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D.I. Berhtraum, L.S. Vovkanych, Y.S. Svyshch, T.I. Dukh, A.V. Dunets-Lesko
Ivan Boberskyi Lviv State University of Physical Culture, Lviv

THE IMPACT OF MODERATE PHYSICAL LOADS ON CENTRAL HEMODYNAMICS OF PHYSICAL THERAPY STUDENTS

e-mail: lsvovkanych@gmail.com

We aimed to study the impact of non-professional sports training on central hemodynamics in physiotherapy students aged 17–18 years. Participants were divided into low-active (44 male, 27 female) and physically active groups (19 male, 12 female). We measured heart rate and central hemodynamics parameters. Non-professional sports activities significantly influenced hemodynamics, leading to bradycardia, a tendency towards lower systolic blood pressure, a decreased cardiac index, and an increase in individuals with a hypokinetic hemodynamic type and inotropic cardioregulation. These activities also decreased Robinson index values, increased cardiovascular system reserve capabilities, elevated the frequency of vagotonia at rest, and improved physical working capacity and maximal oxygen consumption in both genders. Our findings suggest that self-determined non-professional sports activities have significant potential for improving the health and fitness of physiotherapy students.

Key words: systolic volume, cardiac index, Robinson index, Kerdo index, adaptotropic index.

Д.І. Бергтраум, Л.С. Вовканич, Я.С. Свищ, Т.І. Дух, А.В. Дунець-Лесько

ВПЛИВ ПОМІРНИХ ФІЗИЧНИХ НАВАНТАЖЕНЬ НА ПОКАЗНИКИ ЦЕНТРАЛЬНОЇ ГЕМОДИНАМІКИ СТУДЕНТІВ-ФІЗІОТЕРАПЕВТІВ

Метою роботи було вивчення впливу непрофесійних спортивних тренувань на показники гемодинаміки студентів-фізіотерапевтів віком 17–18 років. Учасниками дослідження були нетреновані студенти (44 студентів, 27 студенток) та фізично активні студенти (19 студентів, 12 студенток). Визначали частоту серцевих скорочень та показники центральної гемодинаміки. Вплив непрофесійних занять різними видами спорту на показники гемодинаміки проявляється брадикардією, тенденцією до гіпотонії, зменшення величини серцевого індексу та збільшення частоти виявлення осіб з гіпокінетичним типом гемодинаміки й інотропним типом кардіорегуляції. Такі навантаження знижують індексу Робінсона, підвищують рівень резервних можливостей серцево-судинної системи та збільшують частоту проявів ваготонії у стані фізіологічного спокою, підвищують показники загальної фізичної працездатності та аеробних можливостей організму студентів та студенток. Наші результати свідчать про те, що самостійно визначені непрофесійні спортивні заняття мають значний потенціал для покращення здоров'я та фізичної підготовленості студентів-фізіотерапевтів.

Ключові слова: систолічний об'єм крові, серцевий індекс, індекс Робінсона, індекс Кердо, індекс адаптотропності.

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Sedentary behavior, decreased physical activity, and low cardiorespiratory fitness are prominent risk factors for cardiovascular disease among students [6, 9]. The demanding intellectual and psychoemotional challenges faced by students, compounded by insufficient physical activity, can notably compromise their cardiovascular fitness [3, 5, 11].

The proper level of functional reserves of the cardiovascular system and physical fitness plays a particularly important role for specialists in the field of physical therapy [9, 14]. A positive impact of physical activity on aerobic capacity, endurance, and overall physical fitness of the students has been established [6, 8, 10, 11]. However, some authors [10] point out a low or insufficient level of physical activity among physiotherapy students. This can explain the predominantly low and moderate levels of overall physical performance and aerobic capacity among physiotherapy students [14], as well as the low level of their physical fitness [9].

Currently, there is growing relevance in studying the cardiovascular system's functioning and self-regulation mechanisms in students, along with assessing their organism's adaptive capacities [2]. Many authors [3, 5, 4] believe that parameters of central hemodynamics can serve as indicators of negative changes in students' adaptive capacities.

Some researchers have investigated differences in central hemodynamics parameters, functional reserves, and adaptive capacities of the cardiovascular system among students with different levels of physical activity [3, 5]. It is crucial to examine the correlation between central hemodynamics parameters and the level of physical activity among students specializing in physical therapy.

The purpose of the study was to conduct a comparative analysis of central hemodynamic parameters among students specializing in physical therapy with different levels of physical activity.

