UDC 159.9:796

VOLUNTARY MOBILIZATION OF ATHLETE'S NERVOUS SISTEM IN CASE OF SIMULATION OF SPORT ACTIVITY

ИССЛЕДОВАНИЕ ПРОИЗВОЛЬНОЙ ЭКСТРЕННОЙ МОБИЛИЗАЦИИ НЕРВНОЙ СИСТЕМЫ СПОРТСМЕНА В РЕЗУЛЬТАТЕ СИМУЛЯЦИИ ЕГО ПРОФЕССИОНАЛЬНОЙ ДЕЯТЕЛЬНОСТИ

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Keywords: *heart rate variability, nervous system emergency mobilization, elite rowers.*

Abstract. ***Empirical research aimed to reveal the physiological indicators of athlete's nervous system emergency mobilization during short and intensive physical activity was carried out. 17 elite athletes took part in this study (9 males, 8 females; rowing, kayaking, canoeing). The results show that standard deviation of heart rate and standard deviation of RR-interval duration are both the most sensitive indicators of athlete's functional state changes.***

Ключевые слова: *вариабельность сердечного ритма, экстренная мобилизация нервной системы, гребные виды .*

Аннотация. ***Проведено эмпирическое исследование с целью изучения физиологического обеспечения состояния экстренной мобилизации нервной системы спортсмена в ходе выполнения им короткой, но интенсивной работы. В исследовании приняли участие 17 спортсменов (9 юношей и 8 девушек; академическая гребля, гребля на байдарке/каноэ). Результаты свидетельствуют о том, что наиболее чувствительными показателями, отражающими изменение функционального состояния спортсмена (при переходе от исходного состояния к работе) являются два показателя вариабельности ритма сердца: стандартное отклонение ЧСС и стандартное отклонение длительности RR-интервалов.***

Introduction. Any sports activity and, in particular, competitive causes the athlete not only physical, but also emotional tension. Emotions activate the structures of the limbic system of the brain and provide additional mobilization of body resources in extreme conditions. Researches of a special psycho-physiological state, in which an athlete can enter in competitions, are often found in both domestic and foreign literature [1, 7, 13, 15]. According to authoritative experts, in the field of sports psychology [8], in the context of training an athlete for competitions, it is more correct to speak not of the optimal level of activation, but of the optimal activation state.

This fully agrees with the theoretical concept of individual zones of optimal functioning, proposed by Yu. L. Hanin [7]. The author claims that for each athlete there are certain limits of permissible excitation (excitement). If the athlete is in his individual zone, he acts in the best way. If the level of his excitement is lower – for an excellent performance he lacks energy, but if this level is higher than his individual norm – excessive excitement leads to the appearance of various negative consequences (too high tension in the muscles, the inability to concentrate on the task, negative emotions, toxic thoughts, nausea, somatic pains of different localization, etc.), which leads to an inevitable deterioration in the quality of the performance.

Therefore, it is so important to determine the individual boundaries of the state of the athlete's optimal functioning. This can be done with the help of modern equipment that produces high-precision recording of various physiological parameters that reflect the level of activation of the nervous and other human systems: heart rate variability, muscle tension, peripheral body temperature, skin galvanic reaction, respiratory system parameters, etc. After that, using the appropriate hardware techniques working on the principle of biofeedback (BFB), you can teach the athlete to enter arbitrarily in the zone of its optimal functioning [3, 10, 14].

The method for skin galvanic reaction and evaluating skin conductivity measuring (or skin resistance) is widely used to assess the degree of psychoemotional stress in a person [6], in assessing stress [12], driving load (Healey & Picard, 2005) . This method has a very high sensitivity, because at the slightest change in a person's state, the sympathetic department of the VNS activates, which causes an increase in sweating and a drop in skin resistance (or conduction enhancement).

