

Criteria for assessing status to form individual training trajectory*

Dmytro Vakulenko^{1,*†}, Lyudmila Vakulenko^{2†}, Sviatoslav Gandzyuk^{1,†} and Nadiya Gandzyuk^{1,†}

¹ I. Horbachevsky Ternopil National Medical University, 46001, Ternopil, Ukraine

² Ternopil Volodymyr Hnatiuk National Pedagogical University, 46001, Ternopil, Ukraine

Abstract

The future of world is closely connected with today's youth. The years of study at a higher educational institution are an important stage in the formation of the personality of a future specialist, a citizens. Modernization of higher education in accordance with the requirements of the Bologna Declaration created increased demands on the mental activity of student youth. Daily intense mental work, restriction of motor activity, as well as the occurrence of various stressful situations can negatively affect the physical and mental health of students, contribute to an increase in their morbidity. Before the load, a reliable deviation of one, two or three of the studied indicators from the normal limits was found. Most often (60%) these were indicators of systolic blood pressure (BP). In all examined, the Robinson index was also outside the "safe" level. A visual analysis of the recorded arterial oscillograms (AOGs) showed that none of the AOGs was rated "excellent" and only 2 - "good". The results of the study indicate a decrease in cardiovascular reserves in the examined students, which is one of the leading causes of the occurrence and development of diseases. Therefore, all the examined (even without health complaints) need increased attention to the state of the cardiovascular system. After 20 squats, the studied indicators did not reach the permissible maximum, but in all the examined, a different degree of deviation of their dynamics from the limits of the permissible norm was recorded. It was found that in all examined subjects, adaptation to the performed load occurred due to a significant increase in heart rate ($P < 0.05$) and insignificant dynamics of blood pressure indicators, i.e. a limited volume of systolic blood ejection ($P > 0.05$). What was noted was also confirmed by the "deterioration of the quality" of AOGs registered after physical exertion. Studies indicate an inadequate reaction of the CCS of the examinees to 20 squats in 30 seconds with a barbell, i.e., an excessive load, which dictates the need to correct the dosage of physical exercises.

Keywords

cardiovascular system, blood pressure, Robinson index, Kerdo index, arterial oscillography, physical activity

1. Introduction

The future of Ukraine is closely connected with today's youth. The years of study at a higher educational institution are an important stage in the formation of the personality of a future specialist, a citizen of independent Ukraine (Chertanovsky P.M., 2012). Modernization of higher education in accordance with the requirements of the Bologna Declaration created increased demands on the mental activity of student youth. Daily intense mental work, restriction of motor activity, as well as the occurrence of various stressful situations (caused by hostilities in Ukraine) can negatively affect the physical and mental health of students, contribute to an increase in their morbidity (Prysiazhniuk et al., 2008). Educational and health-training classes, as well as independent physical exercise classes in free time from studies, are important for strengthening

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^{1*} Corresponding author.

[†] These authors contributed equally.

✉ dmitro_v@ukr.net (D. Vakulenko); vakulenko3@tnpu.edu.ua (L. Vakulenko); gandzyuk_svyvol@tdmu.edu.ua (S. Gandzyuk); gandzyuk_n@tdmu.edu.ua (N. Gandzyuk)

ORCID 0000-0001-5062-9278 (D. Vakulenko); 0000-0002-4723-3747 (L. Vakulenko); 0009-0009-5743-0865 (S. Gandzyuk); 0009-0004-2893-1840 (N. Gandzyuk)



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health, reducing the impact of fatigue processes, improving students' mental capacity, and increasing motivation to improve the physical fitness of student youth (Kosynskyi et al., 2008). In this process, adequate dosing of physical activity is important, which requires constant monitoring (Selskyi et al., 2018; Romaniv et al., 2022; Martseniuk et al., 2007, 2018, 2020, 2021, 2022; Mintser et al., 2020 & Vakulenko et al., 2015, 2017 - 2024; Vladymyrov, et al., 2024).

2. Objective

To study the state of the cardiovascular system (CSS) of students aged 17-22 who were engaged in strength development in the gym during extracurricular hours, to assess the adequacy of the load received during training.

