

## Functional state of the cardiovascular system in female students with different academic performance grades

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### Abstract

The work is devoted to the study of the functional state of the cardiovascular system in female students with different academic success.

From the results of our research, we can conclude that the average level of the maximum blood pressure and heart rate in female students with an improvement in academic performance significantly increase, and the minimum level thereof remains unchanged. Also, an increase in the average score in the record book is accompanied by a significant increase in PD, SBV, MBV and BCE, a decrease in TPR, while the values of MAP and CV do not change significantly.

### Keywords

Student, Academic performance, Heart rate, Arterial pressure, Minute blood volume

### Imprint

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### Introduction

The health status of pupils and students determines their quality of life. Caring for the health of students should be among the main tasks of universities, in addition to education and training of highly qualified specialists.

In recent years, an increase in the number of students with various health disorders has been revealed (from 10 to 40%) [1]. Diseases like disorders of the

nervous, cardiovascular and musculoskeletal systems in young people are found more often [2]. The education process at a university is aimed at the acquisition of new knowledge. This is realized through the formation of students' abilities and skills. Knowledge, skills and abilities are the key to success of a specialist in his/her occupational activity.

On the other hand, the level of acquired knowledge and skills in accordance with the approved standard is a reflection of the progress by a university student.

The main task facing the university today is to improve the quality of the educational services. Academic success is the main problem of our time, since a gifted student as a whole person whose goal is to maximize his/her capabilities came to the fore.

Achieving this goal is possible taking into account the individual characteristics of every student only. One of the options for mental work is educational activity, which is characterized by a large amount of information that needs to be processed, stored and used in practice.

A high level of information loading for a long time negatively affects not only the level of functional reserves of the body, but also the general state of health in a student [3]. The effectiveness of mental activity, as well as academic success depends on the conditions of study. They also affect the state of the functional systems of the body. A student's work at a modern higher educational institution should be organized in such a way as to pay special attention to those means and methods that will contribute to the growth of the mental performance and improve health.

Mental activity will be successful with a good memory and high attention.

The main factor that determines the quality of this activity is the state of the body's systems. According to the research results [4, 5], there is a direct relationship between the student's progress and the state of the physiological systems of the body.

According to [6], the level of stress is a factor, which affects memory, concentration and attention that makes a negative effect on the academic performance and the psychological stability.

Bad habits like alcohol consumption reduce the ability to memorize materials, and in addition thereto they cause anxiety [7].

According to [8], 84% of the American students do not smoke cigarettes and have seven hours of sleep per day.

According to O.A. Karabinskaya et al. [9], among the factors negatively affecting students, the most pronounced are the lengthening of their school day, decreased physical activity, improper diet and the presence of bad habits.

A study of the health status in students at the University of Portugal has found that it depends on their lifestyle [10].

An analysis of the research data shows the need to strengthen the work to improve the health in student youth [11].

According to numerous authors, the majority of university students have insufficient functional capabilities of the cardiovascular and respiratory systems, which indicates the requirement for measures aimed at reducing stress, normalizing the functional state of the body systems and increasing adaptive capabilities [12].

Today, mortality and disability in economically prosperous countries are mainly due to diseases of the cardiovascular system. There is an expansion and deepening of diseases of the cardiovascular system. The CVD occurrence is reported to affect both the young and the active.

Therefore, it is precisely the state of this system that determines both the future and health. Every year, 484 per 100 thousand people in Russia die from myocardial infarction and 355 from strokes.

The level of mental activity is determined by the functional state of the systems that provide the body with oxygen. They are the cardiovascular and respiratory systems.

## Materials and methods

To study the functional state of the cardiovascular system in students with different academic performance at the university, we conducted research in the laboratory of human physiology of the Department of Physiology and Anatomy of Humans and Animals at the Chechen State University.

The studies were conducted in 34 clinically healthy full-time female students aged 18-21 years. The tested subjects were divided into 3 groups, from 7 to 16 girls each. The female students were selected into groups, taking into account the average score in their record books. The reference group consisted of female students with the C grade.

