The relationship of the autonomic regulation of heart rate with postural control indicators in young athletes

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PhD, Associate Professor **A.S. Nazarenko**[1]
PhD, Associate Professor **F.A. Mavliev**[1]
[1]Volga Region State University of Physical Culture, Sport and Tourism, Kazan

Corresponding author: hard@inbox.ru

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Abstract

Objective of the study is to study the features of the autonomic regulation of heart rate and postural control in young badminton athletes.

Methods and structure of the study. The scientific work was conducted on the basis of the Research Institute of Physical Culture and Sports of the Volga Region State University of Physical Culture, Sports and Tourism. 16 young athletes engaged in badminton with a level of sports mastery from the second adult category to candidate for master of sports, and 26 representatives of the control group not engaged in sports were examined. Postural control was assessed using a stabiloplatform with biofeedback by means of the Romberg test (eyes-open and eyes-closed test), as well as the registration of the electrocardiogram and heart rate variability using the PowerLab installation (ADInstruments, Australia).

Results and conclusions. Significant correlations were revealed between the indicators of heart rate variability and the stabilographic parameters of postural control, in particular, with the eyes closed. The athletes exhibited a higher level of the absolute power of VLF and a dominance of the sympathetic nervous system, which possibly reflects the role of centralized autonomic mechanisms in ensuring the stability of postural control. At the same time, the differences in motor activity form the features of the autonomic regulation and postural control, but the direct influence of the autonomic system on postural control may be non-obvious.

Keywords: *autonomic regulation, postural control, equilibrium function, stabiloplatform technologies, physical loads, badminton.*

Introduction. The effectiveness of postural control depends on the complex integration of various body systems and is subject to the influence of many external and internal factors. In sports, the variability of postural control is of particular significance, since it directly affects the effectiveness of complex-coordination movements and, consequently, sports mastery [4].

The quality of postural control is especially important in sports where tactical-technical skills require a high level of control, which is characteristic of situational sports. The scientific review by Zemkov E. and co-authors [5] showed that out of 126 analyzed articles, in 14 a connection was revealed between the indicators of postural balance and sports effectiveness. Associations between postural control and sports results were found in shooting, archery, golf, baseball, hockey, tennis, and snowboarding, which emphasizes its significance for sports activity.

The internal factors influencing postural control include the functional state of the body, the level of sports mastery, the degree of biological maturity, and the presence of overtraining or fatigue [3]. The external factors include the specificity of the sports activity, where multiple repetitions of technically complex actions in various conditions can form a certain pattern of postural control, which in a number of cases can be the cause of increased injury rates [5].

In this connection, the study of the features of postural control in young badminton players is relevant, since this sport places high demands on coordination abilities. The importance of the study is also due to the

fact that in adolescence and youth the processes of the morphofunctional maturation of the central nervous system, the sensory systems, and the musculoskeletal apparatus are not yet complete, which may condition the instability of the mechanisms of postural balance. Of particular interest are the systems of autonomic regulation, which in young athletes have not yet reached the level of maturity as in adults. Studies show that with age a decrease in the indicators of the autonomic provision of heart rate is observed both in athletes and in untrained people, which reflects a decrease in the plasticity and reactivity of the autonomic nervous system [1].

Objective of the study is to study the features of the autonomic regulation of heart rate and postural control in young badminton athletes.

Methods and structure of the study. The scientific work was conducted in the first half of the day on the basis of the Research Institute of Physical Culture and Sports of the Volga Region State University of Physical Culture, Sports and Tourism (Kazan). 16 young athletes engaged in badminton with a level of sports mastery from the second adult category to candidate for master of sports, and 26 representatives of the control group not engaged in sports were examined. The age of the subjects was 13–16 years.

The assessment of postural control was carried out using the stabiloanalyzer with biofeedback "Stabilan-01" of CJSC "OKB 'Ritm'" (Taganrog) by means of the Romberg test (eyes-open and eyes-closed test): R (mean scatter), mm – the mean radius of the deviation of the center of pressure; VS, mm²/s – an indicator characterizing the mean-amplitude speed of the change of the area of the statokinesigram; OD (motion assessment), conv. units – characterizes the indicators "curve length" and "mean scatter," which, when decreasing, show improvements in the quality of postural control; QEF, % – the quality of the equilibrium function, assesses how minimal the speed of oscillation of the center of pressure is when maintaining the vertical posture.

The electrocardiogram and heart rate variability were registered using the PowerLab installation (ADInstruments) throughout the entire study protocol, with a spectral analysis of heart rate variability with the isolation of the spectra VLF (Very Low Frequency) 0.0033–0.04 Hz; LF (Low Frequency) 0.04–0.15 Hz; HF (High Frequency) 0.15–0.4 Hz. The processing was carried out using the built-in HRV analysis module in the LabChartPro software.

