Adaptive potential of the cardiovascular system of medical students on the basis of load testing

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Abstract

Objective of the study was to assess the adaptive potential of the cardiovascular system of medical students based on stress testing.

Methods and structure of the study. 127 first-year male students of the Volga Research Medical University participated in the scientific experiment. The age of the subjects was 18-19 years. For ECG recording and analysis of hemodynamic parameters, including those characterizing heart rate variability, the Medical Soft sports testing system (MS FIT Pro variant, Russia) was used. As a tool for stress testing, physical exercises of the GTO complex were used.

Results and conclusions. The informativity of the generated load testing algorithm in monitoring the adaptive reserves of systemic hemodynamics is demonstrated. The use of a functional test with two types of load in medical students generally indicated that they had an adaptive response to them. At the same time, a number of indicators demonstrate the tension of regulatory mechanisms, which can be considered as a prenosological state. In addition, the specificity of hemodynamic reactive patterns for the considered variants of physical activity was revealed.

Keywords: *hemodynamics, cardiovascular system, adaptation, testing, students.*

Introduction. The most informative way to analyze hemodynamic parameters in students is to assess the adaptive potential of the cardiovascular system by heart rate variability (Vasti E. et. al., 2020; Veternik M. et. al., 2018). It is assumed that the use of dosed standard physical activity can act as a means of monitoring the functional state, tolerance to them, as well as adaptive reserves of hemodynamics (Ponomareva I.A., 2019; Duprez D.A., Cohn J.N., 2008; Thomas B.L., Viljoen M., 2019).

Currently, it is possible to monitor the state of the adaptive reserves of the body using special diagnostic hardware systems, one of which is the MedicalSoft sports testing system (Martusevich A.K. et al., 2020; Bocharin I.V. et al., 2021), as well as use the exercises of the All-Russian physical culture and sports complex of the TRP, which has been relevant in the Russian Federation since 2014, as a program and regulatory basis for the physical education of the population at all stages of education.

Objective of the study was to assess the adaptive potential of the cardiovascular system of medical students based on stress testing.

Methods and structure of the study. Scientific work was carried out with the participation of 127 first-year male students of the Medical University (age - 18-19 years). The study excluded students who were distinguished by age, student-athletes, as well as students with a special medical group for physical education and / or cardiovascular diseases. All subjects were included in the study after signing informed consent.

The survey was conducted in the middle of the school day, during the intersessional period, in full accordance with the standard rules for the procedure for taking an electrocardiogram (ECG). For ECG recording and analysis of hemodynamic parameters, including those characterizing heart rate variability, the Medical Soft sports testing system (MS FIT Pro variant, Russia) was used [Bocharin I.V. et al., 2021; Martusevich A.K. et al., 2020]. Standard hemodynamic parameters, statistical and spectral parameters of heart rate variability were used for monitoring. Data analysis was performed in accordance with age standards. To study the effect of physical activity on the cardiovascular system, exercises of the GTO complex were used in the following sequence: shuttle run - three segments of 10 m each and after a two-minute rest, flexion and extension of the arms in the lying position in the amount of 35 repetitions.

Results of the study and their discussion. An indicator that integrally characterizes the reaction of hemodynamics to dosed physical activity is the level of blood pressure. The value of systolic blood pressure (SBP) in students at rest remained in the physiological range, while physical activity contributed to a pronounced increase in this indicator ($p<0.05$). At the same time, a more significant increase in SBP occurred during push-ups, but no significant differences were found between individual exercises.

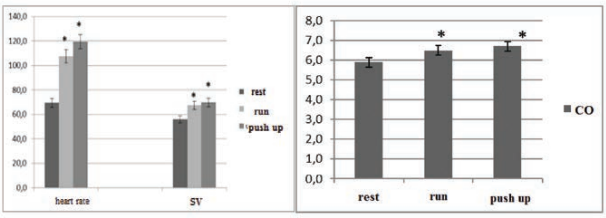

Figure 1. *The level of heart rate (HR), stroke volume (SV), as well as cardiac output (CO) in students at rest and during exercise ("*" - differences relative to the level characteristic of the state of rest, statistically significant, p<0.05)*

