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Original Article

Engaging in sports as a method to enhance the stress resilience of a student's body

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Abstract:
Enhancing students' resilience against exam-related stress remains a pressing concern for both researchers and educators. Sports activities have been identified as a potential avenue to mitigate the adverse effects of psycho-emotional stress associated with exams. **Research objective**: To evaluate the impact of sports activities on the adaptation of university students' functional and psychophysiological systems to the stress induced by exams. **Materials and methods**. 160 boys and girls (aged 17.8±1.2) who were university students in the Altai Territory took part in the research. The students were divided into 2 groups according to their relation to sports activities, non-sports (n=94) and students who have been actively engaged in various sports for at least 3 years (n=66). The examination of students was carried out during the inter-sessional period and on the day of the exam. To assess the physiological parameters of the students' cardiovascular system and higher nervous activity during the inter-sessional period and on the day of the exam, the «BioMysh - Physiologist» software and hardware complex of the «Neurolab» company (Russia) was used. The following parameters were studied: variation chronocardiometry, spectral analysis of heart rhythm and central hemodynamics. Of the psychophysiological research methods, the «Attention distribution» test was used. **Results.** It was found that the students-athletes' indicators values of the cardiovascular system and the psychophysiological status are significantly higher than those of students who do not do sports, $p<0.05$. These data indicate higher characteristics of stress resistance in the body of male and female athletes compared to students who ignore sports activities. **Conclusions.** The data obtained in the research can be implemented in practical recommendations for exam stress prevention among students and in the promotion of physical activity among the population.
Key Words: **physical education, students, exam stress, sports activities, psychophysiological systems**

Introduction

According to UNESCO (United Nations Educational, Scientific, Cultural Organization), more than 150 million young people are currently studying at universities and colleges around the world. Obtaining higher and secondary vocational education is accompanied by stress on the functional systems of the body and a high stress effect on students' psycho-emotional sphere. It can negatively affect the effectiveness of vocational education and worsen the quality of young people's life (Kolokoltsev et al., 2020).

As numerous scientists' observations have shown, when studying in an educational institution, a number of negative factors affect a student's body. These include a large academic load, widespread use of IT technologies, violation of the educational work and rest regime (Gerber et al., 2017; Eksterowicz, & Napierała, 2020). An adverse effect on the student's body is caused by a change of place of residence and separation from parents. It is not uncommon for students to develop bad habits during their studies (Pengpid et al., 2019). Against the background of the influence of negative factors on the body, students have insufficient physical activity (Bakiko et al., 2020; Syamsudin et al., 2021; Mazin et al., 2021). It reduces the characteristics of physical health and makes it disharmonious (Junger et al., 2019; Zhang et al., 2019; Kolokoltsev et al., 2021). Physical inactivity worsens the psychoemotional state and reduces the body's reserve capabilities (Grajek, & Sobczyk, 2021). There is a lag in the motor qualities development (Faílde-Garrido et al., 2022). Despite the

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physiological adaptation of the body to adverse environmental factors, with deterioration of physical health, somatic diseases may occur (Baker et al., 2022; Bocharin et al., 2023), which often turn into a chronic form (Diaz et al., 2020; Jha et al., 2021). It worsens the educational process and students' life quality. According to researchers, a significant incidence of student youth is registered in many countries (Tortella, et al., 2021; Drenowatz, 2021; Tomás Reyes-Amigo, 2021).

Educational activities always involve ongoing and final control of the level of knowledge acquired. These include exams, tests, colloquiums, seminars and other forms of control. Scientists and teachers highlight the psychoemotional and functional overloads occurring during the examination session, which are defined as exam stress. The most common reason for such a negative impact of a stress factor is an overstrain of the body's regulatory systems. It leads to a pronounced disruption of the cardiovascular and nervous system (Machado, Soares, 2022). During the exam, the heart rate, blood pressure and arterial vessel spasm increase. Tremor of the hands appears, increased sweating, and the temperature of the fingertips decreases. Indicators of thinking, attention level, and memory are deteriorating. The indicators of the scale of self-esteem, well-being, mood, mental and physical performance are decreasing (Tokaeva, & Pavlenkovich, 2012). Appetite is impaired and sleep worsens. There is a feeling of fear, anxiety, agitation, the cause of which is the examination situation impact over the body. Therefore, the study of issues related to exam stress in students and the assessment of technologies aimed at increasing the stress resistance of their body is an urgent problem and is in demand by time.

