Digital monitoring of the exercise's heart rate as a tool for determining personalized physical activity norms

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Abstract

Objective of the study was to substantiate digital monitoring of the exerciser's heart rate as a tool for determining personalized physical activity standards.

Methods and structure of the study. Within the framework of the methodology for rationing physical activity of those engaged in health-improving physical culture, the totality of daily measurements of their heart rate is considered as a system of states of the human body. This solution is necessary when determining personalized physical activity standards based on daily heart rate data obtained using wearable devices. The problem of rationing physical activity has two contradictions: the mass distribution of wearable technologies and the insufficient use of their functionality to solve the problems of rationing health-improving physical activity; increasing the effectiveness of health-related activities and the lack of modern technologies for determining personalized standards. To solve the problem of personification of norms, it is proposed to use the theory of rank analysis, which is promising when studying daily non-Gaussian heart rate data obtained using wearable devices. The technology for rationing physical activity consists of the stages of preparation, collection and processing of data and development of proposals. Based on the results of the technology, based on the lower and upper limits and training potential, personalized values of physical activity standards are determined for three levels of training (beginner, intermediate, advanced). The recommendations obtained can be used as personal standards for physical activity and updated if necessary (after a month, quarter or year). Physical activity levels can be monitored using smart watches both during and after classes. At the same time, the obtained heart rate norms are personal and are suitable only for one person.

Results and conclusions. The proposed system of states of the human body creates the prerequisites for determining personalized standards of physical activity and developing effective physical education and health programs for those involved in health-improving physical culture.

Keywords: *health-improving physical culture, rationing of physical activity, pulse, heart rate, wearable devices.*

Introduction. Digital transformation of various sectors of the economy, social sphere, including the sphere of health-improving physical culture (HPC), is defined by the Decree of the President of the Russian Federation of July 21, 2020 No. 474 «On the national development goals of the Russian Federation for the period up to 2030» as one of the priority national development goals of the Russian Federation [2, 9]. However, despite the rapid development and mass distribution of digital wearable devices with the function of continuous heart rate monitoring with sufficient accuracy, most modern methods and approaches to standardizing physical activity do not take into account the data of all daily activity [5, 6, 7, 10, 11]. At the same time, the HPC emphasizes the importance of determining personalized standards of physical activity, since it is standardization that ensures the health effect of the load of those involved in physical culture, on the one hand, and the effectiveness of training, on the other. Personalized standards of health-improving physical activity contribute to effective training, while an insufficient standard does not bring the expected effect, and an excessive standard has a negative impact [1, 4]. Therefore, there is a need for personalized standardization of physical activity for those involved in OFC. In this case, a person involved in OFC is un-

derstood to be an adult who has no contraindications to exercise, who is engaged in (or plans to engage in) organized physical activity for the purpose of improving health, creating an optimal background for life, increasing the body's resistance to various factors and prolonging active longevity [1, 4, 5, 7, 10, 11]. When determining personalized standards of physical activity for those involved in OFC, the functional capabilities of their body should be taken into account. In practice, heart rate (HR) is the most common indicator of the body's response to physical activity [1, 4, 5, 7, 10, 11]. «Smart» watches (fitness bracelets) allow you to collect heart rate data throughout the day (usually using an optical sensor using the plethysmography method) [12, 13]. Having information about all the daily motor activity of the person involved - the entire set of heart rate for the day, you can determine his personalized physical activity standards.

Objective of the study was to justify digital monitoring of the exerciser's heart rate as a tool for determining personalized physical activity standards.

Methods and structure of the study. The analysis of the daily heart rate data showed that they belong to the type of non-Gaussian data (there are also unrelated and Gaussian data), for which the central limit theorems and the law of large numbers do not work. In mathematical statistics, non-Gaussian data are studied and processed within the framework of the theory of rank analysis developed by Professor B.I. Kudrin for non-Gaussian systems of various types [3, 8]. Therefore, it seems promising to use the tools of rank analysis in the theory of OFC in order to study the totality of heart rate data and further determine the norms of physical activity for those engaged in OFC [5, 6, 7, 10, 11]. To implement the tools of rank analysis, it is necessary to consider daily heart rate measurements as a system of human body conditions.

Results of the study and discussion. Let's consider the body of a person engaged in physical fitness as a system. The property of such a system is to transform the energy of food into the energy of the life of the person engaged in physical fitness. The indicator of the system is energy expenditure associated with energy exchange in the process of the life of the person engaged in physical fitness. The parameter of the system is the equivalent of calories - heart rate [1, 4]. Taking into account digitalization, it is proposed to replace the concept of HR with the minute heart rate (MHR) - this is one reading of the arterial pulse of an adult in the process of his life, taken on the radial artery by the method of plethysmography using an optical sensor and measured in the number of heartbeats per minute. One state of the system is understood as one measurement of MHR. Accordingly, there are 1440 such states per day.