Materials and methods. Students from the Department of Therapy and Rehabilitation (T&R) at Ivan Bobersky Lviv State University of Physical Culture (LSUPhC) participated in the study. They were divided into four groups. Group M1 consisted of 44 male students (17.30±0.09 years, 178.6±1.30 cm height,

70.76±1.79 kg weight) who did not engage in any additional physical activities outside of the academic process. Group M2 comprised 19 male students (17.32±0.11 years, 178.79±1.31cm height, 71.74±1.67 kg weight) who regularly participated in non-professional training with moderate intensity for up to 5 hours per week. Group F1 included 27 female students (17.42±0.15 years, 166.19±0.83 cm height, 60.13±1.93 kg weight) who did not engage in additional physical activities. Group F2 consisted of 12 female students (17.56±0.41 years, 166.83±1.86 cm height, 56.77±1.99 kg weight) who regularly participated in non-professional training for up to 5 hours per week. All participants provided informed consent to participate in the research. The study adhered to the established standards of the Helsinki Declaration, adopted in 1964 and revised by the 59th General Assembly of the World Medical Association in Seoul, October 2008.

The main parameters of the cardiovascular system were measured at rest. Heart rate (HR, bpm) was measured using a pulseoximeter PM 100. Systolic blood pressure (SBP, mmHg), and diastolic blood pressure (DBP, mmHg) were determined using the Korotkoff method with a Microlife BP AG 1-30 mechanical sphygmomanometer. Based on this data, the following parameters of hemodynamics were calculated based on Y.O.Mukalov equations (Drozd, Hrydzhuk & Mukalov, 2014): pulse pressure (PP, mmHg), mean arterial pressure (MAP, mmHg), stroke volume (SV, ml), stroke index (SI, ml/m^2), minute blood volume (MBV, l/min), blood circulation index (BCI, ml/(min•kg)), peripheral resistance (PR, dynes/(s•cm^{-5})), Index of peripheral resistance, (IPR, dynes^2•s•cm^{-5}), Kerdo index (KI, arbitrary units – AU), cardiac index (CI, ml/(min•m^2)), coefficient of blood circulation efficiency (CBCE, AU), Robinson index (RI, AU), adaptotropic index (AI, AU), and adaptation potential (AP, AU). In all groups, the level of physical working capacity was determined based on the PWC_{170}. The PWC_{170} values were calculated from the data obtained during two physical loads performed in the step-test [13]. Aerobic capacity was assessed by the level of maximum oxygen consumption (VO_{2max}), which was calculated by the von Dobeln formula [7] on the data obtained during the second load of the step-test.

The data were analyzed using statistical methods in Microsoft Excel 2010 and the Shapiro-Wilk criterion in Origin 2018 assessed the distribution. As the distribution was not significantly different from normal, descriptive statistics including arithmetic mean (M) and standard error of the mean (SEM) were presented. Differences were evaluated using Student's t-test with a significance level set at $p \leq 0.05$.

Results of the study and their discussion. We found a significant influence of regular physical activity on several hemodynamic parameters (Table 1) of the students. Firstly, the resting HR values in groups M2 and F2 were found to be 8–11 % lower ($p < 0.05$) compared to those of students in groups M1 and F1.

Table 1

Main hemodynamic parameters of the students of the T&R department (M±SEM)

Parameter	Male students		Female students	
	Group M1	Group M2	Group F1	Group F2
Heart rate, bpm	83.25±1.99	74.14±2.88	83.55±1.98	77.17±3.15*
Systolic blood pressure, mmHg	131.02±2.0	125.79±2.9*	121.31±1.9	121.67±4.37
Diastolic blood pressure, mmHg	77.39±1.47	74.47±2.32	73.97±1.31	75.83±2.03
Pulse pressure, mmHg	53.64±1.63	51.32±2.75	47.34±1.88	45.83±4.03
Mean arterial pressure, mmHg	95.27±1.52	91.58±2.21#	89.75±1.28	91.11±2.34
Stroke volume, ml	98.31±2.63	101.78±3.71	85.66±3.45	85.02±6.36
Stroke index, ml/m^2	52.78±1.26	54.06±1.68	50.17±2.71	52.82±4.13
Minute blood volume, l/min	8.25±0.33	7.51±0.43#	6.86±0.41	6.61±0.65
Peripheral resistance, dynes/(s•cm^{-5})	975.09±39.	1044.92±63.43#	1052.64±42.03	1194.39±93.65#

Note: * – $p < 0.05$; # – $p < 0.10$

The lower values of SBP (by 4 %, $p < 0.05$), along with a tendency towards lower values of MAP (by 4 %, $p = 0.08$) and MBV (by 9 %, $p = 0.08$), were observed in group M2 compared to group M1. In both the M2 and F2 groups, there was a tendency towards an increase in PR by 7–13 % ($p < 0.10$) compared to groups M1 and F1.

