

Changes in the morphological and functional indicators of students in response to dosed physical activity

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Abstract

Purpose: to determine the features of changes in the morphological and functional indicators of students in response to a dosed physical load.

Material & Methods: practically healthy students of 18±0.7 years of I-II courses of study (n=40) who did not regularly go in for sports in the past and present took part in the study. They were divided into test groups according to the following principle: group 1 (n=20) included students involved in playing sports (sports games and their elements); group 2 (n=20) included students involved in acyclic/cyclic types of physical culture and sports activities (types of athletics). Research methods: theoretical methods of pedagogical research; testing; hardware methods; mathematical and statistical.

Results: the features of adaptation of the functional systems of the body of students to regular physical culture and sports classes by different types of motor activity of a predominant orientation were determined: gaming (sports games and their elements, mini-sports games); cyclic (types of athletics). It was revealed that as a result of regular classes according to training programs, both in terms of types of physical culture and sports, predominantly cyclic / acyclic (types of athletics), and game types (sports games and their elements), there is an improvement in the level of working capacity and endurance of students already in a two-month period. The reactions of the students' organism in response to the dosed physical activity of the Martin-Kushlevsky test at the end of the study allow us to assert an increase in the level of functioning and reserves of the cardiovascular system of the subjects as characteristics of the adaptation of the morphological and functional structures of the body to programmed regular physical exercises. However, when comparing the indicators of the studied groups, no significant differences were found. Consequently, the influence of predominantly different types of training loads is similar. This helps to deepen the understanding of the influence of academic physical education classes on the body of students. Consequently, the main determinant of increasing the level of adaptation to physical activity among students is the regularity of classes, while observing the pedagogical and specific sports principles of their construction. At the same time, the main goal of such classes should be to increase the level of general endurance as a characteristic of the level of physical health.

Conclusions: morphological and functional changes in the body of students in the amount provided for by the program of physical education of higher education do not depend on the predominant nature of motor activity. As a result of the two-month training program, an improvement in the functional state of the students' body was revealed. However, this does not apply to the integral indicators of the functioning of the cardiovascular system. To improve the morphological and functional indicators of students, it is necessary to increase the time of regular physical education classes, regardless of the nature of motor activity.

Анотація

Андрій Єфременко, Світлана П'ятисоцька, Кшиштоф Прусік, Віктор Павленко, Владислав Рожков. Зміни морфофункціональних показників здобувачів освіти у відповідь на дозоване фізичне навантаження. Мета: визначити особливості змін морфофункціональних показників здобувачів освіти у відповідь на дозоване фізичне навантаження. Матеріал і методи: у дослідженні брали участь практично здорові здобувачі вищої освіти 18±0,7 років I-II курсів навчання (n=40), які не займалися регулярно спортом у минулому та

