

ASSESSMENT OF THE FUNCTIONAL STATE OF THE CARDIOVASCULAR SYSTEM OF STUDENTS

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Summary

Student youth are constantly in various stressful circumstances associated with social, economic, and psychological changes. These factors, as well as an unbalanced diet, lack of sleep, negatively affect the physical, mental and social health of students, and create prerequisites for reducing the adaptive capacity of the body. Studying the adaptation capabilities of students in conditions of intensive study load will make it possible to analyze their adaptation potential and level of health in order to introduce health-improving, preventive and medical measures if necessary.

As a marker for evaluating the work of the human cardiovascular system, we used such indicators as heart rate, adaptation potential, endurance coefficient, Ruffier index. We evaluated the functioning of the circulatory system in students of the Faculty of Biology by determining the adaptation potential according to Baevsky, the coefficient of endurance according to the Kvass formula and the Ruffier index. Having assessed the level of functioning of the circulatory system in students of the II year according to the indicator of adaptation potential, we found that the majority of students have a satisfactory level of adaptation. In 30% of male students and 35% of female students, a poor and unsatisfactory evaluation of the reaction according to the Ruffier index and weakening of the cardiovascular system was found in 40% of male students and 71% of female students, according to the endurance coefficient. This is probably explained by a decrease in the reserve capabilities of the cardiovascular system due to the low physical fitness of the students.

Key words: Ruffier index, adaptation potential, endurance coefficient, heart rate.

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1. Introduction

The problem of preserving and strengthening the health of the population, especially young people, remains the most urgent for the state. Throughout his life, a modern person is constantly in various stressful circumstances that are associated with social, economic, and psychological changes (Korovina, Zaporozhets, Kozakevych, 2019). The most vulnerable are student youth, since the rhythm of their life is hypodynamic with simultaneous significant intellectual and emotional loads. All these factors, as well as unbalanced nutrition, lack of sleep, negatively affect the physical, mental and social health of students, create prerequisites for reducing the body's adaptive capacity (Chychkan, Shutka, Pazychuk, 2012).

It is known that the adaptive processes in the human body are associated with various functional systems, most of all with the cardiovascular system, therefore they serve as markers of physical health (*Arabadzhy, 2012*).

Overstrain of regulation systems can lead to failure of adaptation with inadequate functioning of the heart and blood vessels, violation of homeostasis, appearance of various pathological syndromes and diseases.

In order to preserve and strengthen the health of student youth, it is necessary to conduct a comprehensive examination – to assess the level of functioning of body systems (primarily cardiovascular) and the level of functional reserve. This will help to improve the existing and search for new methods of optimizing the functional state, health preservation and future professional longevity of student youth (*Ukrai'nec', Romanjuk, 2014, Tarnovska, Heneha, et al, 2023*).

Studying the adaptation capabilities of students in the conditions of an intensive academic load will make it possible to analyze their adaptation potential and level of health in order to introduce health-improving, preventive and medical measures if necessary (*Goncharenko, Chykalo, 2011, Glazkov, 2013*).

As a marker for assessing the work of the human cardiovascular system, such indicators as heart rate (HR), adaptation potential, endurance coefficient, Ruffier index, etc. are used.

Assessment of the functional state of the cardiovascular system of the body is of primary importance in connection with the huge role of this system in adaptation to physical loads of various nature. It is well known that the normal functioning of the circulatory system determines the operation of a number of other physiological systems, ensures the effective use of the body's energy potential, contributes to its speedy recovery and a kind of exit to a qualitatively new level of functional state (*Harchenko, 2016, Lazorenko, 2023*).

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In order to preserve and strengthen the health of student youth, it is necessary to carry out a comprehensive examination – to assess the level of functioning of body systems (primarily cardiovascular) and the level of functional reserve. This will help to improve the existing and search for new methods of optimizing the functional state, health preservation and future professional longevity of medical students (*Lys, 2016*).

