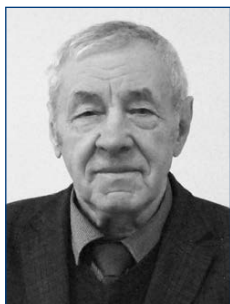


Method of functional evaluation of adaptation of volleyball players in microcycles of sports training

UDC 614.8; 796.071.424.2



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Abstract

Objective of the study was to substantiate the use of the method of variational pulsometry and electrocardiographic active orthotic test for individual assessment of the adaptation of highly qualified female volleyball players in training microcycles.

Methods and structure of the study. The object of the study was 32 volleyball players of qualification from the 1st category to the masters of sports. Variational pulsometry (VP) was recorded under conditions of relative rest in microcycles of the preparatory and competitive periods. After registration of 100 R-R cycles (an indicator of the duration of the cardiac cycle), an active ECG orthotest was performed.

Results and conclusions. In the course of studying the problem, it was revealed that heart rate indicators depend on the period of training and the nature of adaptation to training and competitive loads.

Keywords: heart rate regulation, ECG orthotest, adaptation, maladaptation, stress cardiomyopathy, training microcycle.

Introduction. In any sport, adaptation to the risk factors of sports training can be characterized by both physiological adaptation and its functional impairments or even pathological changes, overstrain syndrome [8]. This syndrome is caused by a discrepancy between physical activity and the functional adaptive reserve of the athlete's body. The clinical characteristic of the overstrain syndrome is manifested by changes in various organs and systems, but most often in the circulatory system by stress cardiomyopathy [6].

According to modern scientific research, psychoneuroimmunoendocrine imbalance is the basis of myocardial stress damage under the influence of inadequate training loads [5]. With stress cardiomyopathy, the process of repolarization of the heart ventricles, autonomic regulation of the heart rhythm is disrupted, an immune reaction occurs with an increase in the content of pro-inflammatory cytokines (interleukins, TNF- α ,) in the blood. As a result, there is a decrease in the physical performance of the athlete and sports results. In this regard, it seems necessary to early diag-

nosis of stress cardiomyopathy by detecting impaired repolarization of the heart ventricles and autonomic regulation of the heart rhythm in training microcycles.

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**Table 1.** Heart rate indicators of volleyball players in training microcycles

Training periods	Indicators (n=32) (\bar{X} , fluctuation limits)			
	ΔX (s.)	Mo (s.)	AMo (%)	VI (conventional units)
Preparatory	0,14 (0,02-0,26)	0,97 (0,88-1,18)	35,5 (18,0-60,0)	57,2 (13,0-102,0)
Competitive	0,19 (0,12-0,26)	1,03 (0,88-1,18)	43,1 (32,0-50,0)	118,7 (86,0-177,0)
P by criterion U	>0,05	>0,05	<0,05	<0,05

paid to the degree of tachycardia and the nature of the repolarization of the heart ventricles in the neuroreflex and humoral phases of the orthostatic reaction [2].

Results of the study and their discussion. The results of the study of the dynamics of the heart rhythm in volleyball players in the microcycles of the preparatory and competitive periods of the training process are presented in Table 1.

It was revealed that heart rate at rest in the preparatory period of sports training is characteristic of the normotonic type of regulation. The quantitative characteristics of the indicators correspond to a good functional state and a high functional reserve. At the same time, in the microcycles of the competitive period, quantitative and qualitative changes in the heart rhythm and indicators of its regulation are observed: the amplitude of the mode and the tension index of the regulatory systems increase significantly. The average duration of the cardiac cycle tends to increase ($p > 0.05$), heart rate is 58.0 bpm.

The indicated direction of changes in the indicators of the rhythm of cardiac activity indicates the state of tension of the body's regulatory systems. This tension is characterized by an increase in the activity of the sympathetic-adrenal system and is expressed by the

centralization of the control of the process of excitation of the sinus node, an increase in the amplitude of the mode and the tension index of the regulatory systems. The state of tension in the mechanisms of central regulation indicates a decrease in the functional reserves of the body and can only last for a short time [4], after which prepathological and pathological changes occur.