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теперішньому часі. Вони були розділені на тестові групи за принципом: до групи 1 (n=20), увійшли здобувачі освіти, які займалися ігровими видами спорту (спортивні ігри та їх елементи); до групи 2 (n=20), увійшли здобувачі освіти, які займалися ациклічними/циклічними видами (види легкої атлетики) фізкультурно-спортивної діяльності. **Методи дослідження:** теоретичні методи педагогічного дослідження; тестування; апаратні методи; математико-статистичні. **Результати:** визначено особливості пристосування функціональних систем організму здобувачів освіти до регулярних фізкультурно-спортивних занять різними видами рухової активності переважної спрямованості: ігрової (спортивні ігри та їх елементи, міні-спортивні ігри); циклічної (види легкої атлетики). Виявлено, що в результаті регулярних занять за програмами тренувань як з видів фізкультурно-спортивної переважно циклічно/ациклічного характеру (види легкої атлетики), так і ігрових видів (спортивні ігри та їх елементи) спостерігається покращення рівня працездатності та витривалості здобувачів освіти вже у двомісячний термін. Реакції організму здобувачів освіти у відповідь на дозоване фізичне навантаження проби Мартіне-Кушелєвського наприкінці дослідження дозволяють стверджувати про підвищення рівня функціонування та резервів серцево-судинної системи випробуваних як характеристики адаптації морфофункціональних структур організму до програмованих регулярних занять фізичними вправами. Проте, при порівнянні показників досліджуваних груп не виявлено значних відмінностей. Відтак, вплив переважно різних за характером видів тренувальних навантажень схожим. Це сприяє поглибленню розуміння відносно впливу академічних занять з фізичного виховання на організм здобувачів вищої освіти. Відтак, головним детермінантом підвищення рівня адаптації до фізичних навантажень у здобувачів освіти є регулярність занять, за умов дотримання педагогічних та специфічних спортивних принципів їх побудови. При цьому, головною метою таких занять має бути підвищення рівня загальної витривалості як характеристики рівня фізичного здоров'я. **Висновки:** морфофункціональні зміни організму здобувачів освіти в обсязі, передбаченому програмою з фізичного виховання закладу вищої освіти, не залежать від переважного характеру рухової діяльності. В результаті двомісячної програми занять виявлено покращення функціонального стану організму здобувачів освіти. Однак, це не стосується інтегральних показників функціонування-серцево-судинної системи. Для покращення морфофункціональних показників здобувачів освіти необхідно збільшити час регулярних аудиторних занять з фізичного виховання, незалежно від характеру рухової діяльності.

Introduction

Emotional imbalance, the negative impact of urbanization and environmental instability, the aggressively growing informatization of social processes, contribute to the deformation of the students' health. This leads to a decrease in the reserve capacity of the functional systems of the body of young people. The risk of new diseases and the exacerbation of existing diseases increases. A characteristic feature of student youth is the presence of significant life potential. However, it is students who are a kind of «target» of the branched structure of the negative factors of modern society. This is due to the formation of a worldview against the backdrop of the temptations of a student lifestyle, as well as social pressure in

the environment (Griban et al., 2020; Gorna et al., 2020).

A characteristic feature of modern educational institutions is the ever-increasing hypokinesia. Its result is a decrease in the physical and mental performance of students. This leads to a decrease in the ability of the body's functional systems to withstand significant amounts of training loads and excessive social activity (Burner et al., 2019). From a pedagogical point of view, there is a decrease in the level of manifestation of physical abilities, from a biological point of view – a decrease in energy potential, from a psychological point of view – psycho-emotional overstrain (Komarov et al., 2019).

An important task of the process of physical education in higher educational institutions is the development of modern programs of physical rights of a health-improving nature. Such programs should be based on the dosed use of physical activity. This is achieved by performing various movements in modes and volumes that exceed the minimum recommended values. It is necessary to form programs of rational motor activity. Use physical exercise not as a way of active recreation. It is necessary to create a set of effective measures to improve health, increase the functional and adaptive capabilities of students' bodies (Kondakov et al., 2018; Wrench, 2019).

Recently, there has been a continued interest in the formation of a modern structure of the health-improving educational environment of higher education. Its basis is a rational motor mode in academic classes in physical education. It is the key to high student performance (Gonzalez-Valero et al., 2019). However, there is a trend towards a decrease in the level of students' health. This is due to a decrease in the level of physical activity (Doroshenko et al., 2021). Currently, the attention of researchers is riveted to identifying the level of physical fitness and the state of health of students (Petruk & Grygus, 2019). The rest of the researchers focused on studying interests in the formation of physical activity of the physical culture and sports type (Thorburn et al., 2019). A number of works actualizes the issue of the influence of certain types of physical activity on the functional state and physical fitness of students (Kuna et al., 2018; Wang et al., 2019; Golovin et al., 2020; Gurner & Reineke, 2020). However, the attention of researchers is focused on ascertaining the fact of the deterioration in the health of young people (Guijarro-Romero et al., 2020) and its correction with dosed physical activity (Zavalishina et al., 2021). Such studies form an idea of the state of physical culture of students. This creates conditions for the formation of effective academic programs of health-improving physical exercises.

