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Vegetative reactivity in athletes in a state of overtraining

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Purpose: *to determine the state of the autonomic regulation of heart rhythm in athletes at various stages of overtraining from the results of an analysis of heart rate variability.*

Material & Methods: *under our supervision there were 49 athletes with signs of overtraining of the I-II stage. To determine vegetative reactivity, an analysis of cardiointervalography data with an orthostatic test was performed.*

Results: *revealed that the most often overtraining of the II stage was found among athletes of playing sports, and with athletic qualifications more often occurs among athletes of the I category than among masters of sports. The results of cardiointervalography indicated that in highly qualified athletes in a state of overtraining, the index of autonomic reactivity does not bring the value of the stress index beyond the balanced work of the ANS. In athletes from the 1st category, compared with masters of sports, hypersympathicotonic activity of the ANS occurs against the background of overtraining.*

Conclusions: *a high indicator of the stress index after an orthostatic test indicates the development of the strain of autonomic and regulatory systems in the body of athletes of the first category, which can lead to a breakdown in the adaptive capabilities of the body.*

Keywords: *athletes, overtraining, cardiointervalography, heart rate variability.*

Introduction

Achieving high athletic performance is closely related to the correct construction of the training process. In this case, one of the most important principles in the preparation of an athlete is the compliance of the load with the functional state of the body. In recent years, there has been a progressive increase in physical activity, the athlete's body is transferred, both during training, and even more during competitions, when a neuropsychic load also joins. Due to this, more and more often, athletes of various specializations, regardless of the orientation of the training process, observe a state of overtraining [3; 4; 7; 11; 16].

Overtraining is a pathological condition in which there is a violation of the ratio of the processes of excitation and inhibition in the cerebral cortex, due to various reasons, such as: monotonous, long-term highly specialized physical activity; violation of the regime of training, rest, nutrition; the use of certain medicinal substances (sometimes even prohibited in sports) training against a background of acute or chronic diseases; in violation of the didactic principles of building the training process [2; 6; 10].

Starting from the first stage, the regulatory role of the nervous system in the function of the systems and organs of the athlete's body is sharply violated, and a focus of stagnant excitation or inhibition is observed. These processes extend to most parts of the brain, leading to inhibition or increase in the function of the humoral regulation link through the system of the hypothalamus – pituitary gland – endocrine glands [9; 12]. This, in turn, leads to a violation of the autonomic regulation of the function of internal organs, including the cardiovascular, respiratory, digestive, excretory systems. In addition, all types of metabolism in the body are disrupted: proteins, carbohydrates, lipids, vitamins, water, macro- and microelements. That is, there are not only functional changes in the athlete's body, but also an organic restructuring of the structure of some organs. The state of all parts of the immune system is sharply disturbed: both nonspecific resistance of the body and specific immunity (its humoral and cellular link). In addition, due to the above reasons, the basic motor qualities of a trained person are violated, that is, first speed, then coordination of movements, strength indicators, and, last but not least, endurance [8; 14; 17].

The organs and systems of the human body are under constant neuro-humoral control, therefore, the close relationship of the sympathetic and parasympathetic departments of the autonomic nervous system and humoral influences ensure optimal results in terms of adaptation to changing conditions of the internal and external environment. Deviations arising in regulatory systems, as a rule, precede hemodynamic, metabolic, energy disturbances, and are the earliest prognostic signs of an imbalance in the athlete's body. Heart rate is an indicator of these deviations, therefore, the study of heart rate variability has important diagnostic and prognostic value for various pathologies, including overtraining in athletes.

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Based on the foregoing, the question of a careful approach to the early diagnosis of overtraining in athletes, the current analysis of HRV is appropriate and relevant, which will allow the timely introduction of methods for adjusting the training process.

Purpose of the study: to determine the state of the autonomic regulation of heart rhythm in athletes at various stages of overtraining from the results of an analysis of heart rate variability.

Material and Methods of the research

The study was conducted in the scientific-problem laboratory of the KSAPC. Under our supervision there were 49 athletes, sports qualifications from the first sports category to the master of sports (MS) with signs of overtraining of the I-II stage. According to demographic indicators, the groups of subjects were homogeneous by sex, age, height and weight indicators. The stage of overtraining was established by clinical signs (Table 1).