In increasing the student's body resistance to exam stress, a certain role is assigned to the teaching staff, which can effectively mitigate the effects of stress. Students can be recommended methods of self-regulation of mental activity and compliance with the regime of educational work and rest, which will increase the productivity of educational activities (Nezhkina et al., 2021).

However, regular motor activity can play the most important role in countering stress (Yapıcı-Öksüzoğlu, 2020; Bocharin, & Guryanov et al., 2023). The «joy» hormone production (dopamine, serotonin and endorphin) during muscle work makes it possible to compensate for the negative effects of stressful factors. It is known that sports have a positive effect on a person's psychoemotional status. Athletes are distinguished by their dedication, rapid mobilization of forces, confidence in actions, determination to cope with difficulties and great motivation for success (Zhang et al., 2019; Zurita-Ortega et al., 2019). In addition, exercising increases the reserve capacity of the cardiorespiratory system (Dupuy & Dugué, 2018; Gumenyuk et al., 2021). With regular exposure to physical activity, there is a stabilization of heart rate variability, an increase in physical performance, stabilization of vegetative balance and increased effects of parasympathetic regulation on the heart (Kamandulis et. al., 2020).

It makes it easier for the body to transfer not only physical, but also psycho-emotional loads, including those caused by the educational process. However, an analysis of the scientific literature indicates a lack of detail on issues related to exam stress and sports activities. We believe that studying this issue will allow us to develop recommendations on the use of sports activities as a means of reducing psycho-emotional stress among students.

Research objective: To assess the impact of sports activities over the adaptation of university students' functional and psychophysiological body systems to the effects of psycho-emotional stress during the exam.

Material & methods

The observation was organized at the University in the Altai Territory (Russia) from September 2022 to December 2023. The research period included two examination sessions. The examination of students was carried out during the inter-sessional period and on the day of the exam. 160 full-time students took part in the project, including 90 boys and 70 girls aged 17.8±1.2. All students were divided into 2 groups in relation to sports activities: non-sports (n=94) and students actively engaged in various sports for at least 3 years before the examination (n=66). Such students attend training sessions 3-4 times a week for 2 hours each, attend training sessions 2-3 times a year and actively participate in competitions at various levels (from international to regional level). The conducted research does not violate the moral and ethical principles of biomedical research, which are set out in the Helsinki Declaration of 2008.

The study of the students' physiological parameters of the cardiovascular system and higher nervous activity state before and after the exam used the «BioMysh - Physiologist» software and hardware complex of the «Neurolab» company (Russia). The complex is a computer mouse with built-in sensors. The following parameters were studied: variational chronocardiometry: mean cardiointerval, ms; stress index of regulatory systems, stress index (SI), cu; index of vegetative systems equilibrium (IVE), cu; vegetative rhythm index (VRI), cu. The spectral analysis of the heart rate was evaluated: relative power of high frequency waves (HF), %; relative power of low frequency waves (LF), %. The parameters of central hemodynamics were studied: heart rate, bpm; systolic and diastolic blood pressure, mmHg; pulse pressure (PP), mmHg; stroke volume (SV) of the heart, ml; minute volume of blood circulation (MVC), l; Robinson index, cu were calculated according to the formula: the product of systolic pressure by heart rate / per 100.

The «Attention distribution» test was used, as one of the psychophysiological research methods, which evaluates the operator abilities of the subject. Minimum, maximum and average reaction time to stimuli, ms; mode, ms; mode amplitude, %; kurtosis, cu; variation range, ms; asymmetry, cu were recorded.

The evaluation of the results was carried out by a comparative analysis of the studied indicators. Statistical processing included calculating the arithmetic mean (x), its error (m) and standard deviation (σ). The reliability of the obtained results was evaluated by the Student's t-criterion with a significance of $p<0.05$. Statistical processing was performed on a computer using the Statistica Microsoft Excel software package. 2010.

Results

Doing sports has a significant positive effect on changing the adaptive capabilities of the cardiovascular system. Tables 1 and 2 present the results of a study of the cardiovascular system of boys and girls, depending on their involvement in sports activities.

