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Individual-typological features of regulation of cardiorhythm in foreign students during education process

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Abstract

Objective: In studies of the mechanisms of human adaptation to professional and educational activities, as well as in clinical practice, the method of mathematical analysis of heart rate variability (HRV) is widely used. Based on this, the aim of this paper is to determine the typology and characteristics of the vegetative regulation of the heart as a prenosological control of the functional state of the body of practically healthy foreign students.

Methods: In 2018, 389 male students from India and Pakistan, which are studying at the International higher school of medicine (ISM) aged 17-24, served as test subjects. For each student, the main HRV parameters were recorded in a sitting position for 5 minutes by means of "PSYCHOPHYSIOLOGIST" software and hardware company Medicom MTD (Russia).

Results: In total, 52% of young men had type I (with a moderate predominance of central regulation), 5% - type II (with a pronounced predominance of central regulation), 36% - type III (with a moderate predominance of autonomous regulation), and 7% - type IV (with a pronounced predominance of autonomous regulation). Students with a predominance of central regulation (types I and II) compared with types III and IV (predominance of autonomous regulation) have an excess of sympathetic influences on the heart, as indicated by reliably low values of the SDNN, Mo, TP and high level of SI, which leads to various dysfunctional disorders, especially with severe centralization. In the group of persons with type III, a balance is maintained between the tone of the sympathetic and parasympathetic nervous system, while type IV shows a significant prevalence of parasympathetic effects on the heart rhythm.

Conclusion: The results indicate a risk of developing disadaptation in the students' body during education process and the importance of systematic monitoring to detect early cardiac arrhythmias.

Key words: foreign students, heart rate variability, statistical and spectral characteristics, stress index, vegetative regulation

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Introduction

Modern educational process in higher school is notable for progressive intensification. Currently, in the study of the mechanisms of adaptation to professional and educational activities in fundamental physiology, the method of mathematical analysis of heart rate variability (HRV) is actively used. It is very important that using this method you can obtain information not only about the state of regulatory systems, but also determine the type of vegetative regulation. The works of recent years have proved that using the principle of a two-circuit model of heart rate control it is possible to distinguish individuals with different levels of vegetative regulation. These individual typological features of regulatory systems can "serve as an objective criterion in assessing the functional state throughout the entire period of study at a university" (1).

Therefore, the aim of this work was to determine the typology and characteristics of vegetative regulation of the heart as a prenosological control of the functional state of the students' body.

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Methods

The study was conducted in 2017, at the International higher school of medicine (ISM) in Bishkek, Kyrgyz Republic, among the male students from India and Pakistan. A total of 389 persons aged 17-24 were examined. The study was approved by the ethics committee at the International higher school of medicine (ISM) (Protocol No. 4 of November 9, 2016) and corresponds to the principles outlined in the Helsinki declaration. Prior to the study, informed consent was obtained from all participants for the examination.

Electrocardiogram (ECG) recording and calculation of heart rate variability (HRV) were carried out by means of "PSYCHOPHYSIOLOGIST" software and hardware company Medicom MTD (Russia) in siting position for 5 minutes. For recording of HRV, recommendation of the Task Force on HRV was followed (2).

The statistical characteristics of a dynamic line of cardio intervals include heart rate (HR), standard deviation of all RR intervals (SDNN), variation range (MxDMn), which are determined primarily by the influence of the parasympathetic part of the autonomous nervous system and is a reflection of sinus arrhythmia associated with breathing (3).

Mathematical analysis of heart rate according to R.M. Baevsky (4) was carried out to analyze the performance of Mode (Mo) and Mode amplitude (AMo), which reflect the measure of the mobilizing impact of sympathetic division. Besides, the stress index (SI) was used in the analysis, which reflects the degree of centralization of heart rhythm management.

To better quantify the periodic processes in heart rate a spectral analysis was involved, which allows evaluating the interaction of cardiac rhythm management levels. Spectral analysis consisted in measuring power of VLF-, LF-, HF-waves in the spectrum of heart rate variability, which was performed in percentage of the total power of the spectrum (TP), which shows the relative contribution of each component in the total power of heart rate fluctuations.

