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Development of a Method and a System for Evaluation Sportsman's Physiological Reserves

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Abstract. The article discusses the solutions to increase the effectiveness in sports based on the parameters characterized on breathing, cardiovascular and musculoskeletal systems of the sportsman. Formed a complex of parameters for complex evaluation of sportsman's physiological reserves. The proposed structure of the biotechnical system, the system and method for the evaluation of sportsman's physiological reserves is based on the dynamics physiological health status of the sportsman to increase the efficiency and accuracy of the evaluation of sportsman's functional status and physiological reserves in sports.

INTRODUCTION

To achieve high sports results, it is required to ensure the efficiency in managing the training process of sportsmen. One of the most important principles for constructing plans for the training process is the correspondence of physical activity (PA) to the current functional status and physiological reserves (PhR). However, the problem in evaluating sportsman's PhR is among one of the most difficult problems of scientific and sports medicine. This means that for their evaluations, the use of only one feature of one body system of sportsman's is not enough, since the accuracy of the score will be low. It is necessary to form a complex of diagnostically significant parameters, use a number of signs of sportsman's condition and logical rules that will take into account the nature of changes in significant parameters. In addition, to ensure the intellectual mode of assessing the condition of the sportsman, it is necessary to use signs, criteria for controlling the recording and processing of physiological signals.

Therefore, the development of a method and a system for evaluating sportsman's PhR play a very important role in sports medicine in order to increase the effectiveness of evaluation of the sportsman's health status and the effectiveness of sports training.

The purpose of the work is to develop a method and a system for the evaluation of sportsman's PhR during training process. To solve the problem, it is necessary:

- Formation of a complex of biomedical parameters and an integral parameters reflecting sportsman's PhR during training process;
- Development of a method for conducting biomedical research and evaluation of sportsman's PhR based on complex parameters of the body systems reflecting on the functioning of the body systems.
- Development of a generalized structure of the biotechnical system and the structure of the system for the receiving, registration, processing and analysis of sportsman's physiological signals.

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MATERIALS AND METHODS

Formation of complex biomedical parameters and integral parameters reflecting on sportsman's PhR during training process. As it is known, in the physiology the autonomic nervous system (ANS) controls the energy and metabolic processes of the human body, mobilizes, accumulates and ensures PhR in recovery. The mechanisms of autonomic regulation play a leading role in the adaptation of the organism and in maintaining the homeostasis of the main systems when environmental conditions change, provide the necessary economization of functions when working on endurance and determines the sportsman's speed of recovery.

With an increase in PA on the body, leads to an increase in the heart rate (HR), pulse rate (PR) and breathing rate (BR). Circulating blood supplies carbohydrates and oxygen to the body cells and produces carbon dioxide and water. Consequently, the values PhR in current time will be determined primarily by the parameters: HR, PR, BR. With an increase in PA, the HR should change adequately [1, 2]. It is advisable to take into account the Bayevsky stress index (INB) [3] for the efficiency of heart rhythm management. The initial signs that determine changes in metabolism under conditions of PA are changes in heart rate variability (HRV), which reflect the mechanism of regulation of physiological functions of the body and allow us to characterize the overall activity, changing metabolic rates to achieve an optimal adaptive response, an adaptive system of the sportsman's general body. Values of HRV are due to the activity of the sympathetic and parasympathetic divisions of the autonomic nervous system. Therefore, HRV have characteristic of the heart rhythms stability and working limit for a given value of PA [4]. In addition, changes in blood pressure (BP) and HR values reflect the amount of oxygen providing for the muscular and entering the cells, which are necessary to perform PA.

During PA, in order to improve the sportsman's performance and achieve high results, it is important to ensure the rhythmic supply of oxygen to the muscle cells. It is no coincidence that in many sports "blood doping" is used, which increases the number of red blood cells. This leads to an increase in the content of oxyhemoglobin and the transport of oxygen to the cells, which allows the muscles to work more stably, and also reduces their fatigue. The key effect of the procedure is improving the performance of sportsman. Although "blood doping" does not increase the maximum strength, it allows the muscles to load more intensively for a long time without fatigue. Therefore, an important feature for evaluation of sportsman's condition is the degree of arterial oxygen saturation – SO_2. With an increase in PA, the level of sportsman's SO_2 decreases. To increase the duration of the workout, a larger volume of oxygen is required, but the breathing system cannot provide it. In this regard, the use of oximetry is important for controlling the level of SO_2 and physical work, since the evaluation of the dynamics sportsman's SO_2 is important not only during training, but also during the recovery period.

The next group parameter, which changes under the influence of the PA and characterizes the physical load of the oxygen-transport system, is the breathing rate. Control breathing is one of the most important tasks in sports medicine and high-performance sports. During recovery, the breathing rate decreases quickly. Therefore, the determination of the dynamics breathing rate to evaluate the sportsman's reserves, of course, it is advisable in the form of informative parameter. Thus, the following important parameters for the evaluation of sportsman's PhR are BR and level of SO_2.

