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Original Article

Swimming as a way to correct vegetative disorders in students

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Abstract:
Improving the methods of the body vegetative disorders correction with the use of swimming seems relevant and timely. *Purpose*: studying a prolonged course of physical activity in an aquatic environment effect on the vegetative support of the body in university students using the heart rate variability method. *Materials and methods***.** 47 young men-1-2 year students of three universities from Nizhny Novgorod (Russia) were included in the experiment. Heart rate variability registration was carried out by the diagnostic complex «Poly-Spectrum» (Neurosoft, Ivanovo) in the supine position. The standard characteristics of heart rate variability were studied. The registration of indicators was carried out before the start of classes and after a four-month swimming course with a frequency of classes 1 time per week lasting 60 minutes. One-factor analysis of variance ANOVA was used to compare these samples with each other. *Results*. It is established that before the start of swimming classes, vegetative support is characterized by a certain increase in the tension of regulatory mechanisms and a decrease in functional reserves, which is associated with high educational and psycho-emotional activity of junior studying years students. After exposure to four-month weekly cyclic physical activity in the form of swimming, stabilization of parameters is observed in the field of the autonomous regulation circuit contribution strengthening, the predominance of normotonia, a decrease in the stress index and an increase in physical performance among the studied university students. *Conclusions.* Taking into account the positive effect of swimming on the body of those engaged in it, it can be recommended for vegetative disorders and improving physical performance correction in junior high school students under the control of the heart rate variability method.
Key Words*:* **physical education, swimming, autonomous regulation, heart rate variability**

Introduction

Statistics from the World Health Organization indicate that approximately three quarters of the world's population suffer from diseases, the occurrence and development of which is associated with various negative environmental factors (Ibrahim Abd Elkader, & Fathi El-Gohary, 2022; Lastkov, & Dubovaya, 2020). Medical and environmental factors have a negative impact on health (Ignatenko at al., 2021), irrational nutrition, inactivity, bad habits, improper dosing of physical activity (Pengpid et al., 2019; Chiriac Paul Bogdan et al., 2021; Setiakarnawijaya et al., 2021).

The risk group for health abnormalities also includes students studying at universities who may have «hidden» maladaptation disorders, the so-called prenosological conditions (Yu-Xiang et al., 2018). There is a significant increase in the volume and intensity of educational and psycho-emotional loads among students in combination with the effects of physical inactivity, bad habits, work and rest disorders (Gerber et al., 2017; Eksterowicz & Napierała, 2020). This fact contributes to a significant strain on regulatory systems and a certain decrease in functional reserves (Hayano et al., 2019; Christiani et al., 2021), which is accompanied by increased requirements for the functional readiness of students' body, in particular, from the level of autonomic regulation of the cardiovascular system (Guzii et al., 2021).

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The functional status level is an integral indicator characterizing the degree of various body systems functioning, and characterizes students' readiness to perform physical activities of varying power and intensity (Cid et al., 2019; Kamandulis et al., 2020; Kolokoltsev et al., 2021).

At the same time, the functional state study is a rather laborious process implemented using differentiated methods for determining various physiological functions. One of the methods may be the assessment of heart rate variability characterizing the systemic level of the cardiovascular system autonomic regulation (Adams et al., 2018; Aparecida Maria Catai et al., 2020). In addition, it is known that with high intensity of training loads, psycho-emotional tension increases, which can lead to a state of sympathicotonia, the prolonged presence of which negatively affects the body and leads to a decrease in the functional state of it (Deschodt-Arsac et al., 2018).

It is known that moderate dosed physical activity contributes to the basic physiological functions vegetative maintenance normalization and has a beneficial effect on leveling psycho-emotional stress, which reduces the degree of tension in regulatory systems (Bocharin et al., 2021). At the same time, it is shown that the use of cyclical physical activity, for example, swimming, is the preferred choice (Karol Görner, 2020). Classes in an aquatic environment have a positive effect on all functional systems of the body, contribute to the musculoskeletal system strengthening, increase the tolerance of the cardiovascular and respiratory systems to physical exertion (Yapıcı-Öksüzoğlu, 2020).