Table 1. The values of the variational chronocardiometry indicators in young students who are engaged and not engaged in sports (M±m)

Indicators	Students, who are not engaged in sports (n=55)		Students-athletes (n=36)	
	On the exam day	Inter-sessional period	On the exam day	Inter-sessional period
Mean cardiointerval, ms	809.1 ±11.6	707.1 ±12.3*	1105.6±10.2#	1053.2±10.8#*
Stress index of regulatory systems (stress index), cu	100.0±4.1	125.7 ±10.7*	72.4±2.2#	83.6±3.5#*
Index of vegetative systems equilibrium, cu	154.5±6.2	196.4 ±14.2*	112.3±3.3#	142.3±4.2#*
Vegetative rhythm index, cu	5.0±0.1	5.0 ±0.2	3.5±0.1#	3.5±0.1#
Relative power of high frequency waves (HF), %	46.9 ±1.6	33.2 ±1.8*	57.2±1.9#	43.2±1.6#*
Relative power of low frequency waves (LF), %	53.7 ±1.6	66.7 ±1.8*	50.3±1.4#	56.2±1.9#*

*Note. * significant difference in the indicators values on the day of the exam and the inter-sessional period ($p<0.05$);*

 # significant difference in the indicators values between students-athletes and students not involved in sports ($p<0.05$)

The analysis of the results of testing the cardiovascular system state according to the data of variational chronocardiometry indicates that there are significant differences in the values of indicators among students, depending on their involvement in sports activities. It was found that on the day of the exam, in young men engaged in sports, all heart rate indicators had a significant difference from the values of the indicators of students not involved in sports activities, $p<0.05$, Table 1. The results of the analysis indicate that students-athletes have a rarer heart rate, significantly lower values of the stress index, vegetative rhythm index and vegetative balance compared with students not involved in sports, $p<0.05$. Athletes have a higher value of the high-frequency waves indicator, which indicates the predominance of parasympathetic innervation of the heart and a decrease in the central regulation of its activity. The values of the indicators for athletes on the day of the exam and the inter-sessional period are within the normative values of the indicators, which additionally indicates the great reserve capabilities of their cardiovascular system compared to young men who ignore sports.

Table 2. The values of the variational chronocardiometry indicators in female students who are engaged and not engaged in sports (M±m)

Indicators	Female students, who are not engaged in sports (n=39)		Female students-athletes (n=30)	
	On the exam day	Inter-sessional period	On the exam day	Inter-sessional period
Mean cardiointerval, ms	798.0 ±38.2	1088.6 ±23.4*	819.6±10.2#	1149.2±10.8#*
Stress index of regulatory systems (stress index), cu	52.3±3.0	61.8±5.2*	32.4±2.0#	43.6±3.5#*
Index of vegetative systems equilibrium, cu	112.5±3.6	176.4 ±19.2*	82.3±3.3#	92.7±4.2#*
Vegetative rhythm index, cu	3.2±0.4	3.4±0.5*	3.0±0.1#	3.0±0.1#
Relative power of high frequency waves (HF), %	52.9 ±6.6	33.2 ±4.8*	70.8±7.6#	43.2±1.6#*
Relative power of low frequency waves (LF), %	29.4±4.4	49.1±5.6*	20.3±1.4#	36.2±1.9#*

*Note. * significant difference in the indicators values on the day of the exam and the inter-sessional period ($p<0.05$);*

 # significant difference in the indicators values between female students-athletes and female students not involved in sports ($p<0.05$)

Girls, engaged in sports activities have higher values of variational chronocardiometry compared to girls who are not athletes. It indicates a higher reserve capacity of such students' cardiovascular system, which compensates for the negative effects of exam stress on the body. Performing regular physical activity during the training process affects the state of the boys' and girls' central hemodynamics parameters, Tables 3 and 4.

Table 3. The values of central hemodynamics indicators in male students who are engaged and not engaged in sports (M±m)

Indicators	Students, who are not engaged in sports (n=55)		Students-athletes (n=36)	
	On the exam day	Inter-sessional period	On the exam day	Inter-sessional period
Heart rate, bpm	109.4±5.6	76.4±5.0*	70.5±4.1#	62.3±3.6#*
Maximal systolic and diastolic blood pressure, mmHg	135.1±9.5	124.6±14.3	123.8±7.6	121.6±7.4
Minimal systolic and diastolic blood pressure, mmHg	92.2±8.4	86.6±5.9	88.6±6.7	83.4±6.2
Pulse pressure, mmHg	42.9±3.6	42.0±3.5	35.2±3.1#	38.2±3.4
Stroke volume of the heart, ml	48.8±4.8	38.0±4.1*	67.8±4.6#	63.3±4.5#
Minute volume of blood circulation, l	5.3±0.6	2.9±0.9*	4.8±2.2#	3.9±1.8#
Robinson index, cu	147.8±8.8	95.2±6.9*	87.2±6.2#	75.7±4.3#*