3. Materials and Methods

An examination was conducted (with verbal consent) of 10 students aged 17-22 (7 male and 3 female) present at training, without health complaints, who were engaged in strength exercises outside of class, in the university sports hall. Examinations were carried out at the beginning of training before and after 20 squats for 30 s with a barbell on the shoulders and after 2 minutes of rest. The weight of the barbell was 20 kg for women, 40 kg for men. Examinations included: measurement of systolic and diastolic blood pressure (BP, BP), heart rate (HR). Derivatives of the indicated indicators were determined and evaluated: pulse pressure, Vegetative Kerdo index (VIK), Robinson index (IR), etc. (Abramov et al., 2014; Vakulenko et al., 2015, 2017 - 2024).

Blood pressure and heart rate before and after exercise were recorded using an electronic tonometer VAT41-2 (manufacturer IKS-TECHNO), which is also capable of recording arterial pulsations and transporting them for further analysis (Vakulenko et al., 2015, 2017 - 2024). The recorded arterial oscillograms (AOG) were subjected to visual morphological analysis (according to the Vakulenko method) (Martseniuk et al., 2007, 2018, 2020, 2021, 2022; Mintser et al., 2020 & Vakulenko et al., 2015, 2017 - 2024). Statistical processing of the results was carried out using the Statistica computer program, the Student's test was used for normally distributed data, otherwise - the Wilcoxon method. Changes in indicators were considered statistically significant if $p < 0.05$. The indicators obtained after squats were compared with variants of reaction types for 20 squats in 30 s in the well-known Martine-Kushelevsky test (Vakulenko et al., 2024).

An important factor in these studies is to take into account the current results of transdisciplinary research, which includes ontological and computer engineering (Kurgaev et al., 1995; Malakhov et al., 2024, 2023; Malakhov, 2022, 2023a, 2023b, 2024c, 2024b, 2024a, 2025; Palagin et al., 2024a, b; 2023; 2022; 2018; 2014; Petrenko et al., 2024a; 2024b; 2023; 2003a, b).

4. Results

The determined average indicators of heart rate and blood pressure before and after 20 squats for 30 seconds with a barbell on the shoulders (for women - 20 kg, for men 40 kg) and after 2 minutes of rest are presented in table 1.

Thus, under different kinds of influences on a biological object, the autonomic nervous system and vascular tone do not react to the same extent, but there are certain regularities. When comparing the effect of different genres of influences, the most influential factors in our study were watching the video fragments of "Fire," "Rest" before imagining, and imagining "Fire" and "Water." Thus, to a certain extent, the simulation of "Fire" and "Rest" video fragments preceding imagination activated parasympathicotonia. Imagination of "Fire" and "Water" contributed to the weakening of sympathicotonia in almost all indicators characterizing the sympathetic link. The sympathetic activity of "Rest", preceding the imagination and the imagination of "Bell" by several parameters and the influence of the image of "Water" by the HVR pos index significantly reduced. At the same time, there is an indisputable connection between the influence of imagination and the functional

state of the autonomic nervous system, which resonates with the theory of Yin-Yang, Wu-Xing and requires further rethinking and refinement. Thus, these simulation effects should be considered from the point of view of psychorelaxation, which should be taken into account when designing an automated telemedicine system for psychological rehabilitation.

For a more detailed understanding of this scientific field, more extensive research is needed, since by regulating the autonomic balance and monitoring it, psychological rehabilitation can be fully carried out remotely. A special role should be given to the study of the influence of imagination on various physiological indicators and stress markers.

Table 1

Average values of blood pressure and heart rate before and after exercise and after 2 minutes of rest (n=10)

№	Examination period	ATc (mmHg)			ATd (mm Hg)			heart rate (bpm)		
		Performance	% 1-2	% 1-3	Performance	% 1-2	% 1-3	Performance	% 1-2	% 1-3
1	To nav**	137±8.2			71.4±4,5			78±8.2		
2	After the	145±10.4	5,1%		71.3±6,3	-0.1%		135±10.1	73%*	
3	After 2 min	135±6,3		-2%	73±6,3		2%	102±9.6		31% *

Note. * - dynamics are reliable. ** Nav - load

The analysis of the conducted studies proved the following

Before loading

HR indicators ranged from 64 to 95, the average was 78±8.2 bpm, in 2 people (female), it was the highest - 93 and 96 bpm. which indicates an increase in the activity of the sympathetic nervous system (SNS). This means that the body spends more effort to maintain balance with the environment (Vakulenko et al., 2018, 2024).

