	7	6,5	6	5,5	5	4,5	4	3,5
63-65	7	7,5	8	8,5	9	9,5	10	9,5	9	8,5	8	7,5	7	6,5	6	5,5	5	4,5	4	3,5	3
66-68	6,5	7	7,5	8	8,5	9	9,5	9	8,5	8	7,5	7	6,5	6	5,5	5	4,5	4	3,5	3	2,5
69-71	6	6,5	7	7,5	8	8,5	9	8,5	8	7,5	7	6,5	6	5,5	5	4,5	4	3,5	3	2,5	2
72-74	5,5	6	6,5	7	7,5	8	8,5	8	7,5	7	6,5	6	5,5	5	4,5	4	3,5	3	2,5	2	1,5
75-77	5	5,5	6	6,5	7	7,5	8	7,5	7	6,5	6	5,5	5	4,5	4	3,5	3	2,5	2	1,5	1
78-80	4,5	5	5,5	6	6,5	7	7,5	7	6,5	6	5,5	5	4,5	4	3,5	3	2,5	2	1,5	1	0,5
81-83	4	4,5	5	5,5	6	6,5	7	6,5	6	5,5	5	4,5	4	3,5	3	2,5	2	1,5	1	0,5	0
84-86	3,5	4	4,5	5	5,5	6	6,5	6	5,5	5	4,5	4	3,5	3	2,5	2	1,5	1	0,5	0	-0,5
87-89	3	3,5	4	4,5	5	5,5	6	5,5	5	4,5	4	3,5	3	2,5	2	1,5	1	0,5	0	-0,5	-1
90-92	2,5	3	3,5	4	4,5	5	5,5	5	4,5	4	3,5	3	2,5	2	1,5	1	0,5	0	-0,5	-1	-1,5
93-95	2	2,5	3	3,5	4	4,5	5	4,5	4	3,5	3	2,5	2	1,5	1	0,5	0	-0,5	-1	-1,5	-2
96-98	1,5	2	2,5	3	3,5	4	4,5	4	3,5	3	2,5	2	1,5	1	0,5	0	-0,5	-1	-1,5	-2	-2,5
99-101	1	1,5	2	2,5	3	3,5	4	3,5	3	2,5	2	1,5	1	0,5	0	-0,5	-1	-1,5	-2	-2,5	-3
102-105	0,5	1	1,5	2	2,5	3	3,5	3	2,5	2	1,5	1	0,5	0	-0,5	-1	-1,5	-2	-2,5	-3	-3.5
106-108	0	0,5	1	1,5	2	2,5	3	2,5	2	1,5	1	0,5	0	-0,5	-1	-1,5	-2	-2,5	-3	-3,5	-4
108-110	-0,5	0	0,5	1	1,5	2	2,5	2	1,5	1	0,5	0	-0,5	-1	-1,5	-2	-2,5	-3	-3,5	-4	-4,5
112-114	-1	-0,5	0	0,5	1	1,5	2	1,5	1	0,5	0	-0,5	-1	-1,5	-2	-2,5	-3	-3,5	-4	-4,5	-5
115-117	-1,5	-1	-0,5	0	0,5	1	1.5	1	0,5	0	-0.5	-1	-1.5	-2	-2,5	-3	-3,5	-4	-4,5	-5	-5,5
Current state assessment scale																					

14-10.5 - excellent; up to 85 good; up to 6.5 above average: 65 average; up to 4.5 below average; up to 2.5 bad; up to 1.5 is very bad.

The analysis of the dynamics of changes in the frequency characteristics of heart contractions, the reaction of the alternating factor, made it possible to establish a general pattern, which is an exponential dependence. The individual distinguishability of its manifestation is associated with the coefficient of curvature of this curve, which forms the basis of the performed modification of the orthostatic test by N. Teslenko. by transforming it on the basis of the use of an individual norm into an individual assessment of the current state of the examined athlete.

Each individual has a range of functional state change, which represents a state scale. The extreme values of the state scale from its max to min determine the range of observed states and are an assessment of its physical state. In terms of their variability, the manifestation of their probability is expressed by a 3-sigma distance from the most common point of the norm. In this regard, the full range is divided into a status scale of six parts, which have 7 boundary points. The introduction of a probabilistic measure determined the division of the state scale into 7 zones with an assessment of their qualitative expression in points from 14 to 1,5.

In the plane of the amplitude-frequency interactions of the body's response to the orthostatic test, the dynamics of relations in the system represented by the I-Ching matrix takes place. All the variability of these ratios is expressed in real frequency-amplitude characteristics of the heart rate response to the orthostatic test, which is presented in the table of the index assessment of the cardiovascular system state.