The analysis of the central hemodynamic indices (Table 2) reveals significant adaptive changes in more physically active students. The CI of students in groups M2 and F2 was 9–13 % lower ($p < 0.05$) than in groups M1 and F1. The BCI values also showed a decrease in M2 ($p < 0.05$) and tendency of decrease in F1 ($p = 0.08$) groups.

In groups of exercise-engaged students (M2 and F2), a hyperkinetic type of hemodynamics was observed in a lower percentage of students (64 % and 58 %, respectively) compared to their sedentary peers in the M1 and F1 groups (81 % in both groups). Conversely, a higher percentage of exercise-engaged students exhibited eu- and hypokinetic types of hemodynamics (36–41 %) compared to those in the M1 and F1 groups (20 % and 19 %, respectively).

The values of adaptotropic index (AI) in the M2 group were 18 % higher compared to the M1 group ($p < 0.05$). A similar trend ($p = 0.08$) was observed in the F2 and F1 groups. This inotropic

mechanism of cardioregulation in the M2 and F2 group was typical for 93 % and 58 % of students. Hence, extracurricular physical activities promote the development of a more efficient inotropic cardioregulatory mechanism in students.

Table 2

Indices of central hemodynamic of the physiotherapy students (M±SEM)

Parameter	Male students		Female students	
	Group M1	Group M2	Group F1	Group F2
Cardiac index, ml/(min•m^2)	4461.84±165.02	4046.90±234.01*	4395.45±185.37	3819.05±327.90*
Blood circulation index, ml/(min•kg)	119.24±4.8*	107.356.41*	121.18±6.19	117.87±11.88#
Index of peripheral resistance, dynes^2•s•cm^{-5}	$6.66\cdot10^5$±2.8910	$7.20\cdot10^5$±$4.57\cdot10^4$	$6.15\cdot10^5$ ±$2.77\cdot10^4$	$6.63\cdot10^5$ ±$5.66\cdot10^4$
Adaptotropic index, AU	2.54±0.58	4.66±0.68*	0.21±0.89	1.23±1.34
Robinson index, AU	109.68±3.27	95.56 ±5.72*	101.42 ±3.36	90.02 ±4.98*
Coefficient of blood circulation efficiency, AU	4512.78±200.12	3790.00±333.85*	3875.19 ±176.49	3263.18 ±286.82*
Kerdo index, AU	4.68±3.18	-6.27 ±5.14*	9.58 ±1.85	0.43 ±3.64*
Adaptation potential, AU	2.38±0.04	2.18 ±0.08*	2.25 ±0.05	2.07± 0.07*

Note: AU – arbitrary units; * – $p < 0.05$; # – $p < 0.10$.

The Robinson index in students of the M2 and F2 groups was 13 % and 11 % lower ($p < 0.05$) than in M1 and F1 groups. Based on RI level, in group M1 the 41 % of students show low cardiovascular fitness, with few having above-average levels. In group M2, only 15 % exhibit low cardiovascular fitness, with a significantly higher number demonstrating above-average or high levels compared to group M1. Similar differences are observed between the F2 (18 %) and F1 (26 %) groups.

The coefficient of blood circulation efficiency (CBCE) in the M2 and F2 groups was 16 % lower ($p < 0.05$) than in M1 and F1 groups. This indicates a higher efficiency of the functioning of cardiovascular system and a reduction in energy cost of blood circulation in groups of individuals who regularly engage in physical exercise.

The Kerdo index in groups M2 and F2 consistently showed lower and more negative ranges compared to the groups M1 and F1. The autonomic balance is shifted towards vagotonia in a significantly higher number of individuals in the M2 and F2 groups (48 % and 25 % respectively) compared to their less physically active counterparts from M1 and F2 groups (25 % and 4 % respectively).

The adaptive potential was 8 % lower ($p < 0.05$) in the M2 and F2 groups compared to the M1 and F1 groups. In the groups of exercise-engaged students, there is a smaller number (7 % in M2 compared to 19 % in M1) or even an absence (F2) of individuals with a lower (normal) level of adaptation. The increase in the values of the AP in the M2 and F2 groups indicates a rise in the level of adaptation to physical exercises under conditions of regular non-professional training.