Studying the adaptation capabilities of students in conditions of intensive study load will make it possible to analyze their adaptation potential and level of health in order to introduce health-improving, preventive and medical measures if necessary (*Mamotenko, Kovalenko, 2017*).

The purpose of the work was to assess the level of functioning of the circulatory system in student youth.

To achieve the goal, we set ourselves the task of evaluating the functioning of the circulatory system in students of the Faculty of Biology by determining the adaptation potential according to Bayevski, the endurance coefficient according to the Kvass formula, and the Ruffier index.

2. Research materials and methods

Our research continued during 2022-2023 at the Department of Biophysics and Bioinformatics, Faculty of Biology, Ivan Franko National University of Lviv. Among the respondents were 2nd-year students, a total of 59 female and male students (49 girls and 10 boys) took part. The respondents had no complaints about their own health, all respondents gave their consent to the processing and use of personal data. The average age of the subjects was 18–19 years.

A survey was conducted among the interviewees. The purpose of the survey was to record anthropometric indicators and find out the peculiarities of the students' lifestyle. In particular, during the experiment, such anthropometric characteristics as height and weight were measured, as well as specific characteristics of the lifestyle that affect the cardiovascular system of a person.

The adaptation potential of the cardiovascular system of the body was determined according to the method of R.M. Bayevski, taking into account heart rate, systolic and diastolic blood pressure, anthropometric indicators and coefficients of the multiple regression equation.

$$AP = 0,011 \times HR + 0,014 \times SBP + 0,008 \times DBP + 0,014 \times BM - 0,009 \times H - 0,27$$

where HR – heart rate, bpm, SBP – systolic blood pressure, mm Hg, DBP – diastolic blood pressure, mm Hg, BM – body mass, kg, H – height, cm.

The Kvass formula was used to calculate the endurance coefficient (CE) of the cardiovascular system: $CE = HR \times 10 / AT_{\max} - AT_{\min}$.

where HR – heart rate, bpm, SBP_{\max} – systolic blood pressure, DBP_{\min} – diastolic blood pressure,

Normally, CE is 16. Its increase indicates that the cardiovascular system is in a state of lower activity, and its decrease indicates increased activity. Its increase is a sign of weakening of the cardiovascular system. The Ruffier index considers the peculiarities of the reaction of the cardiovascular system to physical exertion based on changes in the heart rate at the end of the exercise and sometime after it. The Ruffier index is calculated according to the formula:

$$RI = (4(HR1+HR2+HR3) - 200) / 10,$$

where RI – Ruffier Index, HR1 is the average resting heart rate, HR2 is the maximum heart rate recorded during the first 15 seconds of recovery, and HR3 is the 15 second average after the 1st minute of recovery. Lower scores indicate better exercise tolerance.

All experiments were performed at least three times. Statistical processing of research results was carried out using a personal computer with the help of the analysis package program. Calculating the main statistical indicators from direct quantitative data obtained as a result of research (arithmetic mean – M; standard error of the mean – m).

For the analysis of the material obtained after the tests, the method of comparing the percentages that corresponded to the values of the "norm" was applied. In the samples, where an assessment on a five-point scale is offered, conditionally, in each group, a percentage indicator was determined, which consisted of the sum of indicators with ratings of "4" and "5" and assigned them to the "norm" group, which later took part in the comparison with the results of other tests.

3. Results and discussion

Evaluation of the functional state of the organism of biology students according to the adaptation potential.

Adaptation potential reflects the functional state of the organism, characterizes functional reserves and allows predicting changes in health. We measured heart rate, systolic and diastolic blood pressure, as well as anthropometric parameters in 59 students (49 girls and 10 boys). Adaptation potential was calculated according to Bayevski formula.