Another widely used indicator of the functional state of a person is the variability of the rhythm of the heart. To quantify the heart rate variability and, accordingly, the state of regulatory mechanisms, three main approaches are used: temporal analysis of heart rhythm, frequency (wave) heart rate analysis and geometric analysis of heart rhythm [2, 5].

Also in psychophysiological researches, the measurement of the peripheral temperature of the phalanges of the fingers of the hand is used to assess the functional state. The binding between peripheral temperature and psychoemotional stress is as follows: under stress, the sympathetic department of the VNS is activated, its fibers have a vasoconstrictive effect on the peripheral vessels, the finger receives less blood and its temperature decreases. With relaxation, the reverse process occurs.

Thus, the purpose of the present research, supported by FMBA RF, was to study the physiological support for the state of emergency mobilization and to identify

Table 1 – Mean values and standard deviation of physiological indices in three periods: «background1», «work» and «background2» (*– significant changes between background and work, $p<0.05$).

Physiological Index	bg1	Std. Dev.	work	Std. Dev.	bg2	Std. Dev.
Pulse signal magnitude	9.8	3.3	11.1	4.4	10.9	3.3
Heart rate, bpm	81.6	6.8	88.7	14.3	84.2	6.4
St. deviation heart rate	24.8	7.1	30.2*	2.5	26.6	7.4
The main peak of the heart rhythm spectrum, Hz	0.087	0.031	0.082	0.031	0.078	0.034
SDNN	197.6	63.2	237.5*	32.8	219.6	55.3
VLF, %	24.6	8.63	24.4	6.1	24.1	9.3
LF, %	35.1	8.2	34.8	7.6	31.5	10.6
HF, %	40.25	10.51	40.81	7.54	38.51	12.02
VLF total	990.6	855.4	1244.7	813.5	1150.8	1026.7
LF total	1287.7	801.1	1747.9	896.1	1511.4	1040.1
HF total	1913.5	922.5	2377.8	741.8	2174.6	1140.1
LF/HF	0.798	0.472	0.746	0.332	0.651	0.275
EMG amplitude, μV	52.9	89.4	8.3	8.8	27.4	45.9
Skin conductivity, μSimens	4.83	4.21	5.65	4.23	5.39	4.21
Finger temperature, 0C	31.53	2.95	31.28	2.79	31.45	2.74
Respiratory rate, tpm	12.69	5.91	13.29	5.349	12.48	6.09
Amplitude of breathing	3.84	3.27	3.64	2.10	3.39	2.08