To assess the state of the autonomic nervous system, cardiointervalography was performed. The method is based on a mathematical analysis of the variability of the sinus heart rhythm, as an indicator of the adaptive-compensatory activity of the whole organism. Cardiointervalography was performed in continuous recording over 100 consecutive cardiocycles (R-R intervals) in the II standard ECG lead. After a 10-minute rest in a horizontal position, the first CIG record (initial) was recorded, the second was recorded immediately after moving to a vertical position. The integral parameter of cardiointervalography (CIG) was calculated as the resting stress index (SI1) – an indicator of the initial vegetative tone, and its dynamics in response to changes in the functional state (SI2), which is a reflection of vegetative reactivity (SI_2/SI_1).

CIG indicators were taken into account:

Mo (mod) – the most common value of the duration of the R-R interval, expressed in seconds.

Amo (mode amplitude) – the number of intervals equal to Mo as a percentage of the total number of registered cardiocycles.

Table 1

Characteristics of the examined contingent athletes with signs of overtraining I-II stage

Kind of sport	MS	CMS	I sports category	Total
1. Martial Arts	4	6	5	15
2. Athletics	2	5	3	10
3. Football	2	4	6	12
4. Volleyball	3	5	4	12
Total	11	20	18	49

DX (variational range) – the difference between the maximum and minimum values of the duration of the R-R interval.

SI (stress index) – the most fully informed about the degree of tension of the body's compensatory mechanisms, the level of functioning of the central contour of regulation of heart contractions in arbitrary units, calculated by the formula: **SI=Амо+(2xMoxDX)**.

Statistical analysis of the results was performed using EXCEL tables. For parameters that meet the criteria of normal distribution, parametric statistical methods were used. In this case, the arithmetic mean value – $\bar{X}$; was calculated; the average error of the arithmetic mean is ±m.

All ethical principles for medical research have been followed according to the WMA declaration (Helsinki, 2013).

Results of the research

The studies were carried out at the beginning of the training preparatory period, when the athletes did not show signs of overtraining, and then in the main (base) period, when the training loads are combined with the competitive ones. According to the results of the study, it was revealed that stage I overtraining was observed in 28 (57,1%) athletes with signs of this syndrome. The second stage of overtraining was determined in 21 (42,9%) athletes (Table 2).
When analyzing the data on the distribution of the stages of overtraining by type of sports provided in Table 2, it was found that the second stage overtraining was most common among athletes in sports, and it was more common among athletes of first category athletes than MS.

Table 2

The distribution of the studied athletes by type of overtraining, sport, sports qualification (number of persons, %)

Sports / Qualifications	Stage of overtraining	
	I st.	II st.
	28 (57,1%)	21 (42,9%)
За видом спорту:		
martial arts	12 (80%)	3 (20%)
athletics	7 (70%)	3 (30%)
football	4 (33,3%)	8 (66,7%)
volleyball	5 (41,7%)	7 (58,3%)
By sports qualification:		
MS (11)	8 (72,7%)	3 (27,3%)
CMS (20)	13 (65%)	7 (35%)
I category (18)	7 (38,9%)	11 (61,1%)

One of the objectives of our work was to study the characteristics of HRV at rest and after an orthostatic test. Table 3 presents the indicators of cardiointervalography of athletes of various sports qualifications.

Masters of sports (MS) in various sports are characterized by relatively high heart rate variability.

Given the value of the stress index (SI_1=53,92±6,66), the tension of the mechanisms of autonomic regulation of the ANS in athletes of this group is low. After performing an or-

Table 3

Indicators of cardiointervalography of athletes of various qualifications in a state of overtraining, $\bar{X} \pm m$

Indicators	MS (n=11)	CMS (n=20)	I category (n=18)	p_1	p_2
Mode $(Mo)_1$	0,84±0,03	0,87±0,02	0,89±0,09	>0,05	>0,05
Amplitude mode $(Amo)_1$	18,12±1,19	19,65±1,07	25,89±3,24	>0,05	<0,05
Dx_1	0,26±0,03	0,28±0,02	0,29±0,09	>0,05	>0,05
Stress index $(SI)_1$	53,92±6,66	56,81±7,06	90,88±28,67	>0,05	<0,05
Mode $(Mo)_2$	0,69±0,02	0,64±0,02	0,63±0,04	>0,05	>0,05
Amplitude mode $(Amo)_2$	19,18±1,10	22,13±1,12	39,33±4,60	<0,05	<0,05
Dx_2	0,21±0,02	0,19±0,01	0,25±0,07	<0,05	<0,05
Stress index $(SI)_2$	81,92±10,71	117,4±15,66	207,7±48,41	<0,01	<0,01
SI_2/SI_1	1,82±0,21	2,83±0,31	2,91±0,54	<0,01	<0,01

Remark. *p_1 – comparison the MS group with the CMS group; p_2 – comparison of the MS group with group I category.*

thostatic test, activation of the sympathetic nervous system moderately increases in MS, as evidenced by a mode indicator (Mo_2=0,69±0,02), an increase in mode amplitude (Amo_2=19,18±1,10) and stress index (SI_2=81,92±10,71), but its activation does not bring the value of the stress index beyond the balanced operation of the ANS, as indicated by the indicator of vegetative reactivity (SI_2/SI_1=1,82±0,21).