In addition, such physical activities stimulate metabolism, improve nerve conduction, sleep, appetite, and increase the overall endurance of the body. The widespread use of the aquatic environment for human health improvement suggests the need to study the effect of the process of prolonged swimming on increasing students' vegetative adaptation and physical performance to the conditions of the educational environment of the university using an instrumental control method.

Research aim is studying a prolonged course of physical activity in an aquatic environment effect on the vegetative support of the body in university students using the heart rate variability method.

Material & methods

47 first- and second-year male students from leading universities of Nizhny Novgorod (Russia) took part in the experiment: Volga Region Research Medical University (group A, n=17), Nizhny Novgorod State Agricultural Academy (group B, n=16), Lobachevsky National Research Nizhny Novgorod State University (group C, n=14). All the subjects signed a voluntary consent to participate in the experiment and at any time could refuse to continue participating in the study, which followed the legal framework, according to the directive of the Helsinki Declaration of 2008. All the subjects had no diseases, they had a basic medical group for physical culture and sports.

To register heart rate variability (NRV), the diagnostic complex «Poly-Spectrum» (Neurosoft, Ivanovo) was used, each experiment was performed in the middle of the school day and the inter-session period. HRV was registered in a lying position, in a quiet and calm room, at an air temperature of 20-22° C and its relative humidity of 45-55%. Heart rate (HR) indicators were studied, as well as other statistical parameters of NRV: the standard deviation of NN intervals (SDNN), the proportion of NN intervals with a difference of 50 ms or more from each other (pNN50), the square root of the mean squares of the difference between adjacent NN intervals (RMSSD); spectral values of HRV: the power of the spectrum in the low, very low and high frequencies in relative values (LF, VLF, HF), the total power of the spectrum (TP) and the ratio of low-frequency and high-frequency spectral analysis powers (LF/HF). The stress index (SI) was used as an integral indicator of the degree of regulatory systems stress. HRV was recorded before the start of classes (control indicators) and after a 4-month swimming course with a frequency of classes 1 time per week and their duration of 60 minutes (experimental indicators).

The materials obtained in the course of scientific work were processed using Statistica 10.1 programs for Windows and Microsoft Excel 2016. Arithmetic mean (M) and mean-square deviation (σ) were calculated for each sample. The Shapiro-Wilk criterion was used to check the group data of the samples for the normality of the distribution. To compare the samples with each other in the control (initial) experiment before the start of classes and after the swimming course application, one-factor analysis of variance ANOVA was used. The differences were considered significant at $p<0.05$.

Results

When studying the students' vegetative support before the start of swimming classes, some differences were found in the studied groups (Table 1). It is assumed that these differences may be due to the differing specifics of the studied persons' educational activities, individual features of recovery after exposure to psycho-emotional stress. The heart rate value is observed within the normal range, but is approaching the upper limit of the norm, with the highest value of the indicator being observed in students of group A. When studying the HRV statistical indicators, we can note a tendency to centralize the heart rate according to the indicators SDNN and pNN50, a slight decrease in which indicates a decrease in the differences between adjacent NN intervals. There is an increase in the RMSSD parameter as an indicator of the parasympathetic norm, which approaches the upper limit of the normative values and characterizes an increase in the sympathetic contribution to the body

physiological functions regulation. The presence of moderate sympathicotonia is also indicated by the relative values of low-frequency and high-frequency powers of spectral analysis, and a slight increase in the power of the spectrum in the region of very low frequencies additionally indicates the presence of psycho-emotional tension and an increase in the higher autonomic centers contribution in ensuring the heart rhythm regulation. A slight decrease in functional reserves confirms the value of the total power of the spectrum indicator, and shifts in the index of vegetative equilibrium confirms the assumption of increased sympathetic stimulation of the myocardium, taking into account statistical and spectral criteria. An increase in the stress index above 200 conventional units in all groups of subjects summarizes the presence of general overstrain and excessive stress levels, which, without proper control, can lead to prenosological conditions and a decrease in the adaptive reserves of the body. The data obtained indicate that the risk of a decrease in functional reserves prevails more among students of group A in comparison with other groups of students.