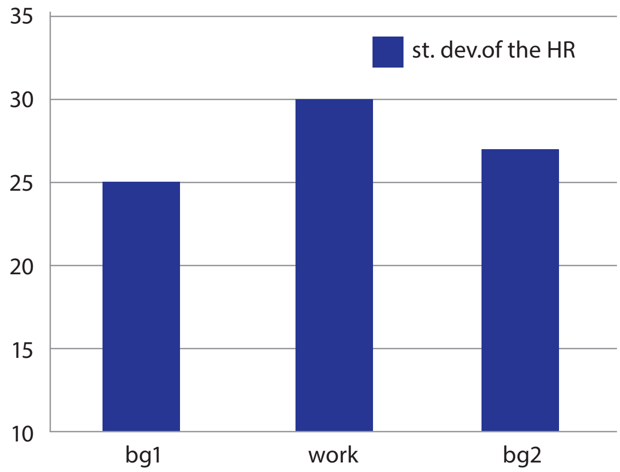

Figure 1 – Dynamics of changes in the indicator standard deviation of heart rate

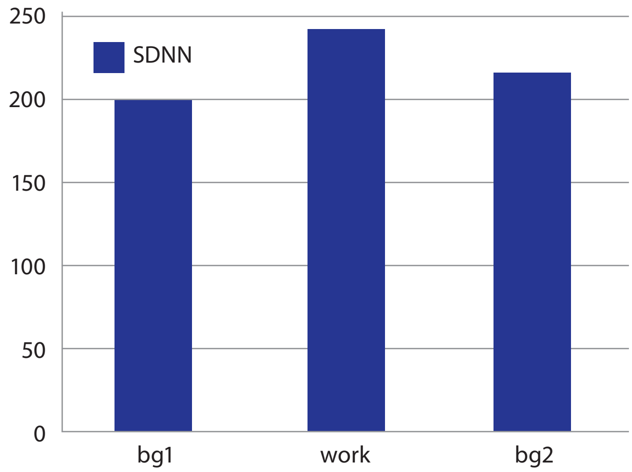

Figure 2 – Dynamics of changes in SDNN

the most sensitive indicators for the development of biofeedback protocols for training arbitrary entry into this state.

Materials and Methods. The research involved 17 athletes (9 men and 8 women): candidates for masters of sport, masters of sports, masters of sports of international level, members of the Russian national teams, champions and record-holders of Europe and the world in rowing and canoeing.

Physiological indicators were recorded in the initial state (background1) with closed and open eyes, then during work on the rowing machine (work) corresponding to the sport and in the recovery period (background2). Printing equipment and software BiographInfinity of ThoughtTechnology (Canada) was used. The following parameters were recorded: photoplethysmogram (for measuring heart rate and calculating heart rate variability), skin conductivity (for assessing the tone of the sympathetic part of the autonomic nervous system and the degree of psychoemotional stress of the athlete), finger temperature (for assessing the tone of the peripheral vessels and the sympathetic department of the VNS), pneumogram (for measuring the frequency and amplitude of respiratory movements).

Results. In our study, we studied the dynamics of athletes' physiological indices (rowing, kayaking and canoeing) in the process of performing a short but intensive work, their usual sporting activity (in the corresponding rowing simulator). Physiological indicators of the activation level (heart rhythm, respiration, skin conduction, finger temperature) were recorded on a polygraph before the work began, during the 1-minute load and during the recovery period after the load. The mean values and standard deviations of the obtained indices are given in Table. 1.

In this sample, only two indicators changed reliably from the background state to the work: the standard deviation of the heart rate (HR) and the standard deviation of the duration of the RR-intervals (SDNN). Both these indicators statistically significantly increased during work on the simulator by all criteria ($p=0.013$ and $p=0.031$ respectively, according to the t-test).

Then during the recovery period (background2), these indicators decreased, but remained slightly higher than the originating values (in the background1). The standard deviation of HR and SDNN reflects such a phenomenon as heart rate variability: the higher their values, the higher the heart rate variability. A sufficiently high level of heart rate variability is considered an indicator of the favorable state of regulatory mechanisms in the human body [4] and good adaptive capabilities of the cardiovascular system [11]. In this regard, we can say that in highly skilled athletes in our sample, in the habitual situation for them, emergency psychophysiological mobilization leads to adequate activation of the cardiovascular system with an increase in the variability of the heart rhythm in some indicators.

It should be noted that not only these indicators, but also all the rest of the recorded during the experiment, there were no significant changes between background1 and background2, so we can speak of the rapid restoration of the physiological resources of highly skilled athletes after a brief and rather familiar work . And also the absence of changes between the background1 and the background2 indicates that the revealed changes in the state of work are caused precisely by the load and the psychophysiological mobilization of the athlete.

A small number of reliable changes in the group as a whole made it possible to assume pronounced individual differences between the athletes. An example of the individual dynamics of physiological indicators is shown in Fig 3.

The study of the individual characteristics of the response to work on the simulator showed that the athletes did respond to the mobilization in different ways. So, as for the dynamics of finger temperature, for 5 athletes it grew, for 7 it remained unchanged, for 4 – it decreased during the load. The respiratory rate grew for 5 athletes, for 3 remained unchanged, and for 6 had a decrease. Amplitude of respiratory movements and skin conduction increased in all athlete.