The question of the influence of certain types of motor activity on the morphological and functional adaptations of the student's body systems remains uncertain. The solution of this issue will improve the morphological and functional indicators of the students' organism. Therefore, the *hypothesis* of the study is: revealing the peculiarities of the reaction of the students' organism to the occupation by the types of motor activity of the overwhelming direction.

The purpose of the study is to determine the features of changes in the morphological and functional indicators of students in response to dosed physical activity.

Material and Methods of the research

Participants. The study involved students 18±0,7 years of I-II courses. Requirements for the subjects: no malformations; are included in the main group in physical education classes; male gender; are not related to regular sports in the past and

present. Those who met the specified conditions were invited to participate in the study. The sample included 40 young men (n=40). The sample was not representative enough, because with a confidence level of 95% of the total number of men enrolled in I-II courses (n=80), its size should be 62 people. However, not all students agreed to participate in the study. This is a limitation of the current work. As an incentive, it was proposed that teachers give additional points when assessing students in the academic discipline "Physical Education". All subjects were informed about the purpose and program of the study and signed an informed consent form to participate in the study. The procedure for conducting the study complied with the provisions of the Declaration of Helsinki.

Methods. To determine the state of development of the problem, theoretical methods of pedagogical research were used. To determine the state of the cardiovascular system, a certified device PAK "Omega-M" (St. Petersburg, RF) was used. The study was conducted by a qualified assistant. He had experience with the instrument for 1.3 years. The indicators were recorded according to the methodological recommendations given in the user manual (Manual, 2019). The parameters were recorded twice: before and after the Martinet-Kushelevsky dosed exercise test. The test was carried out according to the standard procedure (Jaworski, 2021). The state of the respiratory system was determined by measuring the vital capacity of the lungs (VC). The measurement was carried out according to the standard procedure using a portable dry spirometer (M&B, China). Body weight was determined using electronic scales Tefal PP1503V0 (China). Working capacity was determined by the method of bicycle ergometry. The PWC₁₇₀ test was carried out on an Ergoselect 4 bicycle ergometer (Ergoline GmbH, Germany). The test was carried out according to the standard methodology described in the literature (Turner, 2018). To determine the level of general endurance, a 1000-meter run on a standard 400-meter stadium track was used. The time was recorded using a manual electronic stopwatch JUNSD (JS-7061V) (China) with an accuracy of 0,001 s.

Testing/measurement. Indicators of VC, body weight, PWC₁₇₀, 1000 m run were recorded twice: at the beginning and at the end of the study.

Preliminary testing of the level of endurance (100 m run) and working capacity (test PWC₁₇₀) was carried out for two days a week before the start of the study (Monday and Wednesday). Previously, the subjects had two days of rest.

Testing was carried out in the morning hours from 8 to 10. Participants were advised not to eat food and stimulants for 12 hours before testing. On the first (Monday) day, a bicycle ergometer test was performed; after a day of rest (Wednesday), a 1000 m run was held. At the end of 16 lessons, after two days of rest, repeated testing was carried out according to the same scheme. However, on the first (Monday) day, the Martinet-Kushelevsky test was performed with the fixation of indicators using the hardware-software complex Omega-M. It preceded the ergometer testing.

Procedure. The participants were divided into test groups according to the principle: group 1 (n=20) – students involved in team sports (sports games and their elements); group 2 (n=20) – students involved in acyclic / cyclic sports (types of athletics). The division into groups took place in order to determine the benefits of practicing different types of motor activity for the morphological and functional adaptation of the students' organism. In accordance with the requirements of the work program for the academic discipline "Physical Education", programs for physical exercises have been developed (Table 1).