*Note. * significant difference in the indicators values on the day of the exam and the inter-sessional period (p<0.05);*

 # significant difference in the indicators values between students-athletes and students not involved in sports (p<0.05)

A comparison of the central hemodynamics indicators values indicates that students-athletes have more functional reserves of the cardiovascular system compared to young men who do not do sports. It is indicated by a 35.5% lower heart rate and 41.0% lower Robinson index in male athletes on the day of the exam. They have a 38.9% higher stroke volume of the heart and a 9.4% lower minute volume of blood circulation, p<0.05, compared with students who do not engage in sports. High functional reserves of the cardiovascular system make it easier to transfer the effects of exam stress. These are evidenced by lower rates of cardiovascular response in the group of student-athletes compared with young men who do not do sports. If in the group of non-athletes the heart rate on the day of the exam increased by 42.7%, the Robinson index by 59.4%, then in the group of student-athletes these indicators increased by 13.2% and 15.2%, respectively, p<0.05, Figure.

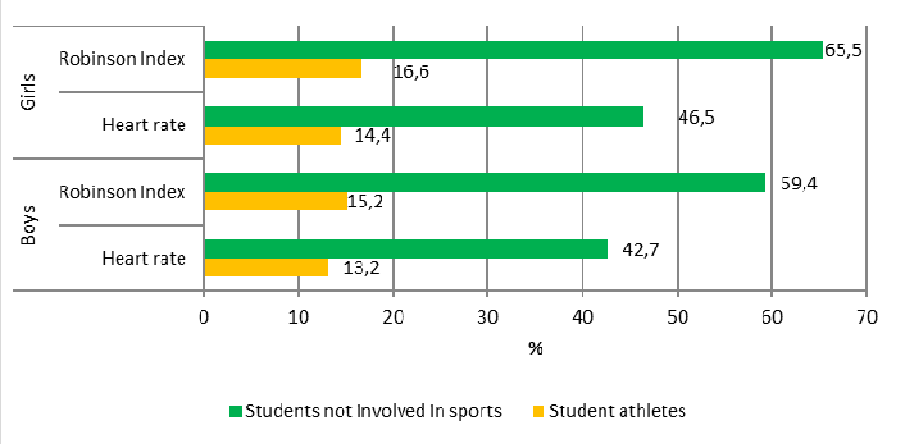

Fig. The increase in the heart rate and Robinson index values among students on the day of the exam (compared with the inter-sessional period)

Approximately the same pattern of cardiovascular response before and after exam stress was found among girls as among boys, Table 4.

Table 4. The values of central hemodynamics indicators in female students who are engaged and not engaged in sports (M±m)

Indicators	Female students, who are not engaged in sports (n=39)		Female students-athletes (n=30)	
	On the exam day	Inter-sessional period	On the exam day	Inter-sessional period
Heart rate, bpm	107.7±6.7	73.5 ±5.2*	72.3±3.9#	63.2±4.3#*
Maximal systolic and diastolic blood pressure, mmHg	136.5±7.2	120.0±11.3	128.0±3.0	125.5±2.8
Minimal systolic and diastolic blood pressure, mmHg	90.7±6.4	83.0±6.3	89.3±7.6	77.8±7.2*
Pulse pressure, mmHg	45.7±4.1	37.0±4.7*	38.7±3.4#	47.7±4.6#*
Stroke volume of the heart, ml	48.2±4.7	43.2±7.5	58.4±6.7	54.2±5.8
Minute volume of blood circulation, l	5.2±0.5	3.2±0.4*	4.2±0.5#	3.4±0.3*
Robinson index, cu	146.0±7.4	88.2±6.3*	92.5±7.8#	79.3±7.2

*Note. * significant difference in the indicators values on the day of the exam and the inter-sessional period (p<0.05);*

 # significant difference in the indicators values between female students-athletes and female students not involved in sports (p<0.05)

Girls who ignore sports activities have a more negative response of the cardiovascular system to exam stress. This fact is manifested on the day of the exam by higher values of the heart rate index and the Robinson index compared to girls who do sports. In the group of non-athletes, the heart rate on the day of the exam increased by 46.5%, the Robinson index by 65.5%, in the group of female student athletes, these indicators increased by 14.4% and 16.6%, respectively, $p<0.05$, Figure. The results of psychophysiological testing of students-athletes and non-sports students are presented in Table 5.