The surveyed contingent was divided into adaptive groups, with the classification of states according to the degree of regulatory stress index by Bayevsky and VLF waves. The contingent under analysis was divided into four types of vegetative regulation according to N.I. Shlyk (5): the type I with a moderate predominance of the central type of regulation (SI>100 c.u. and VLF>240 ms^2), the type II with a pronounced predominance of the central type of regulation (SI>100 c.u. and VLF<240 ms^2), the type III with a moderate predominance of self-contained regulation (SI =30-100 c.u. and VLF>240 ms^2), and the type IV with a pronounced predominance of self-contained regulation (SI<30 c.u. and VLF>240 ms^2).

Statistical analysis

The results of the study were subjected to statistical processing using the SPSS 16 version of the comparison of variables with the normal distribution.

One-way ANOVA analysis with the Posthoc-test Scheffe was used. Data are presented as mean (SD). Variables with a non-normal distribution were compared using the Kruskal-Wallis test. In this case, the data are presented as the median (Me), the first (Q1) and the third (Q3) quartiles (Me (Q1 - Q3)). The level of significance of differences at $p \leq 0.001$ was accepted as significant.

Results and discussion

Male students of type I (with a moderate predominance of central regulation) and type II (with a pronounced predominance of central regulation) amounted to 52% and 5% respectively of the total quantity of the examined. The analysis of statistical characteristics of HRV revealed that students with a predominance of central regulation (type I and type II) demonstrated significantly ($p \leq 0.001$) low values of SDNN (38ms and 20ms respectively), Mo (675ms and 575ms), MxDMn (191ms and 95ms), as compared to type III and IV, which evidences tension of adaptive and regulatory mechanisms (Table 1).

Table 1. Statistical HRV values of students with a different type of vegetative regulation

HRV Values	**Type I**	**Type II**	**Type III**	**Type IV**
HR, b/min	88 (80-96)	106 (94-112)	76 (72-84)	72 (64-76)
SDNN, ms	38 (31-44)	20 (17-25)	62 (54-72)	101 (77-108)
Mo, ms	675 (575-725)	575 (525-625)	775 (675-825)	832 (775-925)
AMo, %	47 (41-54)	65 (54-78)	30 (26-34)	19 (16-22)
MxDMn, ms	191 (154-223)	95 (82-131)	306 (271-357)	505 (402-624)
SI, c.u.	177 (134-266)	580 (386-805)	61 (47-80)	24 (19-29)

Data are presented as median (Q1 - Q3)
AMo - mode amplitude, HR- heart rate, HRV - heart rate variability, Mo-mode, MxDMn – variation range, SDNN- standard deviation of all RR intervals, SI - stress index

High values of AMo (47% and 65%) reflect influence of the sympathetic link of regulation of vegetative nervous system, and adverse condition of the cardiovascular system. The stress index (SI), which reflects the degree of tension of regulatory systems, is also "an important informative indicator of adaptive and regulatory condition of the body" (4). In the group of students with a pronounced predominance of central regulation (type II), stress index (SI) had highest values (580 c.u.), which is indicative of overstrain or unsatisfactory adaptation condition.

The spectral parameters demonstrated low total spectrum power (TP) and its wave structure; these changes are especially noticeable in the group with type II regulation (Table 2).