According to cardiointervalography, in the group of athletes of the CMS, in comparison with MS, activation of both the sympathetic and parasympathetic parts of the nervous system was noted: indicators of Mo increased (0,87±0,02 against 0,84±0,03), variational range (0,28±0,02 against 0,26±0,03), mode amplitude (19,65±1,07 against 18,12±1,19) and stress index (56,81±7,06 against 53,92±6,66). After performing an orthostatic test in CMS, a decrease in the mode parameter (0,64±0,02 against 0,69±0,02) and the variation range (0,19±0,01 against 0,21±0,02), as well as an increase in the mode amplitude (22,13±1,12 against 19,18±1,10) and the stress index (117,40±15,66 against 81,92±10,71), which indicates activation as cute and parasympathetic divisions of the ANS. However, against the background of a normal initial tone (eutonia) with orthostatic test, hypersympathicotonic reactivity occurs (SI_2/SI_1= 2,8±70,31 against 1,82±0,21 in MS). These changes indicate sympathicotonic control of the heart rhythm during an orthostatic test. In a small number of athletes, CMS (18,73%) revealed a decrease in resting SI to 30 c. u. due to the prevalence of the parasympathetic division of the autonomic nervous system in the regulation of heart rhythm. The initial vagotonia may have had a compensatory character, since autonomic reactivity should be hypersympathicotonic type.

In the group of athletes of the 1st category, it was found that against the background of an increase in the amplitude of the mode (25,89±3,24 against 18,12±1,19) and the stress index (90,88±28,67 against 53,92±6,66), there is an increase in the mode (0,89±0,09 against 0,84±0,03) and the variation range (0,29±0,09 against 0,26±0,03), which indicates an increase in the activation of sympathetic and parasympathetic impacts. However, during an orthostatic test, against the background of a decrease in the Mo indicator (0,63±0,04 against 0,69±0,02), a statistically significant increase in Amo occurs (39,33±4,60 against 19,18±1,10) and Dx (0,25±0,07 against 0,21±0,02), and a significant increase in SI_2 was also observed (207,70±48,41 against 81,92±10,71). In athletes of the first category, compared with MS, in terms of cardiointervalography, hypersympathicotonic activity of the ANS occurs against the background of overtraining; at the same time, a high SI_2 indicator indicates the development of tension of regulatory autonomic and regulatory systems in the body of athletes of the first category, and this can lead to a breakdown in the adaptive capabilities of the body.

Thus, in athletes of the I category in a state of overtraining, in most cases hypersympathicotonic reactivity was noted, confirms the more active contribution of the sympathetic nervous system.

Conclusions / Discussion

According to the results of the study, it can be argued that at the main stage of the training period, the athletes we studied were in a state of overtraining. According to clinical signs, 57,1% of athletes were at stage I, 42,9% at stage II. The most often overtraining of stage II was found among athletes of playing sports: among football players 66,7%, among volleyball players 58,3%, as well as stage II overtraining is more common among first-rate athletes than MS, which confirms the data of A. V. Peshkova and contradicts the data of A. M. Alaverdyan et al, who claimed that the first type of overtraining is more common in novice athletes, and type II – among high-class athletes [10]. According to the results of cardiointervalography in athletes of the 1st category, in comparison with MS, the parasympathetic division of the nervous system is activated, a high SI_2 indicator indicates the development of tension of regulatory autonomic and regulatory systems in the body of athletes of the 1st category, and this can lead to a breakdown in the adaptive capabilities of the body. In studies of O. B. Zapovitrenoy, G. V. Korobeinikova, L. G. Korobeynikova (2015), S. V. Pogodina, G. D. Aleksanyants (2015), D. S. Lysenko (2017) activation of neurohumoral was revealed in athletes of various sports and age groups centers and parasympathetic link of the autonomic nervous system, which was confirmed in our work [4; 6; 17].

Prospects for further research are to develop programs for pre-nosological diagnosis and medical-pedagogical correction of functional disorders of the autonomic regulation of heart rhythm in athletes.

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