There was an increase in heart rate (HR) and stroke volume (SV) after the completion of dosed physical activity, which is undoubtedly associated with an increase in SBP due to increased myocardial oxygen demand and increased blood flow in the systemic circulatory bed ($p<0.05$). Adaptive rearrangements of the cardiovascular system are observed, and, as in the case of blood pressure, the indicators approach the peak of their values after push-ups (Fig. 1). At the same time, in the initial state, the level of heart rate and SV is determined in the physiological range. It should be noted that after performing the first exercise (in the intermediate recovery period), the subjects' performance decreased to values close to the state of rest, which may indicate rather high adaptive reserves of students' hemodynamics. It is also necessary to take into account the dynamics of blood pressure, as a functional indicator of the degree of consistency in the implementation of the pumping function of the myocardium and the precapillary system, as well as the adequacy of the response of any of these components to changes in the other.

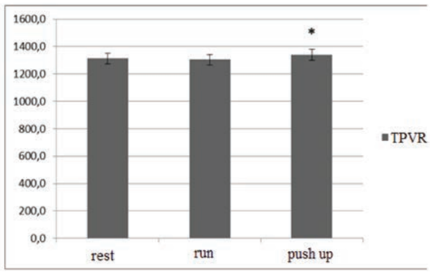

Figure 2. *The level of total peripheral vascular resistance in students at rest and during exercise ("*" - differences relative to the level characteristic of the state of rest, statistically significant, p<0.05)*

The next parameter to be assessed was the level of cardiac output (CO), which is close to SV in its diagnostic value and also characterizes the pumping function of the heart (Fig. 1). Undoubtedly, both options cause a significant increase in the parameter ($p<0.05$ for running and push-ups relative to rest). It should be emphasized that with an increase in the intensity of the load (from running to push-ups), an adequate increase in CO was observed, as evidenced by a higher value of the indicator after doing push-ups compared to running (at the level of a trend; $p<0.1$).

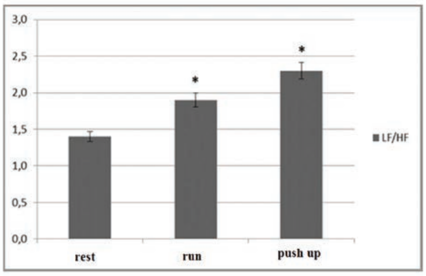

Figure 3. *The level of the spectral index of vegetative balance in students at rest and during physical activity ("*" - differences relative to the level characteristic of the state of rest, statistically significant, p<0.05)*

The contribution of total peripheral vascular resistance (TPVR) to the formation of systemic blood flow was assessed by calculating the corresponding parameter. At rest, the indicator approaches the upper limit of the age range (Fig. 2). After the running exercise, the parameter remained at the initial level, which visualizes good adaptive reserves of the students' body to short-term intense loads. At the same time, longer physical exertion (in the form of push-ups) contributes to an increase in the indicator ($p<0.05$ relative to the state of rest). These shifts are associated with a tendency towards centralization of blood circulation under conditions of increased myocardial oxygen demand, which may reflect latent disadaptation, but for an adequate assessment of the adaptive potential under these conditions, the dynamics of recovery processes should be additionally taken into account.

The revealed trends are also consistent with the nature of the shifts in the autonomic equilibrium index (LF/HF), calculated on the basis of the spectral analysis of the heart rate (Fig. 3). The stress response developing in the process of a nonspecific reaction to physical activity causes an increase in sympathetic stimulation of the myocardium, which manifests itself in a significant increase in the index of vegetative balance in both exercises used relative to the state of rest ($p<0.05$). At the same time, push-ups, as a longer and more intense load, cause a more pronounced increase in the value of the indicator compared to running ($p<0.05$). This characterizes the presence of partial specificity of adaptive responses to various types of exercises.

Conclusion. The study made it possible to demonstrate the informativity of the generated load testing algorithm in monitoring the adaptive reserves of systemic hemodynamics. The use of a functional test with two types of load (short high-intensity and long-term strength) among medical students in general indicated that they had an adaptive response to them. At the same time, a number of indicators (spectral index of autonomic balance and total peripheral vascular resistance) demonstrate the tension of regulatory mechanisms, which can be considered as a prenosological state. In addition, the specificity of hemodynamic reactive patterns for the considered variants of physical activity was revealed, and the test with a series of push-ups modifies the estimated parameters more significantly.

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