The frequency of classes is 2 times a week (n=16 lessons). The frequency and duration of the programs correspond to the time allotted for the study of the program modules «athletics» and «sports games». During the exercise program, the subjects asked not to engage in additional extracurricular organized physical activity. The duration of the lessons is 120 min. Physical exercises lessons had a traditional structure: preparatory part (20 min), main part (90 min), final part (10 min). The preparatory and final parts were identical in both groups of subjects. The main part had a predominant focus (70% of the total time of the main part of the lesson): game types (group 1), athletics types (group 2). Such a construction of the process of physical education of the subjects was agreed with the educational part of the educational institution. Thanks to this, it was possible to swap the modules of the program in the curriculum. So, in group 1, instead of studying the types of athletics in the first semester, it was planned to study sports games from the second semester.

Statistical analysis. Experimental data were processed by methods of mathematical statistics. Descriptive statistics are calculated, the normality of data distribution is determined according to the Kolmogorov-Smirnov criterion. It was revealed that the experimental indicators differed from the normal distribution. To compare the results of the experiment,

Table 1
Experimental programs for physical exercises

Classes	Sports games (group 1)	*	Types of athletics (group 2)	*
1-4	Learning the elements of basketball	50	Short and medium distance running:	
	2x2 game on one ring	25	Running from the start	35
	Double-sided basketball game	25	Running in a straight line and in a turn	65
5-8	Learning the elements of football	50	Throwing the ball from a running start:	
	Mini football game	25	Simulation exercises	10
	Double sided soccer game	25	Throwing from a place	35
9-12	Learning the elements of volleyball	50	Run-up throw	55
	Playing mini volleyball (pioneer ball)	10	Long jump:	
	Double sided volleyball game	40	Simulation exercises	10
13-16	Learning the elements of handball	50	jumping exercises	55
	Performing game combinations in attack and defense	15	Jumping on a shortened and full run	35
	Double-sided handball game	35	Relay run:	
			Simulation exercises	15
			Passing the baton in pairs	50
			Passing the baton in the team	35

Explanation: * – % of the total time of the lesson

the Mann-Whitney U-test was used. Calculations were made using the computer program IBM SPSS Statistics 20 (USA). The difference between the compared indicators at the level of significance was considered reliable $p < 0,05$.

Results of the research

The results of the study are presented in tables 2 and 3.

Comparing the initial indicators of students in group 1 and group 2, it was found that they did not differ significantly

Table 2
Indicators of hardware-software complex "Omega-M" of students in response to dosed physical activity, $\bar{X} \pm S$

Indicator	Measurement	Group 1 (n=20)	Group 2 (n=20)
A, %	I	63,8±13,3	65,5±14,0
	II	**89,1±9,9	71,6±16,8
B, %	I	78,2±7,9	77,5±7,5
	II	*87,5±6,1	**89,9±11,6
C, %	I	58,3±12,7	57,5±13,0
	II	**79,9±10,5	*69,9±11,6
D, %	I	58,0±7,7	58,9±6,9
	II	**85,6±10,9	*69,9±14,1
Health, %	I	66,3±7,5	68,4±8,1
	II	**91,1±8,9	*80,5±13,6
B ₁ , %	I	77,2±8,4	78,0±7,7
	II	**89,6±6,1	*88,5±15,7
B ₂ , %	I	63,2±11,8	64,1±11,0
	II	**91,6±9,9	**89,4±13,5
HR, beats per min. ⁻¹	I	70,1±10,9	70,3±11,5
	II	72,4±9,7	71,9±8,4
SDNN, ms	I	86,7±20,1	87,3±21,5
	II	88,9±22,5	89,4±20,3

Note: A – level of adaptation; B – vegetative regulation; C – central regulation; D – psycho-emotional state; Health – integral indicator of health; B₁ – level of regulation; B₂ – reserves of regulation; HR – heart rate; SDNN – standard deviation of N–N intervals; I – indicators before the functional test; II – indicators after the functional test; significance of differences according to the Mann-Whitney U-test when comparing values for groups according to the mean values of the sample: * – $p < 0,01-0,05$, ** – $p < 0,001$.