Thus, the system of states of the human body (SSOC) is understood as the daily totality of the Ministry of Emergency Situations in the course of life of a person engaged in OFC. Figure 1 shows the life cycle of the data of the Ministry of Emergency Situations in the SSOC.

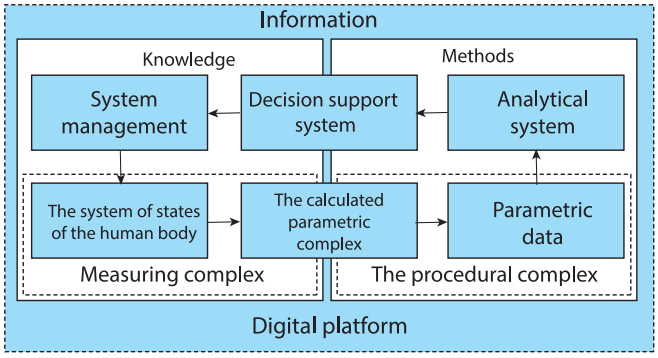

Fig. 1. The life cycle of the data in the SSOC

After measuring the MCHS, the calculated parametric complex (RPC) is an interconnected set of parametric data of the MCHS formed by the results of measuring the MCHS, reflecting from the quantitative, qualitative, and dynamic sides the functional properties of both one state individually and the system of states of the human body as a whole. An element of the RPC is the MOE database (Fig. 2). Further processing of MOE data, their analysis, interpretation and definition of personalized norms is carried out within the framework of the technology of rationing physical activity of the OFC (Fig. 3).

According to the results of the technology, personalized values of physical activity standards for three levels of training are determined. The recommenda-

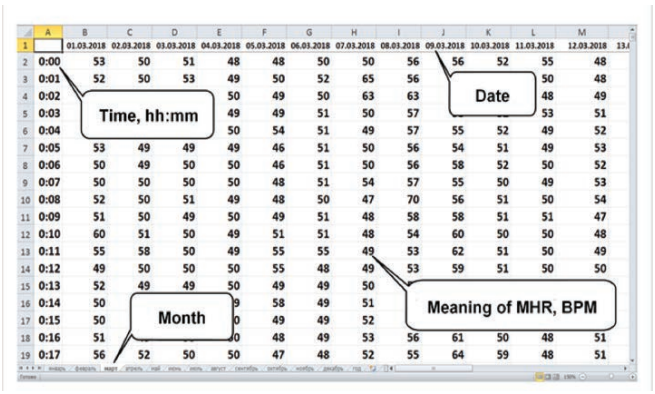

Fig. 2. The Ministry of Emergency Situations database

tions received can be used as personal standards of physical activity and, if necessary, updated (in a month, quarter or year).

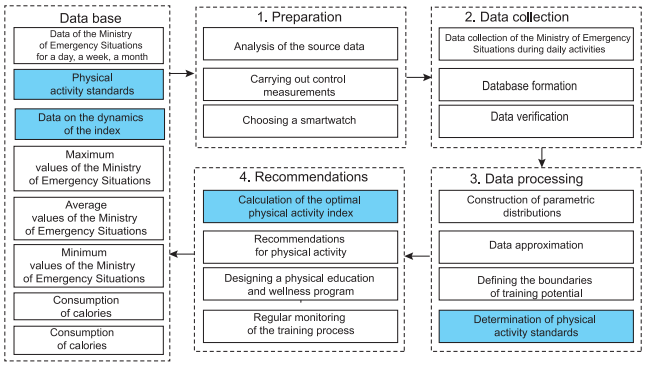

Fig. 3. Stages of physical activity rationing technology

Let's consider the process of determining personalized norms of physical activity. As an example, let's analyze two female students (subject A and B) of the same age (24 years old), weight (52 and 54 kg) and height (159 and 160 cm). Figure 4 shows graphs of the daily heart rate data of the subjects and the results of approximating the average heart rate values of all days. As can be seen from the graphs, the nature of their daily activity is different and, accordingly, the approximations of average heart rate values are different.

Also, during the implementation of the normalization technology, in order to determine the upper and lower limits of the training potential, approximation curves of days with and without OFC training were constructed. As a result, personalized values of physical activity norms for three levels of physical fitness were obtained for the subjects (corresponding to the limits of training potential). The table shows the physical activity standards for subjects A and B.

As can be seen from the table, the obtained values of the norms for the subjects are different. Thus, for the beginner level of fitness, the difference in the volume of physical activity is 13%, for the average - 30%, and for the advanced - 125% (more than twice).