The assessment of the functional state of the cardiovascular system was carried out using the following in-

dicators: heart rate in beats per minute; systolic and diastolic blood pressure in mm Hg; calculated indicators.

Blood pressure and pulse rate meter - digital automatic tonometer OMRON M3 Expert was used to determine the blood pressure and heart rate in female students.

Circulatory functions were assessed using the following calculated indicators:

1. Pulse pressure (PD), mm Hg.:  $PD = BP_s - BP_d$ , where BP is systolic blood pressure, mm Hg; BP<sub>d</sub> - diastolic blood pressure, mm Hg;

2. Mean dynamic arterial pressure (MAP):

$MAP = 0.42 BP_s + 0.58 BP_d$ ;

3. Systolic blood volume (SBV), ml, determined by the Starr formula:

$SBV = [(101 + 0.5 \times AP) - (0.6 \times BP_d)] - 0.6 \times A$ , where A is the subject's age, years, normal SBV = 60–80 ml.

4. Minute blood volume (MBV), l / min, calculated by multiplying the value of SBV by heart rate per minute:

$MBV = SBV \times \text{heart rate}$ ;

5. Total peripheral vascular resistance (TPR),  $\text{dyn} \cdot \text{s} \cdot \text{cm}^{-5}$ :  $TPR = (AD_d + 1/3 PD) \times 1330 \times 60 / MBV$ , where 1330 is a conversion factor;

6. Coefficient of efficiency of blood circulation (BCE). Determined by the formula:  $BCE = (SD - DD) \times \text{heart rate}$ ;

7. The coefficient of endurance (CE), which serves to assess the fitness of the cardiovascular system, is calculated by the formula:  $CE = \text{heart rate} \times 10 : PD$ .

The results of the studies were statistically processed using the Biostatistics software.

## Results and discussion

The indicators of the cardiovascular system in girls with different average grade book scores are presented in Table 1 and Figure 1 herein. It follows from them that the average level of maximum blood pressure in the group of female students, who have the highest score, and the heart rate values in the Grade A and B students are above the respective physiological norm. The values of these indicators significantly increase with the growth of their academic performance. So, systolic blood pressure increased in female students with A grade and B grade by 10.1 (P <0.01) and 11.4 mm Hg (P <0.02), respectively, and the heart rate increased by 5.6 (P <0.05) and 9.8 (P <0.02) beats per minute, respectively, as against the C grade students. Our data are also confirmed by other authors.

According to R.A. Kalyuzhnaya [13], mental work promotes an increase in heart rate, and overloads cause

Table 1.  
Dynamics of blood pressure and heart rate in female students with different learning success

Groups by the average grade in the record book	Indicators		
	Systolic pressure, mm Hg	Diastolic pressure, mm Hg	Heart rate, beats per minute
	M ± m		
C	109,7±2,44	69,9±1,79	78,9±2,59
B	119,8±1,44***	70,0±1,03	84,5±1,59*
A	121,1±2,10**	69,7±2,18	88,7±2,31**

Note: \* - P <0,05; \*\* - P <0,02; \*\*\* - P <0,01

disturbances in the cardiac activity that negatively affects the health in students. According to the results of his research, A.A. Guminsky [14] suggests that the peculiarities of an examination session are an increase in nervous tension, a rise in the production of adrenaline, an increase in the heart rate and arterial blood pressure.

Prokopiev N. Ya. et al. [15] have established that the learning process is accompanied by an increase in heart rate. Heart rate grows with increasing levels of exposure to stress [16].

Obviously, an increase in the heart rate and blood pressure in the female students of the university with an improvement in their academic performance is due to a decline in physical activity caused by mental load expanding. Other authors have come to similar statements in their studies.

Students with high arterial blood pressure, according to E.Yu. Grinene [17], have rapid fatigue and suffer from headaches, which should affect both their general and academic performance.

