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FEATURES OF HEART RATE VARIABILITY IN YOUNG VOLLEYBALL PLAYERS OF KHANTY-MANSIJSK AUTONOMOUS OKRUG – YUGRA

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Annotation. The aim was to identify the features of cardiovascular and heart rate variability among young volleyball players who live and train in the Khanty-Mansijsk autonomous okrug – Yugra. The study involved male volleyball players, who are active players of the Youth Volleyball League (n=22). The comparison group included male students of the Medical Institute (n=22) who do not engage in sports. Statistical characteristics and spectral analysis of heart rate variability were used to assess heart rate variability. The study revealed that young players had high activity of the segmental level of regulation and sufficient reserves for the adaptation of the cardiovascular system. Volleyball players with high activity of the parasympathetic link of regulation need to be examined in order to determine the state of excessive fatigue and stress of regulatory systems.

Introduction. When organizing studies in the field of sports physiology, specific attention is given to studying activity and features of vegetative and neurohumoral regulation of the cardiovascular system, searching for reserves of its activity, methods of sports training that form mechanisms of energy support for an athlete and define performance records in sports [1-6]. The cardiovascular system is a sensible indicator [7-8] that shows changes in adaptation of the organism when exposed to physical exercises [1, 9].

At the present moment, among methodological approaches to analyze the functional state of the cardiovascular system in conditions of training loads when exposed to specific conditions of the northern region, research of heart rate variability indicators takes an important place [2]. A number of works demonstrate that cold is the most significant ecological and physiological factor [3, 10, 11]. Temperature profile of the northern region's territories is able to make a modulating effect on the functional state of the blood circulation system. A reduced heart rate variability can serve as an indicator of the heart's vegetative dysfunction, showing risk of developing cardiovascular pathologies [12]. On the contrary, high variance

of cardiointervals at rest will be indicative of a high adaptation reserve of the cardiovascular system in both elite athletes and people with a moderate mode of motor activity.

Therefore, it is extremely important to monitor the functional state of the cardiovascular system of elite athletes who live and train in conditions of the Khanty-Mansijsk Autonomous Okrug – Yugra.

The aim was to identify the features of the functional state of the blood circulation system and heart rate variability in young volleyball players who live and train in conditions the Khanty-Mansijsk Autonomous Okrug – Yugra.

Methods and organization. The study involved volleyball players (n=22) aged 18-21 years. The observed athletes had following qualifications: candidate master of sports, first sports degree. The athletes were active players of the youth national team of volleyball in Yugra. They were at the beginning of the preparatory period before the annual cycle of the Youth League Championship of Russia. The recovery period form the moment of the last training took not less than 12 hours. The comparison group included 18-21-year old male students of the I and II health groups from the Medical Institute (n=22) who did not engage in sports. The main criterion of including people into the control group is a low level of motor activity.

Evaluation of the heart rate variability of volleyball players of the Youth League of Russia was carried out on the basis of a number of statistical characteristics of cardiointervals: heart rate (HR), mode (Mo), mode amplitude (AMo), mean square deviation (SDNN), range (R), vegetative balance index (VBI), centralization index (CI) and stress index (SI). We also assessed spectral characteristics of the heart rate: power of high frequency (HF), low frequency (LF) and very low frequency waves (VLF), total spectrum power (TP).

The algorhythm of the study included a one-moment recording of parameters from cardiointervalgraphy of examined people in the first half of the day (10-12 hours) during the winter period (January-February). Studying and assessing parameters of the functional state of the cardiovascular system was carried out using the Poly-Specter-12/E electrocardiograph (LLC “Neurosoft”, Ivanovo).

We made the statistical analysis of the data obtained using the STATISTICAv10 software package. In order to define selection normality of the sampled population, we used the Shapiro-Wilk and Kolgomorov-Smirnov criteria. The data obtained did not obey the law of normal distribution and were presented in a form of a median (Me), 25th and 75th percentiles (P25, P75). We also applied the Mann-Whitney U-test in order to compare same indicators in surveyed groups. The level of significance was equal to 0,05 when checking on the level of significance. When comparing percentile shares of surveyed groups, we applied the φ* criterion (Fisher transformation).