Thus, the technology of standardizing physical activity allows you to determine personalized norms. In this case, the system of states of the human body acts as a tool for this technology.

Further, the subjects themselves (those engaged in physical fitness) or the trainer act as a decision support system. They create physical education and health programs (select the necessary exercises) based on the obtained physical activity standards and monitor their implementation. The obtained physical activity standards are tracked using smart watches both during and after physical fitness classes. In this case, the obtained MHR standards are personal and are suitable only for one person.

Conclusions. Within the framework of the technology of standardizing physical activity of those engaged in general physical culture, the set of daily heart rate measurements is considered as a system of human body states. This solution is necessary when determining personalized physical activity standards based on daily pulse data obtained using wearable devices. The proposed system of human body states creates the prerequisites for determining personalized physical activity standards and developing effective physical culture and health programs for those engaged in health-improving physical culture.

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Physical activity standards (volume and intensity) for subjects A and B

Heart rate zone name	Heart rate, bpm	Level of preparedness					
		Beginning		Average		Advanced	
Anaerobic	176 – 196	0	0	0	2	1	8
Threshold	157 – 175	1	1	2	3	2	9
Aerobic	137 – 156	5	6	7	10	9	22
Average	118 – 136	16	18	24	28	27	49
Total training time, min	–	22	25	33	43	39	88
Test subject		A	Б	A	Б	A	Б

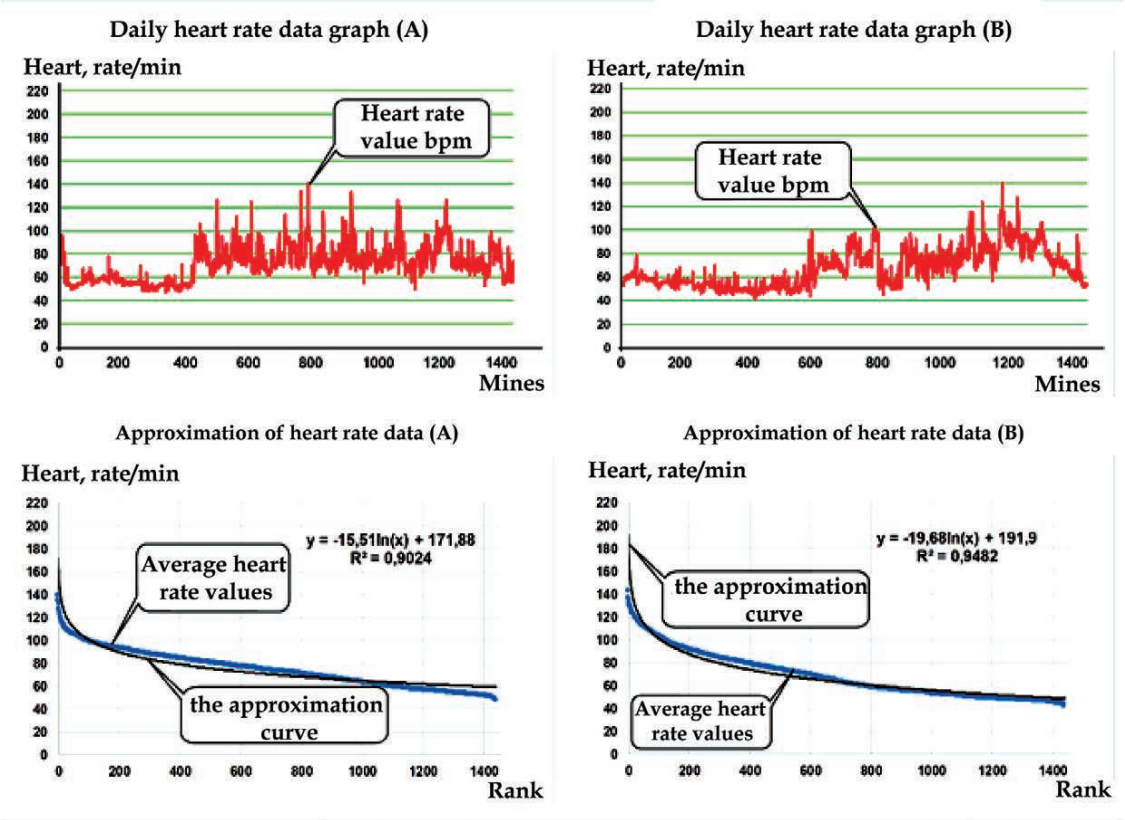

Fig. 4. Graphs of the daily heart rate data of the subjects and the results of approximating the average heart rate values of all days

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