According to some researchers, high mental stress produce loading on the cardiovascular system.

The level of diastolic blood pressure does not change among the groups. Changes in the indicators of the functional state of the cardiovascular system in female students with different academic performance are given in Table 2 and Figure 2 herein. The level of the average pulse pressure indicators for the group of students with the maximum score in the record book is higher than the established norm.

The PP value is 10 mm Hg (P <0.01) higher in the B grade girls and 11.6 (P <0.01) greater in the A grade female students as against those showing satisfactory performance results (grade C). The average dynamic pressure values are subject to an insignificant increase. Thus, its increase in female students with maximum academic success is recorded to be 4.7 mm Hg than in those with the minimal success. This value is outside the normal range.

Systolic output of the heart in all groups of the girls is normal. SBV for the groups of the B and A grade female students are 4.8 ml and 5.9 (P <0.05) higher. Minute blood volume for the group of the students with the C grade is below the norm, for the rest it is within the norm.

The average value of the MBV in the female students with the B grade is 0.9 liters higher (P <0.01), and for the students with the A grade it is 1.3 greater (P <0.001) than for the C grade female students.

Apparently, the high level of the indicators of the functional state of the cardiovascular system in the female students with high academic success is associated with an increase in system tension and a higher production of adrenaline due to an enhancement in mental and emotional load and a decrease in their motor activity. High mental and emotional stress and a low level of muscle work lead to tension in the cardiovascular system and stimulate the production of adrenaline by the adrenal glands [14, 18].

The level of general peripheral vascular resistance in the groups of the female students with good (B) and excellent (A) academic performance is below the physiological norm. It significantly decreases with an increase in the average grade in the record book.

Obviously, this is due to a change in the viscosity and blood clotting induced by an elevation in the tension of the cardiovascular system. In the students with the B grade, its value is 157 dyne s cm<sup>-5</sup> (P > 0.02) lower, and in the A grade students it decreases by 225 dyn s cm<sup>-5</sup> (P > 0.02) as against the C grade female students.

Let us discuss the values of the coefficients of the efficiency of blood circulation for all experimental groups. The value of BCE in the female students with the B grades increases by 1157 (P <0.001) and in the students with the A grade by 1516 (P <0.001), respectively, as against the C grade students (3054).

Obviously, this is due to the increase in stress and fatigue in the female students in the process of study.

Table 2. Dynamics of indicators of the functional state of the cardiovascular system in female students with different academic performance grades

Indicators	Grade Book Average		
	C	B	A
Pulse pressure (PP) in mmHg	39,8±2,37	49,8±1,31***	51,4±1,60***
Average dynamic pressure (MAP) in mm Hg	86,6±1,73	90,5±1,18	91,3±2,00
Systolic blood volume (SBV) in ml	67,4±1,79	72,2±1,03*	73,3±1,78
Minute blood volume (MBV) in l	5,2±0,18	6,1±0,12***	6,5±0,20****
Total peripheral vascular resistance (TPR) in dyn s cm-5	1295±50,9	1138±23,8°°	1070±40,9°°
Circulatory efficiency ratio (CER)	3054±182,3	4211±139,5****	4570±215,6****
Endurance Coefficient (CE)	20,2±1,50	17,2±0,59	17,3±0,63

Note: \* - P <0,05; °° - P > 0,02; \*\*\* - P <0,01; \*\*\*\* - P <0,001

The growth of nervous tension in the process of studying at the university has a negative consequence for the functional state and the mental performance in the student [19].

As reported by N.A. Aghajanyan and T.Sh. Minibayev [20], the school day ends in 82% of the students with signs of fatigue. According to E.Yu. Grinene [17], students with high arterial blood pressure show rapid fatigue and have headaches, which make an unfavorable effect on their general academic performance.

The average CE level exceeds also the norm for the groups of the examined girls.

Apparently, this may be attributed to the low level of conditioning of the cardiovascular system. The number of students performing physical activity is extremely small, and only a few of them are engaged in sports sections [18].