Results and discussion. In the process of analyzing parameters of the heart rate variability (HRV) of surveyed people, we revealed significant differences of examined indicators of the cardiac function between the group of athletes and the group of untrained students (table 1). The HR indicator in the group of volleyball players was statistically lower (63,90 beats/min) and had a tendency of the heart rate fall, which can be estimated as one of the manifestations of the heart activity's economization.

Table 1

HRV indicators in young volleyball players and untrained students (Me, P_{25}–P_{75})

Indicators	Athletes (n=22)	Untrained students (n=22)
	Me (P_{25}–P_{75})	Me (P_{25}–P_{75})
HR, beats/min	63,90* (59,45–66,90)	73,65* (69,08–83,35)
SDNN, ms	68,00* (51,75–66,90)	43,00* (37,25–61,25)
pNN50, %	26,05* (1,90–32,53)	7,20* (2,55–22,45)
Mo, c	0,92* (0,88–1,00)	0,82* (0,72–0,84)
AMo, %	34,50 (26,38–45,08)	46,30 (36,13–55,90)
SI	50,25* (28,24–76,37)	125,16* (62,21–182,39)
R, s	0,50* (0,33–0,64)	0,32* (0,23–0,43)
VBI	69,10* (51,13–110,28)	140,30* (9270–235,73)
IARP	39,05* (27,95–49,30)	62,45* (41,13–70,35)
SIB	19,34* (13,93–24,51)	31,11* (20,64–35,48)
CI	1,43 (1,11–2,37)	1,61 (0,92–2,09)
VRI	2,52* (1,89–3,51)	4,28* (2,77–5,38)
TP, ms²	4405,00* (2742,75–8811,50)	1858,00* (1299,50–3670,75)
VLF, ms²	1452,00* 874,50–3622,25)	804,50* (504,50–1586,00)
LF, ms²	1193,50* (975,00–238,25)	657,50* (501,00–948,00)
HF, ms²	979,00* (734,75–2900,25)	504,00* (179,25–772,25)

Note: *– significant differences on the significance level of p<0,03; pNN50 – percentage of differences between NN complementary intervals; IARP – indicator of the adequacy of regulation processes; SIB – stress index according to R.M. Baevskij; VRI – vegetative rhythm index

SDNN, as a total measure of the variability of cardiointervals' values for the whole examined period, allows giving characteristics to the functional reserves of the cardiovascular system. In the group of athletes, this indicator (SDNN=68,00 ms) was significantly higher than in the comparison group (SDNN=43,00 ms) and insignificantly exceeded the set norm. Such high value of SDNN shows an effort made by the autonomic curve of regulation of the cardiac activity in volleyball players [9].

Mode, as one of the most important indicators of the variation pulsometry, shows a possible level of the sinal angle's function. Among athletes, values of the Mo were reliably different compared to the group of students and insignificantly exceeded the upper limit of the age norm, which corresponded to the normotonic type of regulation of the cardiac activity with a balance's shift towards the parasympathetic influence. At the same time, the AMo values did not have significant differences between volleyball players and students: they were within limits of the age norm, indicating an adequate involvement of the sympathetic link in the regulation of the cardiovascular system's activity.

Values of the most of examined indices of the cardiovascular system (R, VRI, IARP, SIB), which allow evaluating a balance in the activity of sympathetic and parasympathetic links of the heart rate's vegetative regulation, were within limits of the age norm for both examined groups, excluding the vegetative balance index that was lower than the norm in the group of athletes (VBI=69,10 c.u.). Moreover, all aforementioned indices among volleyball players presented a predominance of autonomic influence on the cardiac performance and were significantly different from the same indicators in the group of students.