Table 5. The values of the «Attention distribution» test indicators in male students who are engaged and not engaged in sports (M±m)

Indicators	Students, who are not engaged in sports (n=55)		Students-athletes (n=36)	
	On the exam day	Inter-sessional period	On the exam day	Inter-sessional period
Average reaction time to stimuli, ms	2215.3±61.0	2345.0 ±50.9*	2045.0 ±46.7#	2125.0 ±57.2#
Mode, ms	1546.3±51.2	1895.1±64.2*	1312.3±54.4#	1395.1±59.2#
Mode amplitude, %	17.9 ±0.3	17.4 ±0.3*	15.4 ±0.5#	14.2 ±0.4#
Variation range, ms	4085.9±152.0	4345.2 ±83.1*	3743.5 ±63.1#	3935.2 ±66.8#*
Kurtosis, cu	1.8±0.2	2.0 ±0.3*	1.6 ±0.2#	1.7±0.4#*
Asymmetry, cu	1.3±0.01	1.2 ±0.01*	1.2 ±0.01#	1.1 ±0.02#*
Minimum reaction time, ms	1006.3±18.5	1004.0 ±19.3	957.0 ±16.3#	963.0 ±17.3#
Maximum reaction time, ms	5092.2±155.0	5349.3 ±90.3*	4318.3 ±71.3#	4542.3 ±85.3#*

*Note. * significant difference in the indicators values on the day of the exam and the inter-sessional period ($p<0.05$);*
 # significant difference in the indicators values between students-athletes and students not involved in sports ($p<0.05$)

The results of a comparative analysis of the indicators values in the «Attention distribution» test indicate significant differences between students according to their attitude to sports activities. On the day of the exam, the values of all indicators in the test were significantly lower in young athletes compared to students who do not engage in sports, $p<0.05$. During the inter-sessional period, a decrease in attention was found in both groups of students. However, among athletes, this decrease in attention is less pronounced compared to young men who do not engage in sports. It is indicated by significantly lower values of all indicators in the «Attention distribution» test among male athletes compared with non-athlete students, $p<0.05$.

Table 6. The values of the «Attention distribution» test indicators in female students who are engaged and not engaged in sports (M±m)

Indicators	Female students, who are not engaged in sports (n=39)		Female students-athletes (n=30)	
	On the exam day	Inter-sessional period	On the exam day	Inter-sessional period
Average reaction time to stimuli, ms	2290.7±72.0	2470.5±105.5*	1880.5±115.5#	1940.5±120.5#
Mode, ms	1711.7±102.0	1993.7±133.3*	1493.7±133.3#	1692.5±153.3#
Mode amplitude, %	16.9 ±1.1	16.9±1.0	14.3±1.0#	14.9±1.0#
Variation range, ms	4176.0±358.1	3910.2±352.2	3704.2±332.1	3820.2±342.3
Kurtosis, cu	0.7±0.2	1.7±0.6*	0.3±0.1#	0.7±0.4#
Asymmetry, cu	1.0±0.02	2.7±0.8*	0.8±0.04#	1.1±0.7#
Minimum reaction time, ms	1011.7 ±24.7	1193.7±52.7*	930.7±54.7#	978.7±54.7#
Maximum reaction time, ms	5187.7±242.7	6004±306.2*	3004±266.8	4014±276.4*

*Note. * significant difference in the indicators values on the day of the exam and the inter-sessional period ($p<0.05$);*
 # significant difference in the indicators values between female students-athletes and female students not involved in sports ($p<0.05$)

The results of the analysis of the indicators values in the psychophysiological «Attention distribution» test in girls indicate about the same dynamics of the research parameters as in boys. On the day of the exam, the values of all indicators in the test were significantly lower in comparison with non-sports students, $p<0.05$. After the exam, a decrease in attention was found in both groups of female students. However, in female athletes, this decrease in attention after the examination session is less pronounced compared to girls who do not do sports. It is indicated by significantly lower values of all indicators in the «Attention distribution» test among girls involved in sports compared to non-athlete students. The given data of psychophysiological testing for the distribution of attention among university students may indicate an increase in the psychological reserves of the body during sports. This makes it possible to compensate for the negative stress caused by the examination session.