Table 3
Indicators of the physical condition of students during the study, $\bar{X} \pm S$

Indicator	Measurement	Group 1 (n=20)	Group 2 (n=20)
VC, l	I	3,4±0,5	3,4±0,5
	II	**3,9±0,3	**4,0±0,2
Body weight, kg	I	80,0±2,7	81,2±3,3
	II	79,9±3,2	78,1±4,0
PWC _{170'} (W·min·kg ⁻¹)	I	980,5±50,5	1010,2±44,8
	II	**1222,6±33,4	**1348,4±29,7
Біг на 1000 м, с	I	220,5±17,3	222,4±19,5
	II	215,6±13,7	*210,8±22,1

Note: VC – vital capacity of the lungs; I – indicators at the beginning of the study; II – indicators at the end of the study; Significance of differences according to the Mann-Whitney U-test when comparing values for groups according to the averages of the sample: * – $p < 0,01-0,05$, ** – $p < 0,001$.

in all characteristics ($p > 0,05$). This indicates a rational distribution of the subjects in the test groups.

At the end of the study, the level of adaptation (A) in subjects in group 2 increased, but not significantly ($p > 0,05$). Heart rate after the third minute of recovery at the end of the functional test in both groups did not differ significantly ($p > 0,05$).

The SDNN indicator also did not change significantly at the end of the study ($p > 0,05$). All other indicators significantly improved ($p < 0,001-0,05$) in response to dosed test physical activity in both groups.

Table 3 shows the dynamics of indicators that comprehensively characterize the adaptive processes of the body of students.

The body weight of both groups studied had no significant changes ($p > 0,05$). The same applies to the results of the 1000 m run in the subjects of group 1. Other indicators significantly changed in both groups from the beginning to the end of the study.

Comparing the initial indicators of students of groups 1 and 2, it was revealed that they significantly differed in the following characteristics ($p < 0,01-0,05$): level of adaptation (A); psycho-emotional state (D); PWC_{170'}. Consequently, characteristic differences were revealed regarding the influence of classes on different programs of motor activity on some indicators of morphological and functional indicators of students.

Discussion

To assess the characteristics of the morphological and functional adaptations of the body of students regularly engaged in physical culture and sports recreational motor activity, two groups of indicators were selected. The first group of indicators was recorded by hardware and allowed for an express assessment of the functional state of the cardiovascular system of students. They reflect the features of morphological and functional changes in response to dosed physical activity.

The conducted studies have shown that short-term fixed physical load affects the indicators characterizing the adaptive capabilities of the functional systems of the students' body. The initial characteristics of the subjects were characterized by the normotonic type of autonomic regulation in terms of A, B, C, D, H. After the Martinet-Kushelevsky test, the reaction of the organism of the participants in groups 1 and 2 was characterized by the predominant activity of the parasympathetic division of the autonomic nervous system in the regulation of heart rate. Indicators B₁ and B₂ characterize the current voltage level of control systems and the reserves of these systems. The dynamics of these characteristics in both groups of subjects is similar. This indicates an increase in reserves and regulation in response to dosed physical activity. The subjects of both groups showed timely normalization of the heart rate after the third minute of rest after the test load. The values of the SDNN indicator reflect the general variability: its low values indicate the predominance of low-frequency components in the regulation; high reflect the dominant influence of the parasympathetic link. The dynamics of this indicator in both groups did not change. This indicates a similar effect of classes according to different programs of physical exercises on the functional state of the cardiovascular system. The insignificant effect is associated with the short duration of the use of exercise programs.

The next group of indicators determines the features of

the adaptation of the life support systems of the students' organism. It contains labile characteristics that characterize the performance and endurance of the individual.