Centralization index (CI) between groups of comparison did not have significant differences and indicated a predominance of segmental influence in management of the heart rate. Therefore, the vegetative nervous system of volleyball players and students of the Medical Institute successfully manages to control the heart rate in conditions of sports and learning loads. Nonetheless, revealed values of stress index among students (SI=125,16 c.u.), compared to athletes, SI of whose is equal to 50 and corresponded to a norm for this age, indicated a presence of compensated distress and psychoemotional stress.

Researchers recognize spectral methods of the HRV analysis as more precise. They give a possibility to define the activity of separate regulation systems in the whole structure of the heart rate. When evaluating spectral characteristics, we took into account high frequency, low frequency and very low frequency wave components of the spectrum.

The total spectrum power in the group of volleyball players exceeds by 2,7 times values of untrained students. For both groups, the following spectrum

distribution was typical: VLF>LF>HF. A predominance of low-wave parts of the spectrum, VLF in particular, indicates a dominating suprasegmentary level of the cardiac activity's regulation and a presence of energy shortage states of the organism [13]. Therefore, power of the VLF part in the group of students (40,90%) and athletes (40,7%) corresponded to an increased reactivity of the organism.

However, we registered in the group of athletes a significantly higher share of HF-component and much lower share of VLF- and LF-components of the spectrum in comparison with the untrained students. Increase in HF-component of the heart rate is aimed at increasing speed of gas exchange in alveoli, defines coordination of pulmonary blood flow with volume of the lungs in each respiratory cycle, supporting a "saving mode" for the heartbeat and increasing "efficiency" of pulmonary blood flow [5].

Based on SI, TP, VLF indicators, N.I. Shlyk (2015) suggested an express method of evaluating a dominating type of regulation of the heart activity [13].

In accordance with the suggested classification, 68,18% of athletes were included in the II group, for which an optimal level of regulation systems of the organism against the background of predominating parasympathetic influences of the heart rate is typical (table 2). Combination of these HRV indicators in this group shows a normal level of physical fitness of athletes [13]. A part of volleyball players (18,18%) was included in the IV group of cardiac regulation types. This group is interpreted ambiguously, because such combination of main HRV indicators can show a both high level of athletes' fitness and a "physiologically normal" state of regulation mechanisms, as well as fatigue, overtraining, sine angle's dysfunction, disturbance of the heart rate. In the group of students, 50,00% and 40,91% of surveyed people were included in the I and III groups respectively. People of the I group has a predominance of the central cardiac regulation and stress of regulation systems of the organism.

Table 2

Types of the heart rate regulation in examined groups, %

Type of the heart rate regulation	Groups	Criteria of selecting		Athletes (n=22), %	Untrained students (n=22), %
		SI (c.u.)	VLF (c.u.)		
Predominance of central regulation	I	>100	>240	9,09*	50,00*
	II	>100	<240	4,55	4,55
Predominance of autonomic regulation	III	>25 or <100	>240	68,18*	40,91*
	IV	<25	>500; TP>8000–10000	18,18	4,55

Note: * – statistically significant differences of types of the vegetative nervous regulation between groups of comparison according to the φ* criterion

Conclusion. Analysis and classification of HRV indicators allow revealing changes in interaction between three factors that regulate the heart rate: sympathetic, parasympathetic and humoral-metabolic-transmitting factors. That is the reason why changes in the heart rate's structure as a response to exogenous and endogenous stimulant are the versatile reaction of the organism.

In the course of our study, we discovered that in the group of young volleyball players of the Khanty-Mansijsk Autonomous Okrug, a high level of the segmental level of the cardiac activity's regulation and sufficient reserve of adaptive potential of the blood circulation system was shown clearly, in comparison with untrained students who experienced stress of functional systems of the organism and had a relatively sympathicotonic type of the vegetative nervous system. The functional state of the cardiovascular system of some volleyball players, which was under a pronounced control of the VNS parasympathetic link, requires further observation of athletes in order to identify and exclude states of excessive fatigue and stress of regulatory systems of the organism appearing in case of extremely high loads required in the training process.

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