Consequently, the marked changes in cardiac activity in female volleyball players in the competitive period necessitate ongoing monitoring in order to prevent the development of prepathological conditions.

Individual analysis of the data revealed that the intensity of heart rate regulation in the competitive period is not observed in all female volleyball players (Table 2).

In the competitive period, female volleyball players experience various adaptive changes in the heart rate. The majority of athletes have a normotonic or vagotonic type of heart rhythm regulation in combination with a negative ECG orthotest. However, these types of heart rhythm regulation can be combined with a positive ECG orthotest, and with greater orthostatic tachycardia (athletes No. 7, 9, 11). The latter indicates the relative diagnostic value of quantitative criteria for heart rate indicators for assessing the nature of adaptation.

Table 2. Individual indicators of heart rate in female volleyball players in microcycles of the competitive period

№ Full name	Indicators (\bar{X})					
	ΔX (s.)	MO (s.)	AMo (%)	VI (conventional units)	Δ Heart rate, bpm	T wave with an orthotest
1. S-va	0,22	1,08	32	67	19	+
2. A-ka	0,16	1,18	26	69	31	+
3. R-ich	0,14	0,91	42	164	12	+
4. L-va	0,20	1,08	26	87	20	isoline
5. Ch-va	0,28	1,18	52	79	11	+
6. M-va	0,18	1,18	42	99	19	+
7. V-va	0,42	0,73	28	45	36	(-)
8. T-va	0,46	1,48	18	13	35	+
9. I-va	0,28	1,08	38	63	34	(-)
10. Uf-va	0,28	0,83	24	52	2	isoline
11. B-ia	0,24	1,18	54	95	28	(-)
12. A-va	0,18	1,18	38	89	33	isoline

Table 3. Individual dynamics of heart rate indicators in female volleyball players in four microcycles of the competitive training period

Indicators	Sportswoman No. 4				Sportswoman No. 7			
	Microcycle				Microcycle			
	I	II	III	IV	I	II	III	IV
ΔX (s.)	0,24	0,26	0,08	0,20	0,16	0,48	0,42	0,40
MO (с.)	1,03	1,08	0,93	1,08	1,28	1,38	0,73	0,78
AMo (%)	34	19	45	26	90	25	28	22
VI (с.у.)	69	34	302	87	220	19	45	35
Δ Heart rate, bpm	10	33	10	20	7	28	36	36
T wave with an orthotest	(+)	(+)	(-/+)	(+)	(+)	(-)	(-)	(-)

The need for an individual assessment of changes in heart rate indicators is also indicated by the data in Table 3.

Attention is drawn to the different direction of changes in the quantitative indicators of the heart rhythm and the quality of the orthostatic reaction on the example of two athletes. In athlete No. 4, the sympathicotonic type of regulation (decrease in ΔX to 0.08 seconds and MO to 0.93 s, increase in AMO to 45% and VI to 302 units) is combined with a decrease in the growth of orthostatic tachycardia and initial signs of impaired repolarization of the heart ventricles. Such dynamics of indicators and orthotests can be assessed as a sign of regulation tension, as an unstable nature of adaptation.

In order to establish quantitative individual differences, a comparative analysis of the heart rate, electrocardiography data and the results of the ECG orthotest was carried out. Based on the study of the electrical activity of the heart and its changes under orthostatic impact, 32 female athletes were divided into three groups. The first group (13 people) was characterized by a normal ECG and a negative reaction to the ECG orthotest. The second group (11 people) - elongation of the electrical systole, compared with the proper one, or a sharp flattening of the T wave during the orthotest, its two-phase (- / +). For the third group of volleyball players (8 people), the initial signs of impaired repolarization of the ventricles of the 1st degree and negative T wave during the orthotest were typical. The heart rate data in these three groups are given in Table 4.

The direction of changes in heart rate indicators indicates various physiological conditions. In volleyball players of the 1st group, the heart rate indicators correspond to the criteria for satisfactory adaptation, and in the 2nd and 3rd groups - unstable and unsatisfactory adaptation, respectively. In the majority of sportswomen in the competitive period, the normotonic and vagotonic type of regulation was preserved. When the regulation of the heart rhythm is strained, the "price of adaptation" to the conditions of competitive activity increases. The latter is manifested by a sympathicotonic variant of changes in heart rate indicators (unstable adaptation). So, ΔX significantly decreases, AMo and IN increase. Such changes are in certain accordance with the ECG data (Q-T prolongation, initial signs of impaired repolarization of the heart ventricles during an orthotest) and correspond to the criterion of initial signs of pre-pathological changes in these athletes.

