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ORIGINAL ARTICLE

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Individual Features of Vegetative Support for Student-Athletes of Various Specializations

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The **aim of this paper** is assessment of the features of vegetative support of the body of students of various sports specialization.

Results: Significant differences in statistical and spectral HRV indicators in volleyball and swimming groups have been established. The volleyball players had lower SDNN, RMSSD, total spectrum power, as well as a higher level of the pNN50 parameter and heart rate. They have a tendency to increase the centralization of the heart rhythm and activation of sympathetic regulation. These assumptions confirm the values of the spectral analysis of cardiac rhythm, which shows the initial stage of overtraining and overwork in the volleyball group. To prevent maladaptation conditions, it is advisable to correct the training process in a group of students engaged in volleyball.

Conclusion: In volleyball athletes, an increase in the activation of central regulatory mechanisms has been demonstrated, which leads to impaired functioning of adaptive and regulatory mechanisms, as well as to the initial stage of overtraining. To prevent this, it is advisable to adjust the training process in the volleyball group.

Key words: adaptation, vegetative balance, physical activity, sports, adaptive reserves, students

Human sports activity related to the training process or competitions is accompanied by the maximum mode of operation of various functional systems of the body (Malikov *et al.*, 2021). It has been established that the achievements of a training person depend both on the effectiveness of the training process and on the state of the physiological reserves of his body, in particular, on the work of the cardiovascular system. Insufficient activity of this system is one of the reasons for low results in sports competitions (Lisenchuk *et al.*, 2019). It is the reserves of the cardiovascular system that make it possible to increase the physical performance of an athlete with the help of adaptive and compensatory regulatory mechanisms (Guzii *et al.*, 2021).

During physical work, the functional capabilities of the body are mobilized, accompanied by a waste of energy to ensure complex coordination movements (Solodkov *et al.*, 2007). At the same time, the body of trained people is characterized by the economization of resources in a state of physiological rest, with significant mobilization of all functional systems during the training process, as well as a higher level of recovery (Bosenko, 2013). It is impossible not to take into account athletes studying at universities, because in the conditions of the educational process associated with intense physical exertion, they can be classified as a risk group: due to the high level of psycho-emotional stress and the effects of stress factors (Baiguzhin *et al.*, 2017). Therefore, this category of sports youth needs special control over the functional systems of their body and the state of physical health. Available studies show that significant vegetative changes occur in the body of athletes under the influence of intense physical exertion, in accordance with the program of the training process.

To study the state of the body's adaptive reserves, the method of analyzing the vegetative tone of an athlete is widely used in sports practice, based on the registration and interpretation of heart rate variability (Loskutova, Maksimov, 2013). It represents the variability of cardiac intervals during periods of contraction of the heart muscle. Registration and analysis of the cardiointervalogram allows us to assess the individual ability of the body to tolerate physical activity, which manifests itself in short-term adaptation, and to assess the reserve capabilities that manifest themselves during long-term adaptation (Bocharin *et al.*, 2019). The study and correct interpretation of the data obtained allow the head of the training process to correctly interpret the results and draw a conclusion about the effectiveness of the proposed training program (Rozvodovsky *et al.*, 2020). Thus, it allows you to get the necessary information about the state of regulatory systems, as well as predict the level of success of future sports performances of your ward.

The determination and analysis of the parameters of regulatory mechanisms underlie the prednosological diagnosis, and also allow us to study the functional state and adaptive reserves of the athlete's body, the speed of his reaction to various internal and external stimuli (Kogame *et al.*, 2020). Normally, the work of the heart is carried out with the help of autonomous regulation (Kolumbet *et al.*, 2021). Some HRV indicators are associated with the activation of various links in the regulation of heart rhythm. When the activity of the cardiovascular system is disrupted, central control mechanisms are activated to return the body to a normal state and balance it with the external environment, which is associated with the tension of all regulatory mechanisms (Perkins *et al.*, 2017; Hayano *et al.*, 2019). Consequently, the greater the centralization of the control mechanism, the higher the physiological "price" of human adaptation to various factors and amounts of physical activity (Morgan, Molina Mora, 2017), there is a tendency to the emergence of a state of overstrain and overtraining, therefore, timely monitoring of the work of the regulatory systems of the athlete's body is necessary. Despite the fact that the issue of using the HRV method in sports practice has been studied, the scientific literature does not fully present materials devoted to the study of vegetative balance in student-athletes (Misigoj Durakovic *et al.*, 2016). Therefore, the study of HRV for the control, correction and personalization of the educational and training process in student-athletes seems relevant. Taking into account the above, the aim of the study was to assess the features of the vegetative support of the body of

students of various sports specialization: volleyball players and skiers.