The action of the selected physical activity programs is effective in terms of a significant improvement in most indicators in both groups of subjects. The only exception is body weight. However, the interpretation of this indicator is limited within the framework of the current study, because the analysis of changes in body composition was not carried out. Consequently, physical activity according to the proposed programs did not have a significant effect on the correction of the weight of the subjects. It should be noted that the level of endurance in group 1 improved according to the results of the 1000 m run, but is less pronounced than in group 2. Clearly, higher values of the level of regulation (A) and psycho-emotional state (D) in students of group 1. After all, playing activities involve multiple changes in the load in different bioenergetic zones. This improves regulation. Play is emotional in nature. This is expressed in its greater influence on the psycho-emotional state compared to the routine nature of most athletics exercises. Higher performance of group 2 students in the PWC170 test characterizes the benefits of athletics for increasing the level of working capacity. The obtained intergroup differences at the end of the study confirm the peculiarities of the influence of classes of different motor activities on the morphological and functional indicators of students.

In accordance with the hypothesis of the study, test procedures and indicators for determining the instantaneous reaction and medium-term adaptation of the morphological and functional structures of the students' body were selected. For the current experimental sample, there was no significant difference in the effects of predominantly different types of training loads, according to the results of the body's response to a dosed physical load. The obtained data complement the idea of the characteristics of the adaptation of the cardiovascular system, as well as the morphological and functional adaptations of the body of student youth to physical activity (Kondakov et al., 2018; Brezdeniuk et al., 2021; Hryshko et al., 2021; Petrachkov & Yarmak, 2021). We believe that it is the increase in the regularity of classes, and not their predominant focus, that is the factor contributing to the improvement of morphological and functional indicators, the increase in the adaptation of the life support systems of the students' body and the increase in the overall level of physical activity. At the same time, the methods of performing a fixed training load (acyclic / cyclic types of motor activity) have some advantage in relation to increasing physical endurance. Such programs should be built taking into account the principles of physical education.

Conclusions

It has been established that two-month classroom lessons on the programs of physical exercises of the game and suppressive orientation contribute to the change in the morphological and functional indicators of students. This is expressed in the dynamics of indicators of the physical condition and the body's response to dosed physical activity. The special thing is that, against the background of dynamic improvement in the indicators of regulation, no pronounced changes in the integral indicators of the cardiovascular system of the subjects were found. Consequently, the duration and volume of the load in both programs of physical exercises were insufficient to create significant adaptations of the cardiovascular system of the subjects. We believe that an increase in the number of physical education classes will optimize the amount of load and create a more pronounced effect on the state of the cardiovascular system of students. This will also increase the variability of the physical education program against the background of a decrease in the period of training in certain types of physical activity. After all, positive changes in the indicators of the body of students on the presented programs were revealed. They were similar for both groups of 1st and 2nd year students, regardless of the predominant direction of physical activity. However, regarding the increase in working capacity and endurance, exercises of a cyclic / acyclic nature have an advantage. In turn, sports games contribute to a greater improvement in regulation and psycho-emotional state. This should be taken into account when programming health and conditioning physical education classes in the classroom. The presented results have practical application in the direction of improving the program material for the academic discipline «Physical Education» in higher education institutions. The data obtained expand the understanding of the importance of regular physical activity as a guarantee of the formation of students' physical health. Taking into account the current results, it is planned to develop a comprehensive program of physical culture and health work with students of a special medical group.

Author Contributions

A – research design/planning; B – data collection/entry; C – data analysis/statistics; D – data interpretation; E – manuscript preparation; F – literature analysis/search; G – fundraising.

Andrii Yefremenko: B, D, E, F, G; Svitlana Piatysotska: C, D, G; Krzysztof Prusik: A, D; Viktor Pavlenko: E, F, G; Vladyslav Rozhkov: B, F, G

Conflicts of Interest

The authors declare no conflict of interest.

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