Table 1. The level of vegetative support of the body of students of different educational institutions before the start of swimming classes, M± σ

Parameter	Group A students (n=17)	Group B students (n=16)	Group C students (n=14)
HR, beats/min	82.3±5.2	76.2±4.8*	78.4±4.1*
SDNN, мс	43.8±4.3	46.3±4.7#	46.7±4.2#
pNN50, %	14.6±2.1	17.3±2.0*	15.1±2.3*
RMSSD, ms	61.5±3.3	56.6±3.4*	59.7±3.8*
LF, %	41.6±2.0	37.3±2.6*	39.8±2.2*
HF, %	13.7±2.5	21.8±2.2*	17.5±2.0*
VLF, %	45.2±2.6	41.4±2.5#	42.9±2.7#
TP, ms^2	1134.5±95.6	1337.7±83.4*	1197.3±89.5*
LF/HF, cu.	2.8±0.1	2.2±0.1*	2.7±0.1*
SI, cu.	277.6±13.6	242.2±16.4 *	258.3±14.5*

Note: «» - intergroup differences are statistically significant (p<0.05), «#» - intergroup differences are statistically significant at the trend level (0.05<p<0.01)*

Then there was a study of the studied groups' vegetative status after conducting training sessions using a cyclic load in the form of swimming, lasting four months of classes and with a frequency of training once a week for 60 minutes. Changes in the studied parameters indicate a favorable effect of the proposed physical activity on the level of the functional state of the organism. There is a decrease in heart rate in all groups of students, which may indirectly indicate an increase in their level of fitness and physical performance. In addition, a change in the statistical parameters of HRV (SDNN and pNN50) indicates the absence of heart rate at rest centralization and the predominance of an autonomous regulation circuit, and an increase in RMSSD indicates a certain increase in parasympathetic regulation and an improvement in the regenerative properties of the body.

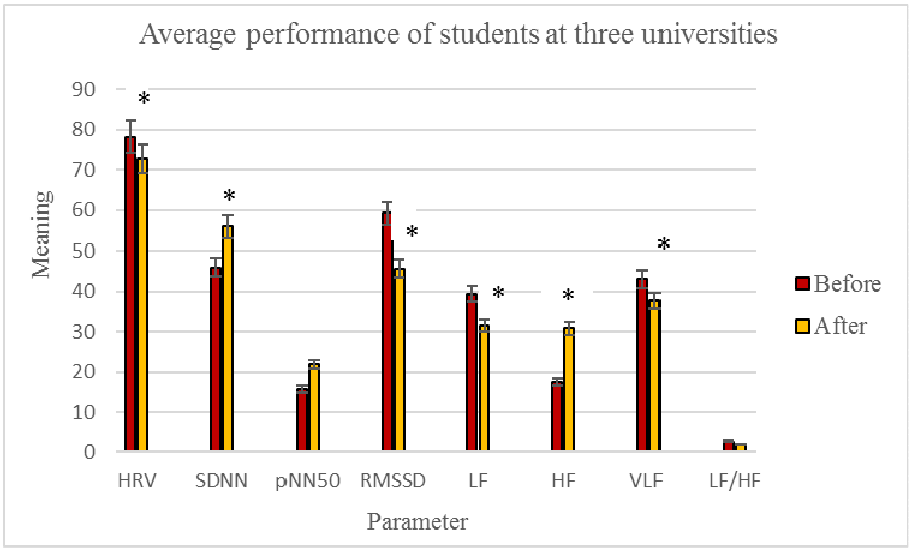
At the same time, there is a decrease in the activity of the sympathetic part of the autonomic nervous system (a decrease in the power of the spectrum in the low frequency region), an increase in parasympathetic regulation of the heart rate (an increase in the power of the spectrum in the high frequency region) and a decrease in the contribution of higher autonomic centers in heart rate management (a decrease in the very low-frequency component of the spectral analysis of HRV), Table 2.