METHODS

The subjects were monitored on the basis of the Volga Region Research Medical University (Nizhny Novgorod). 55 young people aged 18 to 20 years participated in the experiment, of which 23 students were engaged in volleyball, and 22 students were engaged in ski racing. The frequency of classes was 4 times a week for 2 hours. All participants in the experiment were members of the respective national teams (sports sections) of the university. The registration of cardiointervalograms was carried out in the middle of the school day, during the inter-session period, all subjects were in a state of physiological rest, after two months of training as part of a systematic training process. To register the heart rate variability indicators, the software and hardware complex "MedicalSoft Sports Testing System (MS FIT - 01, Russia) was used. The temporal and spectral parameters of HRV were analyzed, namely: SDNN (standard deviation of NN intervals), HR (heart rate), RMSSD (square root of the mean squares of the average difference between neighbouring NN intervals), pNN50 (percentage of intervals that differ from the average by 50 ms or more), TP (total power of the spectrum), LF (low frequency component of the spectrum), HF (high frequency component of the spectrum), VLF (very low frequency component of the spectrum), LF/HF (index of vegetative equilibrium), SI (stress index). The analysis of the obtained data was carried out in accordance with age-related normative values and standards in the field of heart rate variability research developed by the European Community of Cardiology and the North American Society of Electrophysiology.

The data were processed using variational statistics methods using the Statistica 10.1 software package (USA). To check the obtained data for the normality of the distribution, the Shapiro-Wilk criterion was used. To assess the statistical significance of the obtained indicators between different groups of students, the parametric Student t-test was used. The differences were considered statistically significant at $p<0.05$.

RESULTS AND DISCUSSION

The data obtained indicate multidirectional changes in the mechanisms of regulation of the heart rate of athletes of various specializations (Table 1). The RMSSD index in the volleyball group was 24.3% lower relative to the ski racing group ($p<0.05$), which indicates higher body recovery opportunities among the group of skiers. The level of the SDNN parameter in volleyball players was 32.4% lower relative to ski athletes ($p<0.05$), which indicates an increased centralization of heart rate in the volleyball group. Taking into account the RMSSD index, which shifts to the lower limit of the norm in the volleyball group, it is shown that this group of subjects has some inhibition of autonomous autonomic regulation. The parameters of heart rate and pNN50, characterizing the degree of HRV switching, also showed a heterogeneous picture in the tested students. Despite systematic training sessions, the heart rate of volleyball players approached the upper limit of the standard range, and for ski athletes it was 15.2% lower, which indicates higher reserves for mobilizing the body's regulatory systems during intensive physical work. In addition, in the volleyball group, the pNN50 parameter was 59.7% higher relative to the group of skiers ($p<0.05$), which indicates the initial stage of overtraining of volleyball players and their tendency to arrhythmogenic events

HRV spectral analysis indicators characterize the total power of the spectrum, which reflects the total activity of neuromoral effects on the heart. Volleyball representatives have lower values relative to skiers ($p<0.05$). At the same time, the structure of spectral analysis usually looks like HF>LF>VLF. Therefore, spectral analysis reflects the predominance of sympathetic or parasympathetic influences on the functioning of the cardiovascular system and the type of heart rate control. The power of the spectrum in the low frequency range for volleyball players has a relative value of 52.8%, and for skiers – 32.2%. This indicates that the processes of regulation of the heart rate in volleyball players occur through non-specific

mechanisms. The relative value of the spectrum power in the high frequency range characterizes the degree of vegetative maintenance of the heart rhythm. In the group of skiers, it was 37.8%, and in the group of volleyball players – 26.1%. The very low-wavelength power of spectral analysis at rest is 32.7% for volleyball athletes and 22.4% for students engaged in cross-country skiing. Thus, volleyball players have increased sympathetic stimulation of the heart muscle and the presence of a suprasegmental level of regulation.