When monitoring of the sportsman, for comprehensive evaluation of his PhR, it is important to consider the efficiency of recovery. The recovery rate is determined by the health status, the degree of training and the level sportsman's PhR. In this case, the following dependence is noted: the higher the PhR of the body, the faster the recovery of PhR to its initial values. Thus, to evaluate sportsman's PhR, it is necessary to use the following physiological parameters characterizing of PhR of the body: HR, PR, HRV, INB, SBP and DBP (systolic and diastolic blood pressure), BR and level of SO_2. These parameters should be used for an integrated assessment of PhR of the body of sportsman.

Development of the method for the evaluation of sportsman's physiological reserves. During the training process, sportsman under the guidance of coach work out various tasks using the PA according to the developed training schedule with the goal of developing skills. This process, as a rule, includes several sessions, between which a short pause is used to change the task and increase the PA. For a coach and a SM doctor it is important to know how the PhR of the sportsman's body change as loads increase. The number of sessions of the training process depends on many factors: training plan, sport, sportsman's health status, etc. To clarify the methodology of developing a research on the studying of PhR of the sportsman's body, we will use the following simplified scheme (Fig. 1).

In accordance with the proposed scheme, the time points T0, T1, T2, ..., Tk are used to evaluate the potential capabilities of the sportsman's body.

At the time T0 - evaluation of PhR initial (background) value of the sportsman's body, before the start of training. Immediately after the evaluation of PhR (T0), the training process begins.

At the time T1 - evaluation of PhR (T1) after the completion of the first session of training.

At the time T2 - evaluation of PhR (T2) after the completion of the second session of training.

At the time Tk - evaluation of PhR (Tk) after the completion of the training process (the k-th session). After that, at intervals Δt, the PhR is estimated (jΔt) in order to study the recovery time of PhR of the sportsman's body.

At each session of conducting research of PhR of the sportsman's body, the following operations should be performed:

• Receiving and synchronous registration of sportsman's physiological signals, their processing and analysis, evaluation complex of diagnostically significant parameters of the body sportsman's.

• Evaluation of particular absolute, relative parameter of PhR and the integral parameter of PhR of the sportsman's body. Evaluation of the integral parameter values of PhR at the training process sessions, evaluation of the characteristics of the dynamics parameter of PhR and the parameter of sportsman's recovery PhR.

• Identify patterns of changes in the integral parameter of PhR and the parameter of PhR recovery of the sportsman's body from the levels of PA used in sportsman's training.

• Formation of the schedule and sportsman's training process correction, taking into account the dynamics of PhR of the sportsman's body.

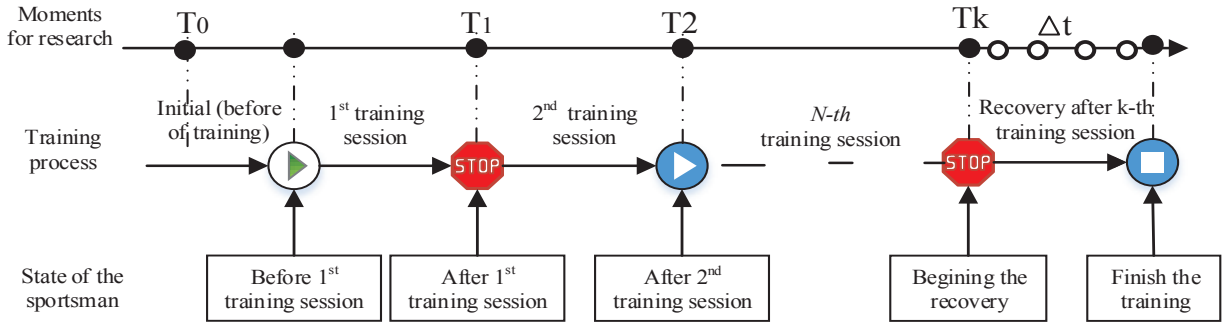

FIGURE 1. A scheme of the sportsman's PhR during training process research.

Development of the structure of a biotechnical system for evaluation of sportsman's physiological reserves. To research sportsman's PhR and evaluate of potential capabilities of the sportsman's body, the biotechnical system should include elements that ensure the receiving and registration of sportsman's physiological signals, processing signal and evaluation of diagnostically significant parameters, evaluation of PhR particular and integral parameter, evaluation of the dynamic characteristics of the integral parameter of PhR, setting the values of the dosed physical load. With that said, the biotechnical system should have the following generalized structure (Fig. 2). To enable the use of the proposed system in the tasks of remote monitoring of the sportsman's health status [5], it provides the following functions:

• Continuous long-term synchronous recording of a complex of physiological signals, characterizing the sportsman's current health status;

• Evaluation and storage of diagnostic information that characterize sportsman's PhR in the devices processing and analysis of SM doctor;

• Information and medical support of the sportsman when a critical condition appears by a SM doctor;

• Operational evaluation of the training effectiveness and the correction of the training plan for the global control loop by coach.