The third group of female volleyball players is characterized by a quantitatively different direction of heart rate indicators compared to the second group. They have a "normalization" of the average values of all indicators (ΔX , AMo, AMo / ΔX and IN). However, a large range of fluctuations in the duration of the cardiac cycle (up to 0.42 seconds) and a decrease in the amplitude of the mode (up to 31.7%) were revealed. This direction, combined with impaired repolarization of the ventricles of the heart, corresponds to a state of overstrain of the mechanisms of regulation of the heart rhythm.

Table 4. Heart rate indicators in female volleyball players of different groups

Показатели	Groups (\bar{X} , fluctuation limits)		
	I	II	III
ΔX (s)	0,27 (0,20-0,35)	0,15* (0,08-0,20)	0,27 (0,14-0,42)
MO (с.)	1,11 (0,88-1,40)	1,02* (0,96-1,18)	0,94 (0,73-1,18)
AMo (%)	36,7 (19,0-50,0)	52,4* (32,0-60,0)	31,7 (26,0-48,0)
AMo/ ΔX	136,9 (73-208)	347,3* (160-562)	116,4 (55-240)
VI (с.у.)	68,7 (28-96)	161,4* (74-302)	69,2 (45-102)

* The difference is significant at the $p < 0.05$ significance level according to the U criterion.



In order to substantiate the assessment of the functional reserve of volleyball players in terms of heart rate, a correlation analysis was carried out. Correlation analysis data revealed significant differences in the ratio of various indicators of heart rhythm depending on the nature of adaptation.

In healthy female volleyball players with satisfactory adaptation, a large number of significant relationships were found that characterize the neurohumoral regulation of the heart rhythm. There are close correlations between ΔX and VI (-0.59), AMo and VI (-0.79), the indicator of rhythm regulation plasticity (PRR) and VI (-0.49). Significant negative correlations between ΔX and VI (-0.59), the PRR indicator with the stress index AMo / ΔX (-0.49) and positive correlations between the magnitude of the increase in heart rate during orthoprobe with PRR (-0.76), indicate a high functional reserve athletes in this group.

Volleyball players with unstable adaptation showed a sharp decrease in the number of significant correlations. Significant associations of ΔX and AMo with other indicators of heart rate disappeared. Thus, in female volleyball players with unstable adaptation, physiologically determined connections in the heart rhythm regulation system are disturbed, which indicates a decrease in the functional reserve.

Volleyball players with unsatisfactory adaptation revealed a large number of significant correlations. Attention is drawn to the higher correlation coefficients of VI with ΔX (-0.92), with AHR (-0.91) than in healthy athletes, there were significant relationships between Mo and AMo (0.60), VI with ΔHR (-0.91). This direction of changes in correlation coefficients reflects the predominance of the central mechanisms of heart rate regulation and allows them to be considered as a compensatory-adaptive reaction to the impact of sports training factors, as a decrease in the degrees of freedom of the system [7]. The results of the correlation analysis convincingly testify to the legitimacy and validity of using heart rate indicators as criteria for assessing the functional reserve of female volleyball players in training microcycles. The formation of close correlations of heart rate indicators with unsatisfactory adaptation can be considered as a manifestation of the general pattern of transition to a more rigidly determined organization of the system in the event of any premonitory and painful condition.

Conclusion. Heart rate indicators depend on the period of training and the nature of adaptation to training and competitive loads, they are informative criteria for assessing the functional state of the circulatory system in female volleyball players in training microcy-

cles. For an individual assessment of the nature of the adaptation disorder, the diagnostic value of the indicators increases with the complex use of variational pulsometry and an active ECG orthotest. Disturbances in the process of repolarization of the heart ventricles during the orthotest reveal types of overstrain of the neuroendocrine system functions in female volleyball players, types of stress cardiomyopathy and cause a differentiated choice of rehabilitation means in training microcycles.

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