The assumptions obtained earlier are also confirmed by the index of vegetative equilibrium, which was recorded in a higher value in the group of volleyball players relative to representatives of ski racing ($p<0.05$). The stress index values of volleyball players were 51.3% higher than the same indicator in the group of skiers ($p<0.05$). Thus, the sports testing conducted by us using the registration of heart rate variability showed the possibility of operational monitoring of the functional state of the cardiovascular system of students of various sports specializations to correct the educational and training process.

It should be noted that various factors of the training process can affect the functional state of the athletes' body. In addition to the development and improvement of general and special physical training, tactical and technical skills, the training process should take place within the framework of countering overtraining and overstrain of an athlete (Bobkov *et al.*, 2023; Castellani *et al.*, 2015). One of the ways to prevent maladaptation in athletes as a result of training activities is regular monitoring of the functional state of the body (Kalinnikova *et al.*, 2023). Hardware monitoring of human heart rate variability indicators allows you to quickly obtain information about the functional state of regulatory systems and the level of adaptation of the body to environmental factors or to physical exertion of various directions (Pak *et al.*, 2023; Adams *et al.*, 2018). Therefore, this method is widely used in clinical practice and sports medicine.

Table 1. Statistical and spectral indicators of student-athletes engaged in volleyball and cross-country skiing, M±m

Indicator/Group	Volleyball players (n=23)	Skiers (n=22)
RMSSD, мs	43,2±9,1	29,6±7,3*
SDNN, мs	34,2±6,9	48,3±8,5*
HR, h/min	77,3±10,1	65,6±9,8*
pNN50, %	27,8±3,6	13,1±4,1*
LF, %	52,8±6,9	32,2±7,1*
HF, %	26,1±6,4	37,8±8,1*
VLF, %	32,7±5,3	22,4±4,9*
LF/HF, con. un.	2,6±0,1	1,5±0,1*
SI, con. un	193,5±22,4	114,7±19,5*

Note: * - the reliability of the differences between the indicators in the volleyball and cross-country skiing groups, $p<0.05$

During the study, it was found that the values of heart rate indicators were significantly higher in student-athletes of the volleyball group, and the values of SDNN, RMSSD, pNN50 and VLF were significantly lower than those of athletes engaged in cross-country skiing. The characteristic of HRV switching speed is the pNN50 indicator, which registers the percentage of heart rate intervals that differ from the previous one by 50 ms or more. Students of the volleyball group have this indicator by 63.5% more than students engaged in cross-country skiing. This indicates an increased risk of arrhythmogenic events. The students of the volleyball group have a heterogeneity of the HRV spectral

analysis, which reflects a decrease in the total power of the spectrum, an uneven distribution of the relative values of low, very low and high frequency waves. This distribution tended to increase the index of vegetative equilibrium and the stress index parameter in accordance with the sympathetic or parasympathetic type of regulation. Athletes in cross-country skiing have a high-frequency oscillation rhythm. This indicates that the functional fitness and reserve capabilities of the body of athletes from this group are significantly higher than those of student-athletes involved in volleyball.

Thus, volleyball athletes demonstrated an increase in activation of the central mechanisms of heart rate regulation. This leads to disruption of the functioning of adaptive and regulatory mechanisms, as well as to the initial stage of overtraining. Various factors can affect the functional state of the body of students engaged in intense physical activity. At the same time, everyone involved, in addition to the development of general and special physical training, should undergo periodic monitoring to prevent overtraining and maladaptation.

CONCLUSION

After monitoring the functional state of the body of student-athletes of different sports, statistically significant differences in statistical and spectral HRV indicators in volleyball and swimming groups were established. Students involved in volleyball had lower SDNN, RMSSD, total spectrum power, as well as a higher level of pNN50 parameter and heart rate. They have a tendency to increase the centralization of heart rhythm and activation of sympathetic regulation. These assumptions are further confirmed by the values of the spectral analysis of the cardiointervalogram, which shows the presence of an initial stage of overtraining and overwork in the volleyball group.

To prevent maladaptation conditions, it is advisable to correct the training process in a group of students engaged in volleyball. Thus, the analysis of HRV indicators provides high information content for determining the vegetative supply of the body and the state of adaptive reserves, which can be recommended for use in educational and training sessions among people engaged in intense physical activity.

CONFLICTS OF INTEREST

The authors declare that they have no potential conflicts of interest.

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