The essence of the tabular material for presenting the assessment of the current state actually consists in the fact that it contains information from a three-dimensional space consisting of three independent scales: the scale of the observed difference in the pulse response to the orthostatic test; the scale of the initial state of the pulse before performing the orthostatic test; school of index assessment of the current state of the body.

The graphical presentation of this information is as follows: Proceeding from the fact that the most effective reaction of the organism to the sample is characterized by a zero difference in pulse rate to it (the speed of the test is not considered). It must be that way to get zero difference. In this case, the index score will be 14; in case of a

different outcome, the resulting index will be reflected in the point of the corresponding difference in accordance with the tabular data; A similar operation is performed for each baseline heart rate before the test.

Thus, in three-dimensional space, the display of tabular data, the (Z) axis of the applicate (vertical scale) is an index assessment of the state. The (Y) axis of the ordinate is the difference in heart rate per sample. The (X) axis of the abscissa is the baseline heart rate before the test.

Unlike a number of other methods of remote assessment of the current state of a person, which can give a sufficiently accurate analysis only with video recording of the performed motor act, the modified test of N. Teslenko is based on a non-specific (universal) heart rate response to the action of any altering factor of any nature, which is inaccessible to any method of remote monitoring and assessment of the current functional state. Modification of test by N.Teslenko became possible with the introduction of a comparison standard, which is the individual norm of the state and its relatively accessible norm of its variation. In each specific case, which is determined by the specifics of the considered professional activity, a qualitative assessment of the final result of this activity is formed, which characterizes its performance rank. In accordance with professional activity, in full analogy with the modification of N. Teslenko is assessing the current state.

With the intensification of production activities, the control of the current state of a person in the “man-machine-environment” or “man-machine” systems becomes an increasingly urgent task, and its solution has not yet been found. The reason for this state of affairs is that in each specific case, to assess the current state, the concept of a norm is used as a comparison criterion, but it does not take into account the comparison with which norm this comparison is made: with a general, universal, reflecting the body's nonspecific response to the influencing altering factor that acts as an analogue of the modified orthostatic test N.E. Teslenko either with the norm of the end result of specialized professional activity, or at the same time use a non-specific universal norm and a specialized one, which also takes place when solving a number of practical tasks.

The use of the practice of assessing the measure of fatigue by the dynamics of heart rate as a non-specific universal response is not the only one. These can be the frequency of respiration, the pH of saliva and blood, a measure of tissue swelling and a number of other reactions reflecting the constancy of the internal environment (its homeostasis). The use of heart rate in monitoring the manifestation of the observed dynamics of changes is the most accessible and there are a large number of means to ensure their registration. However, in the processing of the information received and its interpretation, there is no understanding and identification of the characteristics of the individual norm and the dynamics of its behavior in the adaptation processes of the whole organism. In particular, control of the measure of fatigue and residual potential for the further performance of a certain intensity of a given work.

In fact, the performed index assessment of the qualitative characteristics of the cardiovascular system in the orthostatic test "sitting-standing" carries information about the degree of fatigue in the content of the average statistical understanding of its norm, since this follows from the principle of collecting the information itself. The main merit of the development of an index assessment of the current state of the subject is that, without performing any load, to determine the measure of fatigue only according to the data of changes in heart rate. In the conditions of the test, the need for a quick change in the sitting-standing posture was noted. The test was developed as an alternative to the widely used S. Letunov, which consisted of three consecutive loads of varying intensity and duration: 20 squats, a 15-second run in place with a maximum speed and a 3-minute run in place at a pace of 180 steps per minute. Letunov's test took 5 minutes, could be carried out before and after the training session, based on the average statistical data of the norm of a conditionally healthy individual [5].

N. Teslenko test took 10 seconds, could be carried out during the training session using the table of index assessment of the current state. The concept of an individual norm at that time was completely absent, but the structure of constructing an index assessment contained this information.

When modifying the N.Teslenko test and the developed theory of the individual norm, as a result of the three-dimensional presentation of its content, the conditions for establishing the individual norm, and, consequently, the current state of working capacity or fatigue, as indicated by a single beat of the pulse, were revealed.

Presenting the subsequent blow as a reaction of a change in state relative to the previous state, it is necessary to establish the observed increment, which led to the concept of the norm of the state and the state of the individual norm. The presentation of the dynamics of the behavior of the increments relative to a certain state reflects disturbances in the homeostasis of the internal environment to the transferred load. The individual norm is considered to be 0-difference in increment when changing the sitting-standing posture. When analyzing the data table, it follows that by changing the speed of the rising of the rising, you can always achieve this effect. This load mode will be the norm of the state. Considering the modern miniaturization of sensor sensors and the computer capabilities of the received signal, it can be considered that the set goal has been fully achieved.