Our data showed that students engaged in extracurricular physical exercises (M2 and F2) exhibit a 34–36 % higher ($p < 0.05$) physical working capacity (PWC_{170}) compared to their less active peers (M1 and F1). The PWC_{170} values in the M2 and F2 groups were 262.2±15.7 W and 193.4±20.6 W, respectively, while in the M1 and F1 groups, they were 191.8±10.6 W and 144.2±11.3 W. Calculated values of maximal oxygen consumption (VO_{2max}) in the M2 group were 4.43±0.16 l/min (62.04±2.20 ml/min/kg), and in the M1 group – 3.81±0.10 l/min (54.62±2.13 ml/min/kg). In the F2 and F1 groups, VO_{2max} values were 4.10±0.30 l/min and 3.25±0.13 l/min, respectively. This indicates that aerobic capacity in the M2 group was 16–21 % higher compared to the M1 group ($p < 0.05$). The difference between the F2 and F1 groups reached 13–26 % ($p < 0.05$). Thus, the results indicate a significantly higher level of physical working capacity and maximal oxygen consumption in exercise-engaged students.

The initial impetus for our research stemmed from the issue identified by many authors regarding the decline in physical fitness among students, including those studying physiotherapy [9, 10, 12]. A significant body of literature underscores the importance of maintaining high levels of physical activity among students to optimize body composition, enhance physical fitness, and prepare for professional responsibilities. Despite this, the curriculum for students enrolled in “227 Physiotherapy, Occupational Therapy” includes only 2 hours of physical activity per week. Given that WHO recommendations advocate for up to 300 minutes of moderate-intensity aerobic physical activity or 75–150 minutes of vigorous-intensity aerobic physical activity per week, it is clear that additional forms of physical activity are necessary. Research has shown that medical students who meet WHO physical activity requirements have 7 % lower diastolic blood pressure and 37 % higher maximal oxygen consumption compared to those who do not meet the requirements [12]. Therefore, it is pertinent to analyze the opportunities for students to engage in extracurricular activities based on their preferences.

Our data indicate that non-professional, self-selected physical activities lead to positive changes in key parameters of central hemodynamics and physical fitness among students. Notably, we observed bradycardia and a reduction in systolic blood pressure at rest in those who engaged in exercise. These

changes are typical for athletes [1] and are recognized by other researchers as indicators of university students' adaptation to physical exercise [2, 6, 8, 15]. Voloshyn et al. found up to a 4 % lower blood pressure in individuals with higher adaptive capabilities [2]. Male students in sports-focused curricula showed a 10 % lower level of systolic blood pressure and a 14 % lower diastolic blood pressure [8]. It should be noted that, consistent with our study, other authors have found no significant difference in blood pressure between female students with different levels of physical activity [8]. Analysis of several studies reveals that low-to-moderate intensity continuous training can cause up to an 11 % decrease in diastolic blood pressure and up to a 9 % decrease in systolic blood pressure [15]. Al-Hariri & El-Ashker demonstrated an 8 % decrease in resting heart rate in students influenced by moderate exercises [6].

Our study also reveals another positive effect of non-professional moderate exercise: a shift towards eu- and hypokinetic hemodynamic types in exercise-engaged groups. These hemodynamic types are common among endurance runners and individuals with high levels of physical activity [1, 3], indicating efficient blood circulation at rest. Extracurricular physical activities also promote the development of a more efficient inotropic cardioregulatory mechanism and increase vagotony, typical for individuals with high physical activity levels or low body mass index [4].Based on the changes in central hemodynamic parameters, we suggest an increase in the number of individuals with high levels of cardiovascular fitness among physically active students. This suggestion is supported by the analysis of RI values among students. The RI values observed in groups with non-professional moderate physical activity are typical of individuals with high physical activity levels and optimal body mass index [5, 4].

Numerous studies indicate that engaging in physical exercise improves students' aerobic capacity [6, 11, 12, 15]. For example, after ten weeks of moderate exercise, students' VO_{2max} levels increased from 37.2±6.3 ml/min/kg to 40.3±6.2 ml/min/kg [6], and eight weeks of moderate-intensity continuous training resulted in a 13 % increase [11]. Analysis of various studies reveals that low-to-moderate intensity continuous training can increase VO_{2max} levels by 3–15 % [15]. Consistent with these findings, our research shows a significant increase in physical working capacity and maximal oxygen consumption in exercise-engaged students.

Therefore, our results point to a significant influence of regular physical exercise on parameters of central hemodynamics, the balance of the activity of the divisions of the autonomic nervous system, and the level of adaptive potential in physiotherapy students, bringing them closer to the indicators of professional athletes. Such changes are accompanied by a significant increase in the level of overall physical fitness and aerobic capacity among students.