Blood pressure. Systolic arterial the pressure ranged from 110 to 153, the average was 137.4±8.2 mm Hg. Art. 2 women had the lowest blood pressure (110 and 116 mm Hg), which is optimal for this age. It was greater than the upper limit of normal (139 mm Hg) in 5 examinees, which corresponds to 1 degree of arterial hypertension (Vakulenko et al., 2018, 2024).

Diastolic pressure was in the range of 46-90, the average - 71.4±4.5 mm Hg. It was higher than normal (85 mm Hg) in only one female representative, which indicates an increase in the tone of peripheral vessels. The lowest in No. 3, BP – 46 mmHg, which is a sign of vascular dystonia (Vakulenko et al., 2018, 2023, 2024).

Comprehensive analysis of the obtained indicators in each of the examinees found the following. In 2 examinees (#3 and 7), all (three) studied indicators were outside the normal range. In No. 3, blood pressure is 151/46 mm Hg, heart rate is 87 bpm, which indicates vascular dystonia against the background of increased heart rate. In No. 7, an increase in blood pressure to 141/90 mmHg, heart rate of 93 bpm was recorded, which indicates arterial hypertension. In other participants, one or two indicators were outside the norm. The absence of complaints about the state of health of the examinees against the background of the deviation of the observed indicators from the normal limits may indicate the activation of the body's protective forces, which does not yet have a noticeable effect on the physical condition of the examinees (Vakulenko et al., 2018, 2023, 2024).

Vegetative index Kerdo (AGE). Its indicators were in the range from -12 to +50 um.od. The most positive indicators in this group were those of examinees #3 and #8 (respectively, 50 and 30 um.od), which indicates a significant increase in the activity of the sympathetic nervous system

(SNS) even at rest (Abramov et al., 2014; Vakulenko et al., 2015, 2017 - 2024). In others, the AGE ranged from -12.5 to +10. It was not possible to reveal the interdependence between the activity of the ANS and the blood pressure indicator.

Robinson index (IR) (double product). Our research testified that in 10 examined, IR indicators ranged from 88 to 131 um.od. and was outside the 'safe' level." The noted indicates an increase in the intensity of the heart at rest, a decrease in CVS reserves, which requires increased attention to the condition of the CVS (Abramov et al., 2014; Vakulenko et al., 2015, 2017 - 2024).

After 20 squats for 30 s with a barbell on the shoulders (men 40 kg, women 20 kg), the studied indicators had the most diverse dynamics.

Heart rate. The heart rate did not reach the maximum permissible for the contingent of the examined (200 - age) (Abramov et al., 2014; Vakulenko et al., 2015, 2017 - 2024). The heart rate ranged from 118 to 162, the average was 135.4 ± 10.1 bpm, which is 37% more than at the weekend and is within the aerobic-anaerobic threshold (Abramov et al., 2014; Vakulenko et al., 2015, 2017 - 2024). The exception is examinee No. 10, whose heart rate increased to 162 bpm. Heart rate response was different both among the group of men (118-162 bpm) and among women (120-146 bpm). According to the heart rate indicator determined after squats with a barbell, the physical load was medium for 2 (#2, 9), heavy for 5 (#2, 3, 4, 6, 7), very heavy for 3 participants (#5, 8, 10) (Abramov et al., 2014; Vakulenko et al., 2015, 2017 - 2024). At the same time, for none of the examined loads was extremely difficult or tiring.

Blood pressure. Systolic blood pressure after loading ranged from 122 to 186, the average - 145 ± 10.4 mm Hg, compared to the original - increased by 6%. As for the individual dynamics of ATs, it turned out to be the most diverse. Attention was drawn to the fact that blood pressure in 4 people decreased in the range of 6-16%. It was in them at the beginning of training that blood pressure was higher than 140 mm Hg, which indicates an inadequate reaction of the cardiac factor of hemodynamics to the performed load: a decrease in systolic ejection during the load (Vakulenko et al., 2015, 2017 - 2024). At the same time, in No. 4, the blood pressure increased from 148 to 186 mmHg. (26%), which indicates a hypertensive type of response to exercise. In No. 8 and No. 9 with the lowest blood pressure before exercise (110 and 116 mmHg) after squats, blood pressure increased by 43% and 29%, respectively, which is characteristic of the normotonic type of reaction in Mariina_Kushelevsky's sample (Vakulenko et al., 2015, 2017 - 2024).