The CV value slightly declines with the improvement of the academic performance; this decrease in the girls with an average grade book score of B and A is 3.0 and 2.9, respectively, as compared with the C grade female students.

A.A. Artemenko [18] studied the physical conditioning and working capacity in students and arrived at a conclusion on their low physical activity.

Based on the results of his research, V.V. Gorinevsky [21] argues that physical inactivity is one of the main factors that worsen health, reduce the mental performance and inhibit the development. Shtrikh E.A. [22] reports that students demonstrate their insufficient health and physical conditioning. The peculiarity of the lifestyle of a modern student is the constant growth of mental and emotional stress, which results in the limitation of muscle work.

The main cause of a decrease in the student's physical activity is an increase in his/her mental loading. Therefore, taking into account natural motor activity, when developing modes and creating the conditions required for learning, has become one of the important problems in pedagogy, since both the working capacity and the physical health of the student depend on the solution of the latter.

## Conclusions

The average level of pulse pressure, significantly increasing with the improvement of the academic performance, reaches its maximum of 51.4 mm Hg in the group of the A grade female students and demonstrates the rate of 39.8 in the C grade female students.

The systolic blood volume is significantly higher (4.8 ml) in girls with the B grade than it is the case with the C grade female students.

The growth in the academic performance of the female students is accompanied by a significant increase in the minute blood volume values. So, its level increases for those with the A grade by 0.9 liters and for the B grade girls by 1.3 liters, as against the C grade female students.

The values of the mean peripheral blood pressure significantly decrease with the growth of the average score in the record book. Its greatest decrease occurred in girls with the maximum academic performance: it was reported to be 225 dyn s cm<sup>-5</sup>.

The coefficient of efficiency of blood circulation significantly increases with success in studies. It increased by 1516 maximum for excellent students in comparison with 3054 in the female students with the C grade.

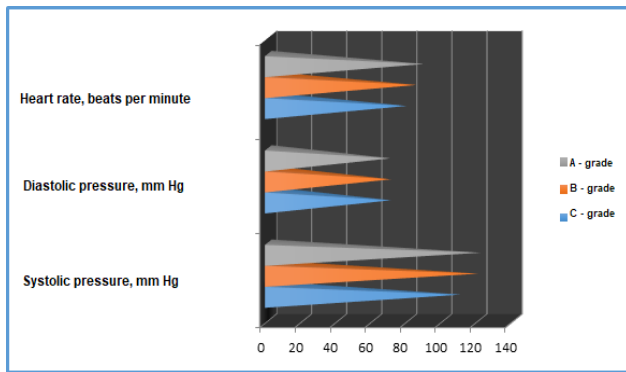


Figure 1. Changes in blood pressure and heart rate in female students with different academic performance grades

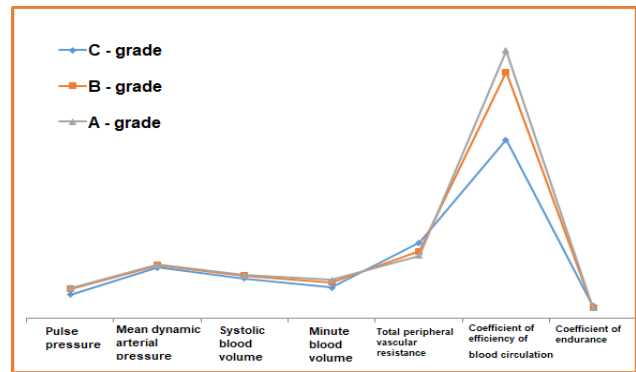


Figure 2. The average values of the functional indicators of the cardiovascular system in female students

## Statement on ethical issues

Research involving people and/or animals is in full compliance with current national and international ethical standards.

## Conflict of interest

None declared.

## Author contributions

The authors read the ICMJE criteria for authorship and approved the final manuscript.

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