If, instead of the amplitude-frequency characteristic of the vessel wall oscillation, we take any other indicator of the oscillation of the final equifinal result of the professional activity performed, then the pattern of his behavior does not change. Consequently, both a nonspecific universal reaction and a differentiated specialized reaction have the same nature of the mechanism of their construction and constitute the structure of a complex of continuous diagnostic monitoring of the current state of the observed individual.

Conclusions / Discussion

Today there are several approaches to teaching individual elements of technology: start learning from simple to more complex elements [2, 4]; training should be carried out at the beginning of the lesson [5; 6]; use special and underwater exercises, etc. [3].

At that time, along with the positive use of these and other techniques, in our opinion, The previous experience in sports medicine shows that the amplitude-

frequency response of the smooth muscles of arterial vessels has two opposite directions of its response to the action of the hydrostatic shock of the orthostatic test. In one case, this manifests itself in an increase in their tension tone and the manifestation of a hypertensive reaction, in the other, a decrease in tone and a manifestation of a hypotonic reaction is observed. Changes in vascular tension tone are closely related to changes in the frequency response of the contraction of the heart muscles (according to the principle of hyperbolic dependence), which underlies the physiological mechanism of the striated muscles [18].

This reaction of vascular tone regulation is determined by the need to regulate the value of the constancy value by maintaining the pulse pressure with a constant dynamics of systolic and diastolic pressures. In general, this dynamics is characterized by nine different directions of its change and seven ranks of changes in the strength of deviations from the stress norm. Depending on the magnitude of the violation of the norm, the direction of the accumulation of fatigue develops irreversible pathological disorders [16, 25].

Systematic monitoring of ongoing deviations from the norm of the process of optimal regulation makes it possible to identify and predict emerging occupational diseases, which is the basis for diagnostics based on a 7-point gradation from syndrome to symptoms, and then to prodrome [1, 8, 14].

The systematization of the results obtained allows us to draw the following conclusions: the underlying physiological processes that determine the morphofunctional changes in the body are analytical patterns. This allows you to control the development of violations and timely anticipate their manifestation.

The analytical patterns that have been identified in the control of the dynamics of amplitude-frequency changes in heart rate are: periodic manifestations reflected in trigonometric functions, hyperbolic dependencies, catenary lines, cycloidal dependence, arithmetic and geometric progressions, which in their interdependent relationships lead to constants π, e, φ, their numerical expressions represent infinite fractions. Their rounding in the practice of actually occurring processes determines

the tolerance of the space of relations, which limits the complexity of building a system of relations.

Individual manifestations of general patterns are associated with a coefficient that determines the curvature of the noted analytical expressions.

The peculiarity of the behavior of the noted patterns is the discrete nature of their manifestation.

Further research It is planned to build a unified system for controlling the development of fatigue for all situational types of sports activity, based on the use of a universal (nonspecific) reaction of the body in response to a change in static stress, controlled only by its rank.

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References

1. Artemeva, G. P., Pugach, Ya. I., Druz, V. A. (2014), Problemyi adaptatsii v strukture nauchnyih issledovaniy sistemyi olimpiyskogo obrazovaniya [Adaptation problems in the structure of scientific research of the Olympic education system], monografiya, Harkov, HGAFK, 114 p. (in Russ).
2. Ashanin, V. S., Pugach, Ya. I. (2014), Postroenie semanticheskih prostranstv dlya opisaniya psihosomaticheskoy deyatelnosti cheloveka v ekstremalnyih usloviyah [Construction of semantic spaces to describe the psychosomatic activity of a person in extreme conditions], uch. posobie, Harkov: HGAFK, 88 p. (in Russ).
3. Babskiy, E. B., Zubkov, A. A., Kositskiy, G. I., Hodorov, B. I. (1966), Fiziologiya cheloveka [Human physiology], Moskva: Meditsina, pp. 370–379. (in Russ).
4. Bakanova, A. F. (2013), Organizatsiya fizicheskogo vospitaniya studencheskoy molodezhi na sovremennom etape reformirovaniya vyisshih uchebnyih zavedeniy [Organization of physical education of student youth at the present stage of reforming

higher educational institutions], dissertatsiya kand. nauk : 24.00.02, Harkov, 248 p. (in Russ).