Conclusion

The significant impact of non-professional sports activities on several hemodynamic parameters among students specializing in "227 Therapy and Rehabilitation (227 Physical Therapy, Occupational Therapy)" has been revealed. This impact results in bradycardia, a tendency towards hypotension, a decrease in cardiac index, and an increased number of individuals with hypokinetic type of hemodynamics and inotropic type of cardioregulation. Non-professional physical exercises leads to a decrease in Robinson index, an increase in the level of cardiovascular system reserves, and an increase of vagotonia manifestations at rest. Regular non-professional training increases the levels of physical working capacity and maximal oxygen consumption in the groups of exercise-engaged students.

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O.M. Bilovol, I.I. Kniazkova, O.M. Kirienko, N.V. Kuzminova[1], V.K. Mishchenko, D.O. Kirienko, L.P. Abramova
Kharkiv National Medical University, Kharkiv
[1] National Pirogov Memorial Medical University, Vinnytsya

THE INFLUENCE OF PSYCHOEMOTIONAL DISORDERS ON THE THICKNESS PARAMETERS OF THE INTIMA-MEDIA OF CAROTID ARTERIES AND TUMOR NECROSIS FACTOR-α IN YOUNG MEN WITH ARTERIAL HYPERTENSION

e-mail: sskripka72@gmail.com

The purpose of the study was to establish the peculiarities of changes in the parameters of the structural state of the common carotid arteries, as well as the content of tumor necrosis factor-α in blood serum depending on psycho-emotional status in young men with arterial hypertension. We examined 76 men (mean age 36.4±3.5 years) with grade 1 hypertension, including 55 patients with moderate and high anxiety (group 1) and no disorders of psychoemotional status (group 2). The control group consisted of 20 healthy men. It was established that in group 1, the levels of systolic and diastolic blood pressure during office measurement and daily monitoring exceeded ($p<0.05$) the data of group 2. Also, in group 1, the serum levels of tumor necrosis factor-α and the thickness of the intima-media of the carotid arteries were higher ($p<0.05$) than the indicators of group 2. Thus, in young patients with arterial hypertension, there is an increase in the serum content of tumor necrosis factor-α and signs of structural changes in the carotid arteries, more pronounced in the group with anxiety disorders.

Key words: arterial hypertension, psycho-emotional disorders, tumor necrosis factor-α, intima media complex.

О.М. Біловол, І.І. Князькова, О.М. Кірієнко, Н.В. Кузьмінова, В.К. Міщенко, Д.О. Кірієнко, Л.П. Абрамова

ВПЛИВ ПСИХОЕМОЦІЙНИХ ПОРУШЕНЬ НА ПАРАМЕТРИ ТОВЩИНИ ІНТИМА-МЕДІА СОННИХ АРТЕРІЙ ТА ФАКТОР НЕКРОЗУ ПУХЛИН-α У ЧОЛОВІКІВ МОЛОДОГО ВІКУ З АРТЕРІАЛЬНОЮ ГІПЕРТЕНЗІЄЮ

Метою роботи було вивчити особливості змін параметрів структурного стану загальних сонних артерій, а також сироваткового вмісту фактору некрозу пухлин-α в залежності від психоемоційного статусу у чоловіків молодого віку з артеріальною гіпертензією. Обстежено 76 чоловіків (середній вік 36,4±3,5 років) з артеріальною гіпертензією 1 ступеня, з яких 55 осіб з помірною та високою тривожністю (група 1) та без порушень психоемоційного статусу (група 2). Групу контролю склали 20 здорових чоловіків. Встановлено, що у групі 1 рівні систолічного та діастолічного артеріального тиску при офісному вимірюванні та добовому моніторингу перевищували ($p<0,05$) дані групи 2. Також у групи 1 сироватковий вміст фактору некрозу пухлин-α та товщина комплексу інтима-медіа сонних артерій були більшими ($p<0,05$), ніж у групі 2. Отже, у пацієнтів молодого віку з артеріальною гіпертензією відзначаються підвищення сироваткового вмісту фактору некрозу пухлин-α та ознаки структурних змін сонних артерій, більш виражені в групі з тривожними розладами.

Ключові слова: артеріальна гіпертензія, психоемоційні порушення, фактор некрозу пухлин-α, комплекс інтима-медіа

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All over the world, hypertension (AH) is a leading risk factor for cardiovascular disease and mortality for all causes [5]. It is established that there is a recent increase in the incidence of hypertension among young people: the prevalence of AH among young people is from 6 to 14 % and above [1]. According to meta-analysis, the incidence of comorbid hypertension and anxiety disorders is approximately 38 % [3].