According to the results of adaptation potential, male students ($n = 10$) were divided into two categories: students with satisfactory adaptation (2.05 ± 0.06 ; $n = 4$) and students with a strained adaptation mechanism (2.46 ± 0.13 ; $n = 6$). Female students ($n = 49$) were divided into three categories based on the result of adaptation potential: students with satisfactory adaptation (1.79 ± 0.06 ; $n = 31$), students with a strained adaptation mechanism (2.43 ± 0.05 ; $n = 16$) and students with unsatisfactory adaptation (3.68 ± 0.02 ; $n = 2$) (Table 1, Fig. 1).

This study showed us the degree of human adaptation to living conditions that are constantly changing under the influence of environmental, social and economic factors.

Table 1

General assessment of adaptation capabilities and health level of male and female students

Gender (n = 59)	Satisfactory adaptation	Tension of adaptation mechanisms	Unsatisfactory adaptation	Failure of adaptation
Male (n=10)	2.05 ± 0,06 40% n = 4	2.46 ± 0,13 60% n = 6	0	0
Female (n=49)	1.79 ± 0,06 63% n = 31	2.43 ± 0,05 33% n = 16	3.68 ± 0,02 4% n = 2	0

The analysis of the results showed that the percentage ratio among male students is dominated by the group with satisfactory adaptation, which is 60% (I health group) of the total number of male respondents against 40% (II health group) of students with a strained adaptation mechanism. Analyzing the results of adaptation potential among female students, it should be noted that the group with satisfactory adaptation prevails here, which is 63% (I health group) of the total number of female respondents against 33% (II health group) of students with strained adaptation mechanism and 4% (III health group) of students with unsatisfactory adaptation (Table 1, Fig. 1).

The reason for the lower level of adaptation in male students compared to female students may be related with greater sensitivity of women to social factors and stress, as well as a greater tendency to bad habits of male students, hormonal differences (estrogen and prostacyclin concentrations).

Evaluation of the physical state of the heart in biology students by endurance coefficient

The next stage of our research was to assess the physical condition of the heart in students of the Faculty of Biology. To calculate the endurance coefficient of the cardiovascular system, we used the Kvass formula. The coefficient characterizes the functional state of the cardiovascular system and is an integral value that combines heart rate with pulse pressure. Normally, the ratio is 16%. Its increase indicates that the cardiovascular system is in a state of

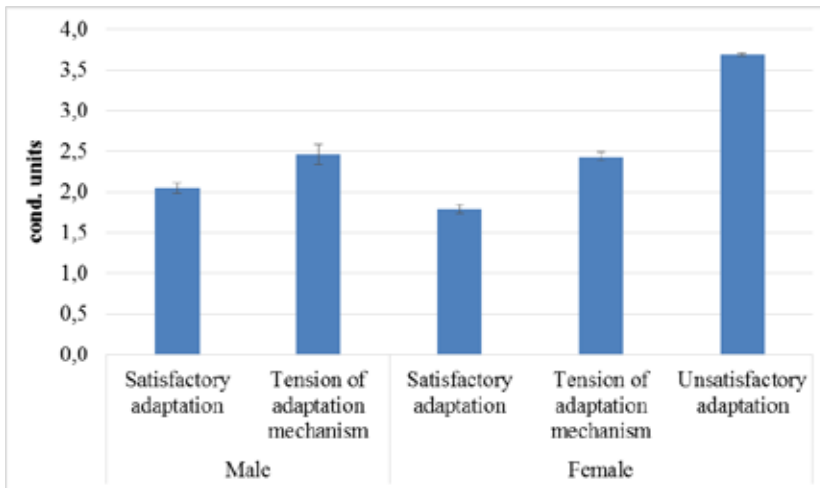


Fig. 1. General assessment of adaptive capabilities and health level of students of the Faculty of Biology

weakness activity, and its decrease, on the contrary, is increased. Its increase is a sign of weakness of the cardiovascular system.