Dicussion

It is known that studying in an educational institution can be accompanied by some negative effects on the a student's body (Kolokoltsev et al.2020). One of these factors is the examination session. Scientists have found that during the exam, a significant response of the functional, neurophysiological and psychoemotional systems of the body is recorded (Tokaeva, & Pavlenkovich, 2012; Machado, & Soares, 2022). In conditions of weak physiological adaptation of the student's body to adverse factors, there may be a breakdown of compensatory regulation mechanisms, which worsens not only the quality of vocational education, but also affects the quality of students' life. It can often lead to the development of a particular disease (Junger et al., 2019; Zhang et al., 2019; Kolokoltsev et al., 2021). Therefore, the multilateral study of issues related to the impact of exam stress continues to be an urgent and in-demand problem.

Various technologies can be used to reduce the negative impact of exam stress (Nezhkina et al., 2021). One of them is the use of physical activity in the form of sports activities (Yapıcı-Öksüzoğlu, 2020; Bocharin et al., 2023). The positive effect of sports is manifested in increasing the reserve capacity of the cardiovascular, respiratory, nervous and other systems for physical loads. Exercising leads to a decrease in the heart rate at rest, an increase in the stroke volume of the heart, and normalization of blood pressure. Significant psycho-emotional stress during examination stress, as well as sports activity, causes a significant increase in heart rate, pulse blood pressure, Robinson index, which characterizes systolic blood output by the heart. According to our data, it was found that among students who do not exercise on the day of the exam, the heart rate increases in boys by 42.7%, the Robinson index by 59.4%, in girls by 46.5% and 65.5%, respectively, compared with the inter-sessional examination period. However, for students-athletes, such an increase was 3.2 and 3.9 times less. This fact indicates the adaptation of the cardiovascular system not only to physical load, but also to exam stress in students-athletes, which does not contradict the opinion of the above-mentioned authors.

Sports activity causes an increase in the autonomous regulation of cardiac activity. This fact indicates an increase in the adaptive capabilities of the body, which are due to an increase in the high-frequency waves power. It is indicated by some scientists' research (Kamandulis et. al., 2020). Such waves are characteristic of the predominance of parasympathetic innervation of heart activity and an increase in its autonomy. According to our data, the power index of high-frequency waves among young athletes was 21.9%, and 33.8% higher among girls than among students who do not engage in sports. Stress index parameters also play a role. It gives an idea of the state of the central circuit of the human cardiac activity regulation. Lower values of the stress index in students involved in sports compared to non-athletes also indicate a decrease in central regulation of heart activity. Similar results were obtained by other authors (Bocharin, & Guryanov et al., 2023). According to these researchers, students involved in sports recorded similar characteristics of heart rate variability.

Sports activities play an important role in improving the adaptation of psychoemotional status (Zhang et al., 2019; Zurita-Ortega et al., 2019). The results of our research indicate higher values of attention stability for students involved in sports compared to students who do not engage in sports. For boys and girls who do sports on the day of the exam, the values of all indicators in the «Attention distribution» test were significantly lower compared to students who did not do sports. During the inter-sessional period, athletes' attention loss is less pronounced compared to boys and girls who do not engage in sports.

The data presented by us on the state of the cardiovascular and psychophysiological system indicate that the body of athletes has great reserve capabilities to withstand exam stress compared with students who ignore sports activities.

Conclusions

A comparative analysis of the study results of the cardiovascular system and the psychophysiological status of the body of boys and girls showed significant differences in the indicators values between students who regularly engage in sports and those ignoring sports activities.

Students-athletes have registered more reserve capabilities of the cardiovascular system to withstand exam stress. This fact is manifested in a significantly lower resting heart rate by 3.2 times, and a low value of the Robinson index by 3.9 times on the day of the exam. The autonomy of cardiac activity is more pronounced in students-athletes, as indicated by a higher value of the high-frequency wave power indicator and a lower value of the stress index indicator. According to our data, the power index of high-frequency waves among young athletes was 21.9%, and 33.8% higher among girls than among students who do not engage in sports. The students-athletes' stress index was lower by 25.7 and 18.2%, respectively, compared with students who do not engage in sports.

Higher values of students' involved in sports attention stability compared to those, who are not athletes have been established. For boys and girls who were involved in sports on the day of the exam, the values of all indicators in the «Attention distribution» test were significantly lower compared to non-athletes' students.

The materials obtained as a result of the research project can be used in practical recommendations for the prevention of exam stress in students. They can be used to promote sports activities among young people and the population.

Conflicts of interest. The authors declare no conflict of interest.

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