Conclusion. The analysis of empirical data lets us conclude that for highly trained sportsmen, emergency psychophysiological mobilization leads to an adequate activation of the cardiovascular system with an increase in the variability of the rhythm of the heart. The most sensitive indicators reflecting the change in the functional state of a person (in transition from the initial state to work) were two indicators of heart rate variability – the standard deviation of heart rate and the standard deviation of the duration of RR-intervals.

Identified large individual differences in the dynamics of physiological indicators in emergency psychophysiological mobilization allow us to talk about the need for an individual approach to developing trainings based on the biofeedback method for training athletes to manage their own condition. Unambiguous dynamics was observed only in skin conductivity indices (growth during mobilization) and amplitude of respiratory movements (growth during mobilization). Thus, in the absence of the possibility of an individual approach, BOS-training aimed at achieving adequate mobilization can be carried out according to SDNN, skin conductivity, and respiratory amplitude.

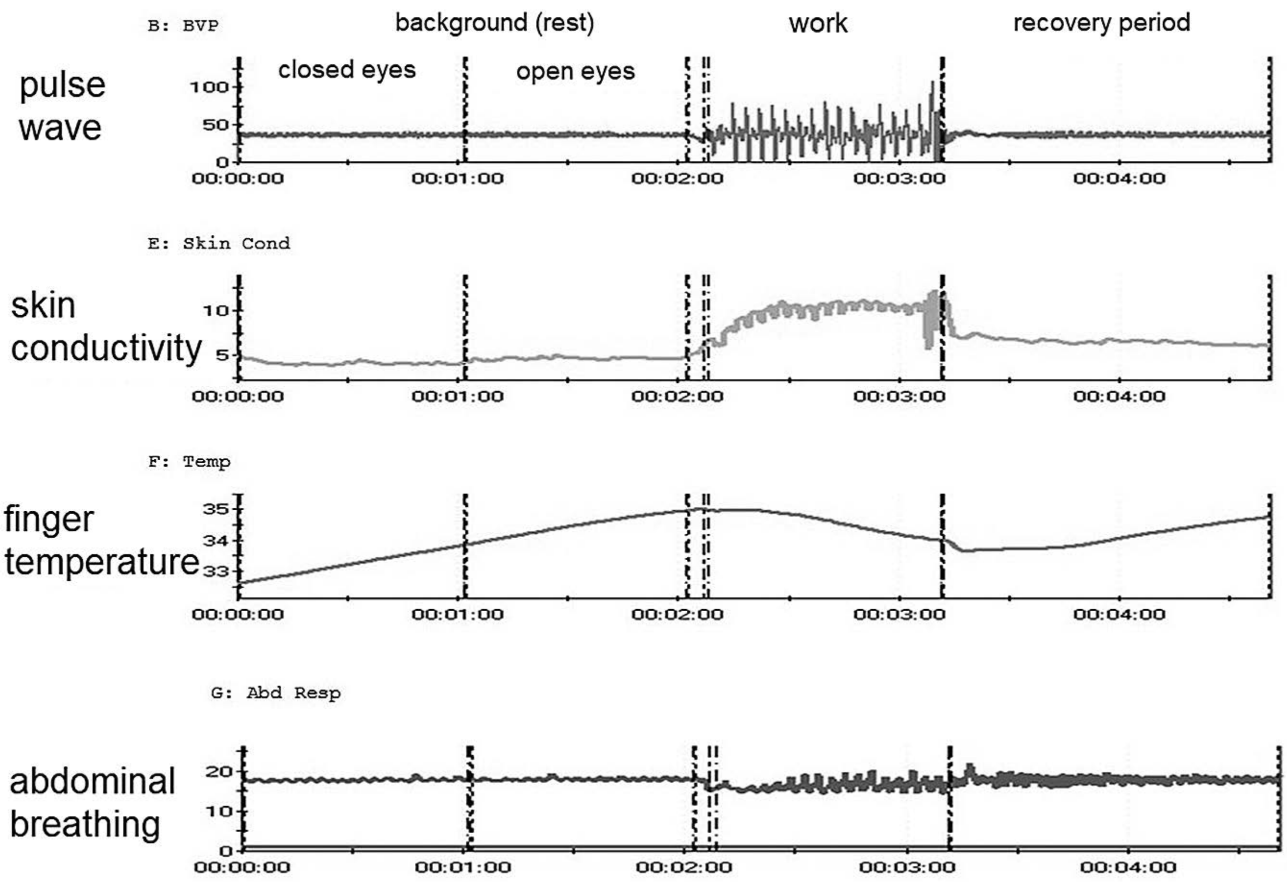

Figure 3 – Individual dynamics of physiological indicators in an athlete (rowing) at rest (with closed and open eyes) (background1), while working on the simulator and during the recovery period (background2)

Literature

1. Alekseev A. V. Overcome yourself!: Psychic training in sports. – M., 2006.

2. Alom M, Begum N, Naher Lad, Kabir R, Faruky Sb, Akhter N. Study on heart rate variability in adolescent male athletes by time domain (Short-Term) method // The Orion, vol. 33, issue 1, 2010.

3. Blumenstein B., Orbach I. Mental practice in sport: sports and athletic preparation, performance and psychology. Twenty case studies. Nova Science Publishers, New York, 2012, 125 p.

4. Chen Ju-Yi L, Tsai Yungling Leo, Lee Wei-Chuan, Chen Cheng-Han et al. Cardiac autonomic functions derived from short-term heart rate variability recordings associated with heart rate recovery after treadmill exercise test in young individuals // Heart and vessels, 2011 (26): 282-288.