5. Vasileva, V. V., Graevskaya, N. D., Kukalevskiy, G. M. (1961), Sportivnaya meditsina [Sports medicine], Moskva: Medizdat, pp. 207, 233–235. (in Russ).

6. Volkov, V. M. (1977), Vosstanovitelnyie protsessyi [Recovery processes], Moskva: Fizkultura i sport, 143 p. (in Russ).

7. Volkova, Ya. (2020), "Modern methods of fatigue assessment", Slobozhanskyi naukovo-sportyvnyi visnyk, No. 4 (78), pp. 30–36. (in Ukr.).

8. Gika, M. (1936), Estetika proportsiy v prirode i iskusstve [Aesthetics of proportions in nature and art], Moskva: Vsesoyuznaya akademiya arhitekturyi, pp. 119–120, 262–263. (in Russ).

9. Gippenreyter, Yu. B. (1966), Vosstanovitelnyie protsessyi pri sportivnoy deyatelnosti [Recovery processes in sports activities], Moskva: Fizkultura i sport, 56 p. (in Russ).

10. Druz, V. A. (1985), Analiz obschih printsipov funktsionalnyih otnosheniy sistem organizma v dinamike [Analysis of general principles of functional relationships of body systems in dynamics] : dissertatsiya d-ra biol. nauk : 05.13.09, ANUSSR. Kiev, 504 p. (in Russ).

11. Druz, V. A., Omelchenko, M. V., Omelchenko, D. A. (2015), "Sprint technique basics", Slobozhanskyi naukovo-sportyvnyi visnyk, No. 3 (37), pp. 41–46. (in Russ).

12. Zimkin, N. V. (1964), Fiziologiya cheloveka [Human physiology], Moskva: Fizkultura i sport, pp. 381–398. (in Russ).

13. I-tszin (2016), Kniga peremen [Book of Changes], Moskva: Azbuka-Attikus, 576 p. (in Russ).

14. Markov, G. V. (2006), Sistema vosstanovleniya i povyisheniya rabotosposobnosti v sporte vyisshih dostizheniy [System of recovery and improvement of performance in elite sports], Moskva: Sovetskiy sport, 52 p. (in Russ).

15. Pugach, Ya. I. (2014), Vliyanie emotsionalnogo sostoyaniya na uspeshnost sorevnovatelnoy deyatelnosti [The influence of the emotional state on the success of

competitive activity]: dissertatsiya kand. nauk po fiz. vosp. i sportu : 24.00.01, Harkov: HGAFK, 198 p. (in Russ).

16. Pugach, Ya.I. (2013), "Basic principles of constructing semantic spaces for the orderly presentation of research results", B'deschego voprosyi ot sveta na nadkata: materialyi IX mezhdunarodnoy nauchno-prakticheskoy konferentsii, Sofiya, pp. 5–13 (in Russ).

17. Rozenblan, V. V. (1976), Problemyi utomleniya [Fatigue problems], Moskva: Meditsina, 220 p. (in Russ).

18. Samsonkin, V. N., Druz, V. A., Fedorovich, V. S. (2010), Modelirovanie v samoorganizuyuschihsya sistemah [Modeling in self-organizing systems], Donetsk, 104 p. (in Russ).

19. Farfel, V. S. (1960), Fiziologiya sporta [Physiology of sports], Moskva: Fizkultura i sport, pp. 301–311. (in Russ).

20. Chzhou Tszunhua, Dao I-tszina (1999), Put k proritsaniyu [The path to divination], Kiev: Sofiya, 368 p. (in Russ).

21. Shesterova, L., Druz, V., Efremenko, A. (2017), "Analysis of the kinematic characteristics of the movement of the general center of body mass of an athlete when performing a low start", Slobozhanskyi naukovo-sportyvnyi visnyk, No. 2 (58), pp. 113–118. (in Russ).

22. Hirata K. (1968), The evaluating method of physique and physical fitness and its practical application, 240 p. (in Eng)

23. Hoffman J., Mohri M., & Zhang N. (2018), Algorithms and Theory for MultipleSource Adaptation, CoRR 805 p. (in Eng)

24. Hristovski R., Balague Serre N., & Schollhom W. (2014), "Basic notions in the science of complex systems and nonlinear dynamics", Complex Systems in Sport. London, UK: Routledge, pp. 3–17. (in Eng)

25. Sheldon W. H., Lewis N. D. C., Tenney A. (1969), Psychotic patterns and physical constitution, N.Y., 325 p. (in Eng)

26. Zadeh L. A. (2015), Fuzzy logic – a personal perspective, Fussy Sets and Systems, 281 p. (in Eng)

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