Table 2

General assessment of the coefficient of endurance in male and female students

Gender	Normal cardiovascular activity	Weakness of cardiovascular activity
Male (n = 10)	13.83 ± 0.87 60% n = 6	22.00 ± 2.27 40% n = 4
Female (n = 49)	13.67 ± 0.63 29% n = 14	24.19 ± 1.59 71% n = 35

Analyzing the results of physical endurance studies, it was possible to observe that out of 59 students, 14 girls (13.67 ± 0.63) and 6 boys (13.83 ± 0.87) had an endurance coefficient within the normal range, and 35 girls (24.19 ± 1.59) and 4 boys (22.00 ± 2.27) showed weakening of the activity of the cardiovascular system (Table 2, Fig. 2). Thus, it should be noted that weakening of the cardiovascular system was found in 40% of male students and 71% of female students (Table 2).

Evaluation of the reaction of the cardiovascular system of biology students to physical activity according to the Ruffier index.

The next stage of our research was to analyze the reaction of the students' cardiovascular system to physical exertion. For this analysis, we used the Ruffier index, which takes into account the features of the cardiovascular system's response to physical exertion based on changes in heart rate at the end of the exercise and some time after it. According to the results of the sample of male and female students, they were divided into four groups (Table 3, Fig. 3): 1) good evaluation of the reaction (men 0.90 points, n = 1; women 2.97 ± 0.39 points, n = 7), 2) average evaluation of the reaction (men 8.00 ± 0.33 points, n = 6; women 7.43 ± 0.28 points,

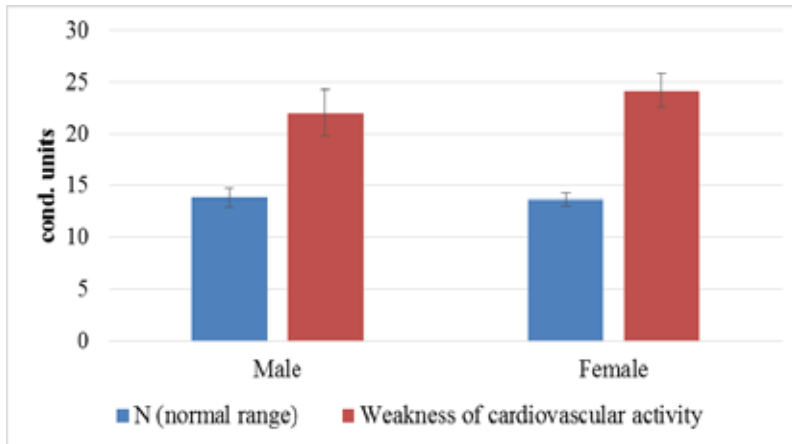


Fig. 2. General assessment of the endurance coefficient of students of the Faculty of Biology

n = 25), 3) poor evaluation of the reaction (men 11.55 ± 0.95 points, n = 2; women 12.55 ± 0.32 points, n = 14), 4) very poor evaluation of the reaction (men 15.30 points, n = 1; women 16.93 ± 1.11 points, n = 3). This study makes it possible to evaluate the reserve capabilities of the cardiovascular system.

Table 3

General assessment of the Ruffier index in male and female students

Gender	Excellent	Good	Average	Poor	Very poor
Boys (n = 10)	0	0.90 10% n = 1	8.00 ± 0.33 60% n = 6	11.55 ± 0.95 20% n = 2	15.30 10% n = 1
Girls (n = 49)	0	2.97 ± 0.39 14% n = 7	7.43 ± 0.28 51% n = 25	12.55 ± 0.32 29% n = 14	16.93 ± 1.11 6% n = 3

The results showed (Table 3, Fig. 3) that among the students who took part in the study, there are 10% and 7% of male and female students, respectively, with a good reaction rating, 60% and 51% of male and female students, respectively, with an average evaluation of the reaction, 20% and 29% of male and female students, respectively, with a poor evaluation of the reaction and 10% and 6% of male and female students, respectively, with a very poor evaluation of the reaction according to the Ruffier index. Therefore, it should be noted that 30% and 35% of male and female students had a poor and very poor response rating according to the Ruffier index. This is probably explained by a decrease in the reserve capabilities of the cardiovascular system due to the low physical fitness of the students. The body needs more blood to support its vital activities. The cardiovascular system is the main system that ensures adaptation and limits mental and physical performance. Such results indicate low reserves of the cardiovascular system, which is characteristic of insufficiently trained individuals.