5. Corrales, MM, Blanca de T, Esquivel C, Salazar M, Orellana G, Naranjo J. Normal values of heart rate variability at rest in a young , healthy and active Mexican population // Health (4) 2012, 377-385.

6. Dindo L., Fowles D.C, The skin conductance orienting response to semantic stimuli: significance can be independent of arousal, Psychophysiology 45 (1) (2008) 111–118

7. Hanin Y.L. (1980) A study of anxiety in sport. In W.F. Staub (ed.), Sport Psychology: An Analysis of Athletic Behavior, Movement Publications, Ithaca, NY, pp, 236-249.

8. Hardy, L., Jones, G., & Gould, D. (1996). Understanding Psychological Preparation for Sport: Theory and Practice of Elite Performers. Wiley, Chichester.

9. Healey J.A., Picard R.W., Detecting stress during real-world driving tasks using physiological sensors, IEEE Trans. Intell. Transport. Syst. 6 (2) (2005) 156–166

10. Landers D., Han, M., Salazar, W., Petruzzello, S., Kubitz, K., and Gannon, T. et al., (1992) Effects of learning on electroencephalographic and electrocardiografic patterns in novice archers, International Journal of Sport Psychology.

11. Muralikrishnan K, Balakrishnan B, Balasubramanian K, Visnegarawla F. Measurement of the effect of Isha Yoga on cardiac autonomic nervous system using short-term heart rate variability // Journal of Ayurveda and integrative medicine, vol.3, issue 2, 2012, pp. 91-96.

12. Setz C., Arnrich B., Schumm J., La Marca R., Trџster G., Ehlert U., Discriminating stress from cognitive load using a wearable EDA device, IEEE Trans. Inf. Technol. Biomed. 14 (2) (2010) 410–417

13. Solodkov A.S., Sologub E.B. Physiology of man. The total. Sports. Age: the Textbook. Ed. 2 nd, corrected. and additional. – Moscow: Olympia Press, 2005. – 528 p.

14. Vernon, D., Dempster, T., Bazanova, O., Rutterford, N., Pasqualini, M., Andersen, S. Alpha neurofeedback training for performance enhancement: Reviewing the methodology // Journal of Neurotherapy, 13(4), 2009.

15. Weinberg R.S, Gould D. Foundation of Sport and Exercise Psychology Human Kinetics, 2007.