Table 2. The level of vegetative support of the body of students of different educational institutions after swimming lessons, M±σ

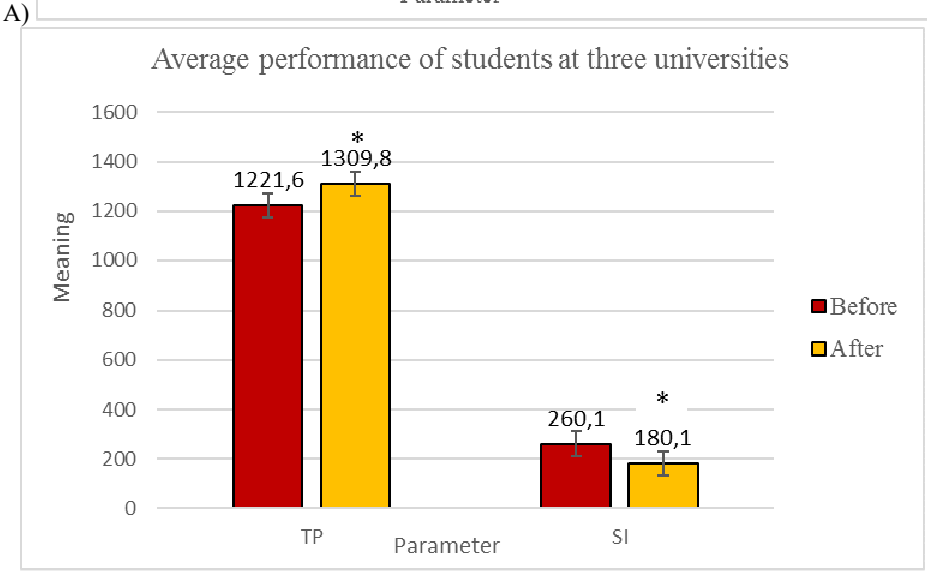
Parameter	Group A students (n=17)	Group B students (n=16)	Group C students (n=14)
HR, beats/min	73.6±5.2	68.7±5.2*	73.9±5.5*
SDNN, ms	55.4±4.2	57.4±4.1#	54.6±4.3#
pNN50, %	18.5±1.7	24.7±2.3*	22.5±2.2*
RMSSD, ms	49.4±3.5	45.8±3.3*	41.9±2.7*
LF, %	32.2±2.2	30.4±2.5*	31.5±2.0*
HF, %	28.1±2.3	31.9±2.6*	31.7±2.4#
VLF, %	37.4±2.0	38.4±2.7#	35.8±1.8#
TP, ms^2	1212.4±88.3*	1377.4±78.5*	1327.7±90.5*
LF/HF, cu.	2.2±0.1*	1.7±0.1*	1.8±0.1*
SI, cu.	187.7±15.5*	171.2±15.8*	178.3±16.4*

Note: «» - intergroup differences are statistically significant (p<0.05), «#» - intergroup differences are statistically significant at the trend level (0.05<p<0.01)*

This trend is confirmed by a decrease in the ratio of low and high frequencies of spectral analysis, the value of which additionally shows the predominance of normotonic regulation of cardiorhythm (Figure A).



A)



B)

Fig. *Vegetative support for students before the start of swimming classes and after the end of a 4-month course of physical exercises: A – parameters HRV, SDNN, pNN50, RMSSD, LF, HF, VLF, LF/HF; B – parameters TP, SI («*» – the differences between the indicators before and after classes are statistically significant, p<0.05)*

There is an increase in the total power of the spectrum, which complements our assumption, given the shifts in heart rate, some increase in the students' physical performance. At the same time, there is a decrease in the stress index to normative values in all groups of students studied, but these values indicate the preservation of a certain level of psychological and physical stress and the preservation of a low risk of adaptation loss (Figure B).