Table 2. Spectral HRV values of students with a different type of vegetative regulation

HRV Values	Type I	Type II	Type III	Type IV
TP, ms^2	2315 (1462-3121)	599 (432-897)	6688 (4980-9054)	17293 (11001-20360)
VLF, ms^2	741 (476-1140)	177 (152-208)	2537 (1728-3426)	5369 (3279-6874)
LF, ms^2	861 (510-1236)	259 (183-408)	2006 (1371-3045)	3910 (2739-5983)
HF, ms^2	497 (311-788)	130 (84-296)	1700 (1104-2618)	6153 (2949-8245)
VLF,%	37.4 (13.2)	27.9 (10.7)	39.0 (14.8)	35.9 (15.5)
LF, %	38.7 (12.1)	46.0 (11.6)	32.6 (11.4)	27.2 (8.5)
HF, %	23.9 (10.9)	25.9 (11.1)	28.4 (12.2)	39.9 (13.8)

Data are presented as median (Q1 - Q3) and mean (SD)
HF- high frequency power, HRV - heart rate variability, LF – low frequency power, TP – total power, VLF – very low frequency power

In particular, the TP indicator, which reflects the total effect on the heart rhythm of all levels of regulation, decreased to 599 ms^2 in the group of students with type II, which indirectly indicates a decrease in the adaptive capacity of the cardiovascular system and low stress resistance of the body. A decrease in TP, as mentioned above, entails changes in the structure of the HRV spectrum: HF values are 130 ms^2, LF-259 ms^2, VLF-177 ms^2. In addition, they are significantly ($p \leq 0.001$) lower as compared to type III and IV. The rate spectrum of this group demonstrated predominance of low frequency (LF% - 46) and very low frequency waves (VLF% - 27.9) with insignificant contribution to the rate spectrum of high frequency waves (HF% - 25.9).

The above data, together with high values of stress index (SI – 580 c.u.), evidence the condition of increased functional tension of the adaptation mechanisms. It also creates the danger of the adaptation breakdown and disruption of the intersystem and intrasystem functional links in the body and, as a result, occurrence of pathological processes. In some cases, for example, "excessive intellectual and psychoemotional stresses can lead to the development of myocardial electrical instability" (6).

The third group of male students (type III), with a moderate predominance of autonomous regulation (36% of the total quantity of examined) as compared to first group with a moderate predominance of central regulation (type I) had normal values of SDNN, Mo and MxDMn. The stress index within the third group of students had significantly ($p \leq 0.001$) lower values (61 c.u.) than the first group. Students of this group demonstrated high level of the total spectrum power (TP – 6688 ms^2, $p \leq 0.001$), which indicates a fairly high functional capabilities of the body and is a sign of sustainable adaptation to the effects of educational and psycho-emotional stress. In accordance with these shifts, the power of the high- and low-frequency components of the HRV spectrum (HF-1700 ms^2, LF-2006 ms^2, VLF-2537 ms^2) increases, while the moderate prevalence of respiratory waves (HF-28%) in the spectrum structure is consistent with "the ideas on the adaptive-trophic protective effect of the n. vagus on the heart" (6).

The fourth group of male students with a pronounced predominance of autonomous regulation (type IV) amounted to 7% of the total quantity of examined and demonstrated highest statistical values of HRV (SDNN-101ms; Mo-832 ms; MxDMn-505 ms; TP-17293 ms^2; HF-6153 ms^2). Increase of such values registered in this group gives evidence of significant predominance of the parasympathetic regulation link over the sympathetic link. Thus, predominance of the parasympathetic tone of the vegetative nervous system and high activity of autonomous control structures at rest evidence that the regulation systems of foreign students of this group are in "optimal condition and reflect high energy and reserve capabilities of bodies" (7).

Conclusion

The study findings indicate a balance between the tone of the sympathetic and parasympathetic nervous system in the students with moderate predominance of autonomous regulation (type III) and a significant prevalence of parasympathetic effects on heart rhythm in individuals with a pronounced predominance of autonomous regulation (type IV), which can be seen as the best condition of the adaptive and regulatory systems.

In students with a predominance of central regulation (types II and I) there was an excess of sympathetic influences on the heart, which may be the cause of the development of various dysfunctional disorders, especially with pronounced centralization. Therefore, there is an urgent need for monitoring of the functional state of students in order to identify early cardiac arrhythmias.

Conflict of interest: None to declare

Authorship: A.M.S., S.Yu.A., A.S.Sh. equally contributed to the study and preparation of manuscript

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