The influence of an active factor of significant strength and duration (for example, nervous tension, chronic lack of sleep, physical exertion, etc.) is accompanied by a pronounced stress on the regulatory systems, which ensures the mobilization of functional reserves

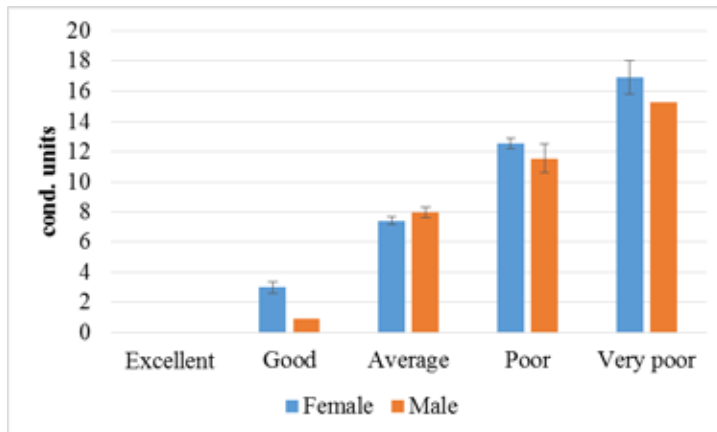


Fig. 3. Evaluation of the reserve capabilities of the cardiovascular system of students of the Faculty of Biology using the Ruffier Index

of the cardiovascular system and the activation of protective devices. This leads to the necessary adaptive effect. Overstrain of the regulatory systems causes a disruption of adaptation, during which there are inadequate changes in the functioning of the heart and blood vessels, a violation of homeostasis with the appearance of various symptoms of diseases. An organism with a high functional reserve of the cardiovascular system ensures high adaptation to the environment. This reserve is a biological indicator of the adaptation reserves of the entire organism.

4. Conclusions

Thus, the assessment of physiological reserves makes it possible to reveal the etiology and process of changes in the functional state and physical capacity, to predict negative changes in health and performance. The decrease in the functional reserves of a person and the team indicate the need to carry out various medical and preventive measures, including the optimization of the environment.

1. We assessed the level of functioning of the circulatory system in students of the II year according to the indicator of adaptation potential according to the formula of P.M. Bayevski. The majority of students have a satisfactory level of adaptation

2. The ratio of levels of satisfactory adaptation and tension of adaptation mechanisms among boys and girls is different. Among girls, there was a greater number of persons with satisfactory adaptation than among boys. Perhaps it could be explained by hormonal differences, fewer people with bad habits and greater resistance to stress among girls.

3. General health measures can be recommended to students who belong to the 1st health group: increasing physical activity, carrying out hardening procedures, normalizing the regime of nutrition, work and rest, walking and cycling, swimming, as well as giving up bad habits. Individuals belonging to the II group need not only health care, but also preventive measures aimed at preventing the development of various diseases individually in each individual case. Taking into account that the students belong to the category of people with intense mental work,

it was explained to them that, in addition to medical and biological methods, psychological recovery methods should be used, for example, autogenic training. Persons belonging to the III group need preventive and medicinal measures.

4. In 30% of male students and 35% of female students, a poor and unsatisfactory evaluation of the reaction according to the Ruffier index and weakening of the cardiovascular system was found in 40% of male students and 71% of female students, according to the endurance coefficient. This is probably explained by a decrease in the reserve capabilities of the cardiovascular system due to the low physical fitness of the students.

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