The results of the study were processed in the SPSS 27 program. Spearman's correlation analysis was performed, and the ANOVA test with the Bonferroni correction was carried out. Differences were considered statistically significant at $p<0.05$.

Results of the study and discussion. In the course of the data analysis, correlations of a number of heart rate variability indicators with the stabilographic parameters of postural control were found; at the same time, the greatest correlations, both in number and in strength, were in the athletes. Thus, the greatest correlations were noted with the indicators of the spectral power of the slow-wave range VLF, measured in absolute values, with the indicator of motion assessment (r=0.68, p=0.003), obtained in the stabilographic test with the eyes closed, and with the mean scatter of the center of pressure (R), obtained in the eyes-closed position (r=-0.8, p=0.0001, see the figure).

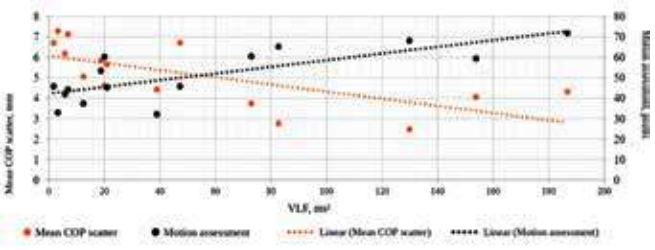

Figure 1. Spectral power of the low-frequency range of HRV and its correlations with the indicators of the mean scatter of the center-of-pressure position (COP) and motion assessment

Table 1. Spectral characteristics of HRV in athletes and non-athletes

Indicators	Athletes	Non-athletes
VLF	228.87 ± 704.00* (8.99 ± 8.54)	127.59 ± 145.03 (9.96 ± 7.10)
LF	888.28 ± 1768.67 (45.90 ± 18.88*)	1050.42 ± 1170.36 (60.43 ± 18.70)
HF	1480.29 ± 3167.68 (39.36 ± 23.97)	466.13 ± 666.27 (28.74 ± 17.15)
LF/HF	1.76 ± 1.72*	3.70 ± 3.43

Note. The table presents the absolute values of the spectral power (ms²); the relative values (%) are indicated in parentheses. The data are given as the mean value and standard deviation (M ± SD); "" – statistical significance between the groups.*

A similar correlation was also noted with the indicators of the speed of change of the area of the statokinesigram (r=-0.7, p=0.0001). On the one hand, it can be assumed that the increased activity of the low-frequency range, from the standpoint of postural control, is a positive internal factor improving its quality. The presence of stronger connections with the indicators obtained with the eyes closed is possibly connected with the fact that the demands on the central integration of sensorimotor and autonomic regulation increase. At the same time, this is expressed not only in the absolute values of VLF, but also in the percentage of contribution to the total spectrum. The dynamics of the changes in response to the closing of the eyes also has negative correlations with the mean scatter of the center of pressure (r=0.8, p<0.0001).

On the other hand, the comparison of the spectral data with the data of the non-athletes showed that the athletes exhibit a higher level of the absolute power of the VLF component, as well as a more pronounced dominance of the sympathetic nervous system – statistically significant differences in the LF/HF ratio (see the table), which is also noted by other researchers [1]. Possibly, this testifies to a more pronounced role of the slow, centralized mechanisms of autonomic regulation, ensuring the stability of postural control. This is partly confirmed by studies of judokas, which showed that the indicators of heart rate variability are associated with better performance of technical techniques, which is impossible without good coordination qualities and postural control [2]. The most well-known indicator – the quality of the equilibrium function – did not have any correlations with the indicators of the autonomic regulation of the heart in the studied groups.

We believe that the differences in motor activity determine both the features of the autonomic regulation and postural control. The direct influence of the autonomic system on postural control may thereby be absent.

Conclusions. This study demonstrated the presence of interrelations between the indicators of the autonomic regulation of heart rate and the characteristics of postural control in young athletes specializing in badminton. It should be especially noted that the most pronounced correlations were observed for the indicators of the slow-wave range of heart rate variability under conditions of sensory deprivation. This fact suggests that under conditions of reduced sensory afferentation, the central mechanisms of regulation play a key role in ensuring postural stability in this group of subjects.

In addition, the comparative analysis revealed significant differences between the athletes and the non-athletes, namely: a higher level of the absolute power of the VLF component and a lower value of the LF/HF index in the athletes. These differences probably reflect the adaptive functional changes of the autonomic nervous system, conditioned by the specificity of the training process in badminton. The obtained data confirm the hypothesis that the observed features of the indicators of heart rate variability and postural control in young athletes are rather a consequence of the long-term adaptation to specific motor activity than a direct effect of the autonomic nervous system on the mechanisms of maintaining balance. It is important to note that this adaptation is apparently connected with the restructuring of the central mechanisms of the control of postural control under a deficit of sensory information.

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