Thus, the peculiarities of the regulatory mechanisms reactivity indicate the need to continue systematic swimming lessons. At the same time, the various data obtained from students of three educational institutions indicate the need to take into account the specifics of studying at different universities, which must be taken into account in planning the dosing of physical activity during physical activity classes.

Dicussion

The state of physical and somatic health and functional reserves of the body can significantly deteriorate due to students' improper lifestyle, nutrition (Ulyanova et al., 2018) and low level of motor activity (Martin, & Naziruddin, 2020; Kolokoltsev et al., 2022). This is especially true for undergraduate students who are faced with various factors affecting the functional state of the body and the level of its adaptive reserves (Krivobokova et al., 2020). At the same time, it is known that the vegetative regulation state can determine the degree of the body adaptation to physical work, stress effects of various origins (Nezhkina et al., 2022). The predominance of one or another part of the autonomic nervous system tone characterizes the initial vegetative status. It can affect not only the state of the body's reserve capabilities, but also a person's physical health (Snedden et al. 2019). As

evidenced by the data of Rodriguez et al. (2021), a violation of the balance between these parts of the nervous system increases the risk of the body to negative effects.

In our research, it was found that the students' initial vegetative status is characterized by a tendency to a certain decrease in functional reserves, an increase in the contribution of autonomic regulation higher circuits, c the heart rate entralization and the predominance of sympathictonia. Hayano et al. (2019) emphasize that the predominance of central regulation of the cardiovascular system indicates the tension of all regulatory mechanisms, which is consistent with our research results. In our opinion, such a violation can be explained by high educational and psycho-emotional loads on the students' body, especially in the junior courses of study. Therefore, the search for means and methods of compensation for vegetative disorders may indicate the relevance of our chosen research theme.

The use of weekly swimming of students as a means of physical education made it possible to effectively correct the students' vegetative status, which is consistent with the data of many authors who have shown the positive effects of physical exercise in the aquatic environment in their works (Karol Görner, 2020; Semenyakina et al., 2018). According to the authors, loads during swimming have a positive effect not only on the functional systems of the body, but also increase the tolerance of the cardiovascular system to physical work (Yapıcı-Öksüzoğlu, 2020).This fact is confirmed by the results of our observations at the end of the experiment. It was found that after exposure to the proposed course of physical activity, stabilization of all heart rate variability indicators is noted, there is a slight increase in physical performance, an increase in the contribution of the autonomous circuit of cardiac rhythm regulation, vegetative balance stabilization and an increase in the parasympathetic regulation contribution. Similar positive changes in vegetative regulation have been noted by other researchers (Cid et al., 2019; Kamandulis et. al., 2020; Guzii et al., 2021).

Our research indicates the need to continue swimming lessons and further study the vegetative status, taking into account the differences in the specifics of students', studying at different educational institutions of higher education educational activities.

Conclusions

As the research result, it was found that before the start of swimming, heart rate variability indicators, in general, are within the physiological norm. However, vegetative support is characterized by a certain increase in the tension of regulatory mechanisms and a decrease in functional reserves, which is associated with high educational and psycho-emotional activity of students in junior studying years. After exposure to four months of weekly cyclic physical activity in the form of swimming, there is a decrease in heart rate in all groups of students, which may indirectly indicate an increase in their level of fitness and physical performance. In addition, the change in the statistical parameters of HRV (SDNN and pNN50) indicates the absence of centralization of the heart rate at rest and the predominance of the autonomous regulation circuit, the predominance of normotonic regulation of cardiac rhythm, a decrease in the stress index to normative values, and an increase in RMSSD indicates a certain increase in parasympathetic regulation and improvement of the body's restorative properties.

Therefore, in order to prevent the development of possible autonomic disorders, cardiovascular complications and increase physical performance in junior studying years students, it is possible to recommend the use of swimming in the physical education curriculum under the control of the heart rate variability method.

Conflicts of interest. The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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