Blood pressure is diastolic. After squats, blood pressure ranged from 48 to 94, with an average of 71.3 ± 6.3 mm Hg. Attention was drawn to the various dynamics of ATd.. In No. 9, BP increased from 70 to 93 mmHg. , which is evidence of an increase in the tone of peripheral vessels. In No. 3, blood pressure increased from 46 to 69 mm Hg. At the same time - in No. 2 - on the contrary: it decreased from 71 to 48 mm Hg, which is characteristic of a dystonic type of reaction (Abramov et al., 2014; Vakulenko et al., 2015, 2017 - 2024). In 6 persons ATd decreased within the normal range, which is an adequate response to physical exertion and indicates a decrease in the tone of peripheral vessels (Vakulenko et al., 2015, 2017 - 2024).

Comprehensive analysis of the dynamics of the obtained indicators in each of the examined testified that only 2 people (No. 6 and No. 7) had a favorable reaction of the heart rate after squatting with a barbell: heart rate and blood pressure increased, without changes or blood pressure decreased. In others, one, two or three indicators differed from the adequate response of blood pressure and heart rate. Most often, this was characteristic of individuals with elevated baseline blood pressure, before exercise. Thus, an increase in blood pressure at rest is already the main sign of a violation of the adaptive capacity of the examined body (Abramov et al., 2014; Vakulenko et al., 2015, 2017 - 2024). The most pronounced inadequate reaction was recorded in numbers 3, 5, 10.

Vegetative index Kerdo. After physical exertion, the activity of the SNA increased significantly in all subjects: in the range of 22-68%, the highest in No. 5

Robinson index after loading ranged from 165 to 247, average - 196 um.od. Compared to the average before the load, it increased by 83%, which indicates an increase in the intensity of the work of the heart (Vakulenko et al., 2015, 2017 - 2024). The work required the greatest effort in

examinees #8 and 10 (IR, respectively, 229 and 225 um.od). At the same time, in a female representative for number 9, IR turned out to be even smaller than in some men (180 um.od).

When evaluating the Robinson Index, the dynamics of its studied indicators (heart rate and blood pressure) were compared for each examinee. It was found that the individual dynamics determined by BP ranged from -15 to +42%, while the dynamics by HR was much higher - from 46% to 84%. Thus, the increase in minute blood volume during adaptation to loads in the examined subjects was mainly due to the increase in heart rate, much less - stroke volume, systolic ejection (Vakulenko et al., 2015, 2017 - 2024). The study shows an adverse reaction to physical exertion of all the examinees, which requires correction of the dosage of physical exertion.

After 2 minutes of rest after squats in the majority of the examined, the investigated indicators had a varying degree of tendency to recovery, which indicates various manifestations of disharmony in the activity of the autonomic nervous system, cardiac and vascular factors of hemodynamics, which can be visually confirmed by analyzing the AOG recorded before and after the load (Vakulenko et al., 2015, 2017 - 2024).

Arterial oscillogram (AOG). Visual analysis of the morphological characteristics of AOG made it possible to assess the state of the vascular factor of the hemodynamic system. The analysis of AOGs registered for the load showed that none of them received an "excellent" rating, only 2 - "good" (Vakulenko et al., 2015, 2017 - 2024). Among the "best" of them is the AOG of the examined No. 9 with an assessment of its type "good" before the load and "satisfactory" after the load. As a matter of fact, No. 9 was characterized by the dynamics closest to the norm of the majority of the investigated indicators and were even "better" than those of individual male representatives (Fig. 1).