The system for evaluation sportsman's PhR should provide a function of continuous monitoring of sportsman's health status during training to eliminate life threatening conditions of the sportsman. In this regard, the system should have two levels of control loop that cover both SM doctor and coach:

The first level of a hierarchical system (Local control loop) involves evaluating the parameter of PhR locally, through the use of receiving and registration systems of sportsman's physiological signals based on the wearable sportsman's device (WSD), and the tool for processing and analyzing physiological signals and information based on the wearable doctor's computer (WDC). Using this control loop, SM doctor controls the mode of operation: receiving and registration of physiological signals, carries out the choice of the method for processing, analyzing

and displaying information about sportsman's PhR, performs the selection and adjustment to sportsman's PhR research program using dosed physical load.

The second level of the system (Global control loop) provides communication between the SM doctor and coach for the formation of activities and for the preparation of sportsman (training plan), taking into account previously received information about sportsman's PhR. All data about sportsman's PhR downloaded to the wearable doctor's computer WDC are copied to the server to fill in the electronic card of the sportsman. Having access to the server, coach can analyze data on the dynamics sportsman's PhR during an ongoing workout or for an extended period training, develop events and make changes to the sportsman's training program. In the activities of an emergency situation that threatens the life of the sportsman, the connection between the SM doctor and coach should be carried out directly (Fig. 2).

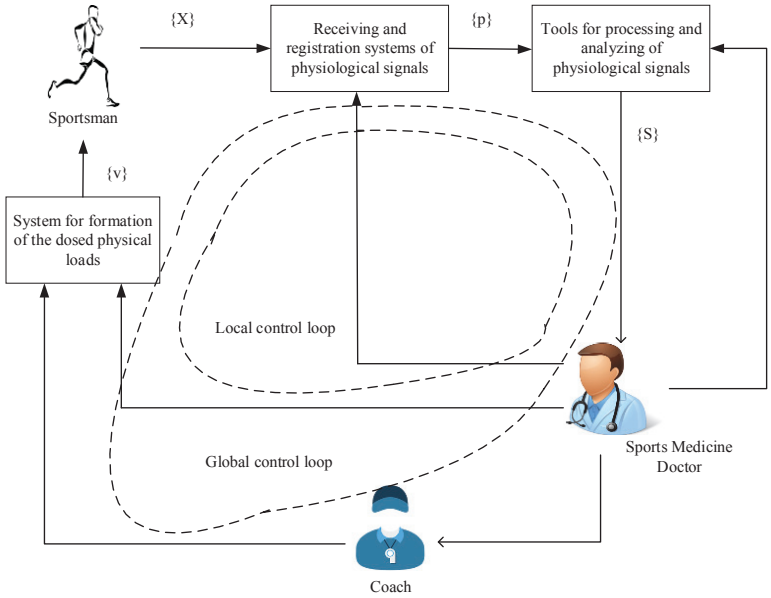

FIGURE 2. A Structure of the biotechnical system for evaluation sportsman's PhR.

All registered physiological signals after performing pre-processing, filtering, suppressing of noise and artifacts, are fed to the WDC to evaluate diagnostically significant parameters. The sports medicine doctor forms an integral assessment of the health status and the sportsman's PhR. According to the conclusion, coach compares the status sportsman's with the efficiency of performing the task during the training, assesses the sportsman's PhR level, fixes the training plan, and also for corrects the intensity level of PA in a timely manner according to the systems of dosed physical load.

CONCLUSION

To evaluate the potential capabilities of the sportsman and predict his results in sports, it is necessary to evaluate sportsman's PhR using complex of physiological signals recorded during training process. The estimated complex of diagnostically significant parameters reflects the effectiveness of the breathing system, cardiovascular system and musculoskeletal system of the sportsman. The health status of the sportsman should be characterized by parameters of PhR at the current time, as well as its dynamics during training process. Evaluation of the dynamics PhR on completion of training process allows the evaluation of the recovery of PhR.

The proposed method of conducting sportsman's PhR research and the biotechnical structure with a spatially distributed architecture of biotechnical system to allow coaches and sports medicine doctors to evaluate the effectiveness of sportsman's training process, taking into account his potential and the training process management effectiveness.

REFERENCES

1. M. Stork, J. Novak and V. Zeman, *2017 11th IEEE International Conference on Measurement* (2017), pp. 251–254.
2. M. Scott, K. S. Graham and G. M. Davis, Frontiers in physiology **8**, 301 (2017).
3. R. M. Baevsky and G. G. Ivanov, Arrhythmology Bulletin **24**, 65–86 (2001).
4. J. G. Dong, Experimental and therapeutic medicine **11(5)**, 1531–1536 (2016).
5. Tr. T. Nguyen, Tr. H. Tran, M. T. Nguyen and Z. M. Yuldashev, Journal of the Russian Universities. Radioelectronics **5**, 71–80 (2018).