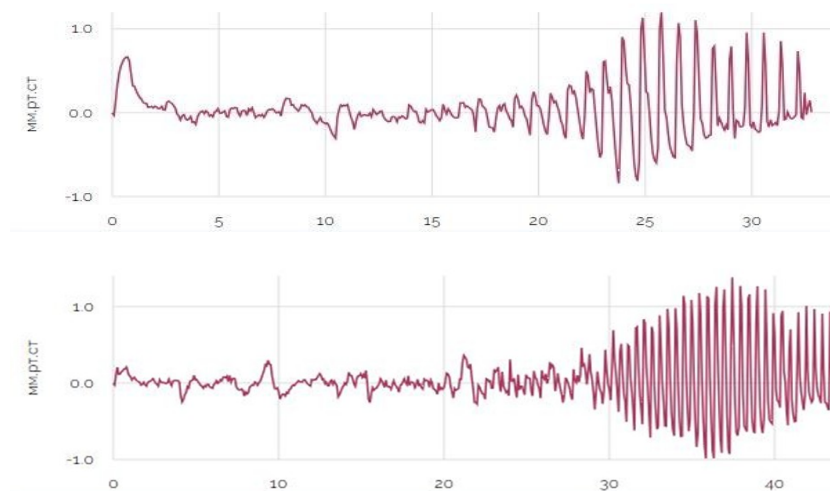


Figure 1: Arterial oscillogram of subject No. 9. On the X axis - the time of recording individual oscillations (s), on the Y axis - the value of pressure fluctuations in the cuff under the influence of the vascular wall of the artery (mm Hg). The upper figure is before the load, the lower one is after 20 squats in 30 seconds with a barbell on the shoulders.

Before loading: blood pressure 116/67 mm Hg, heart rate 73 bpm. AGE 10 od, IR - 85 um.od

After exercise, blood pressure 150/94 mm Hg, heart rate 120 bpm. AGE 2 od, IR - 180 um.od

Note. AGE - Kerdo's vegetative index, IR - Robinson's index

Visual analysis of the AOG of the examined No. 9 shows the hemodynamic state of the vascular factor of blood circulation before and at the beginning of compression of the shoulder with a cuff: the harmony of pulsations is disturbed both in terms of rhythm and amplitude. With further compression, harmonic pulsations are formed gradually (from 17 s), which are maintained until the end of the measurement with minor deviations from the norm for 28 s. AOG after exercise demonstrates its variant with an increase in both BP, BP, and heart rate. After physical exertion, disturbances in the harmonicity of pulsations are more pronounced and last up to 30 seconds. After that, rhythmic pulsations appear, which harmoniously increase and decrease (with the exception of

certain phases) until the end of AOG registration. On other AOGs, violations of the harmony of pulsations both before and after the load were much more pronounced (Vakulenko et al., 2015, 2017 - 2024).

The perspective of further scientific research involves further study of the state of the cardiovascular system under static loads, their influence on the state of the vascular factor of hemodynamics using the arterial oscillography method.

Conclusions

1. During the study of the state of the cardiovascular system (according to heart rate, blood pressure, blood pressure and their derivatives) at the beginning of training in all students aged 17-22, deviations of one, two or all indicators from the normal limits were found. Most often (in 60% of the examined) it was a deviation from the normal BP values. In all examined, the IR indicator is outside the "safe" level", which indicates a decrease in cardiovascular reserves, is a prognostically unfavorable sign and one of the leading causes of the occurrence and development of diseases. Therefore, all examined students (even without health complaints) need increased attention to the state of the cardiovascular system, and No. 10 is an examination by a doctor.

2. After 20 squats in 30 seconds with a barbell on the shoulders (40 men, 20 kg women), the studied parameters (heart rate, blood pressure, blood pressure) did not reach the permissible maximum. At the same time, in all examined subjects, adaptation to the load took place due to a significant increase in heart rate and insignificant dynamics of blood pressure indicators, that is, the volume of systolic blood ejection. This indicates an inadequate reaction of the cardiovascular system to 20 squats in 30 seconds with a barbell, which dictates the need to correct the dosage of physical activity

3. Indicators of blood pressure, heart rate and their various ratios (Robinson index, Kerdo index, etc.) are available methods of self-monitoring and assessment of the initial state of the cardiovascular system and its functional reserves when choosing and dosing physical activity.

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Declaration on Generative AI

The authors have not employed any Generative AI tools.

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