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ORIGINAL SCIENTIFIC ARTICLE

IMPACT OF PHYSICAL EDUCATION ON PECULIARITIES OF FUNCTIONAL STATE OF 18-22 YEAR OLD FEMALE STUDENTS' CARDIOVASCULAR AND RESPIRATORY SYSTEMS

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Abstract

The purpose of the study was to determine the age-related peculiarities of the functional state of the cardiovascular and respiratory systems of 1st-5th year female students of a higher education institution.

Materials and methods. The study participants were 200 female students: 1st year (n = 44); 2nd year (n = 38); 3rd year (n = 42); 4th year (n = 44); 5th year (n = 32). To solve the tasks set, the following research methods were used: analysis of scientific-methodological and medical literature, pedagogical observation, index method, medical and biological methods, ascertaining experiment, and methods of mathematical statistics.

Results. The study found that at the age of 19 there is a significant deterioration in the results of breathhold in the Stange test (49 s) and the Genchi test (38 s) ($P < 0.05$). At the age of 21, there is a decrease in the Ruffier index (12.4 – "satisfactory") and the average heart rate after exercise ($f_1 = 34.7$), while there is a decrease in heart rate ($f_2 = 25.8$) after a standard recovery pause ($P < 0.05$). This indicates that during this period, there occur the most successful compensatory processes of cardiovascular activity. At 21-22 (4th-5th years of study), there is an increase in heart rate before exercise (f_0), and the Stange test result improves.

Conclusions. The results of comparative analysis show that with age the number of female students with a "satisfactory" result of the Ruffier index increases (59.4%), and a "good" heart result decreases (15.6%). At the age of 21, women have better heart rate, and at 22, they have better results in breath-holding under hypoxia.

Keywords: women, Ruffier index, heart rate, Stange test, Genchi.

Introduction

The era of urbanization, automation of production, strict regulation of work and leisure set before humanity new objectives aimed at improving the education system and training of highly qualified specialists (Chernenko, Honcharenko, & Marchenko, 2019; Solohubova, Lakhno, Shyyan, & Shyyan, 2020; Bielikova, Tsos, Indyka, Contiero, Pantik, Tomaschuk, Dedeliuk, & Podubinska, 2021). In the course of their study, Bakanova (2011), Podrigalo, Prusik, Krzysztof, and Prusik, Katarzyna (2012) observed insufficient motor activity and mental strain in young people. Decreased physical activity and motivation to exercise in adults, as well as children and young people is a global phenomenon (Sigmundová, Chmelík, Sigmund, Feltlová & Frömel, 2013; Cachón-Zagalaz, Sánchez-Zafra, Lara-Sánchez, Zagalaz-Sánchez, & Shmatkov, 2020; Doroshenko et al., 2021).

The need to control the functional fitness of students is pointed out by Aguilera, Rivera-Aguilera, and Cordovés-Peinado (2020); Amin, Karim, and Jassim (2019); Aparicio-Sarmiento, Gómez-Carmona, Martínez-Romero, Gamonales, and Sainz De Baranda (2021). The most popular control test in mass research is the Ruffier index (Chernenko, Jagiello, Ivashchenko, Khudolii, & Pashkevich, 2021; Solohubova, Lakhno, Shyyan, & Shyyan, 2020). The availability of registration of heart rate indicators, the simplicity of calculations and evaluation of research results make it a universal tool that characterizes the adaptive capabilities of the human cardiovascular system (Hjalmarson, 1991; Fox, 2005; Fox, Ford, & Steg, 2008). In recent decades, perceptions of the importance of heart rate in clinical practice have changed significantly. The studies by Morman and Kheller (2000) revealed a linear relationship between heart rate and myocardial oxygen consumption. According to Fox (2005), Hjalmarson (1991), heart rate affects life expectancy, increased risk of atherosclerosis, myocardial infarction, hypertension, cardiovascular

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disease. Thus, the study of the peculiarities of dynamics of the functional fitness of female students aged 18-22 is relevant.

The purpose of the study was to determine the age-related peculiarities of the functional state of the cardiovascular and respiratory systems of 1st-5th year female students of a higher education institution.

Materials and methods

Study participants

The study participants were 200 female students: 1st year (n = 44); 2nd year (n = 38); 3rd year (n = 42); 4th year (n = 44); 5th year (n = 32) of Donbas State Engineering Academy, Kramatorsk. All the students participated in physical activity twice a week.

Organization of the study

To solve the tasks set, the following research methods were used: analysis of scientific-methodological and medical literature, pedagogical observation, index method, medical and biological methods, ascertaining experiment, and methods of mathematical statistics.

The program of functional state testing included the Ruffier index, the Stange test, and the Genchi test given in Tables 1, 2 (Romanenko, 1999; Dubrovskij, 2005).

Testing procedure

Ruffier index. The test was used to assess the cardiovascular system activity. Equipment required. Stopwatch.

Test description. On command, the participant, after 5 minutes of sitting calmly, counts the number of pulses for 15 seconds, then performs 30 squats for 45 seconds. Immediately after squatting, the pulse is measured for the first 15 seconds and the last 15 seconds from the first minute of the recovery period.

The testing result is the Ruffier index (RI), which is calculated by the formula: $IR = (4(f_0 + f_1 + f_2) - 200)/10$, where f_0 is the heart rate before the load for 15 s; f_1 is the heart rate after the load; f_2 is the heart rate for the last 15 s from the first minute of recovery.

The cardiovascular system activity was assessed according to the index.

The Ruffier index is less than 0 – athletic heart;
0.1–5 – excellent (very good heart);
5.1–10 – good (good heart);
10.1–15 – satisfactory (heart with moderate insufficiency);
15.1–20 – bad (heart with significant insufficiency).

General instructions and remarks. When measuring the pulse, the student places 2–4 fingers on the inside of her left hand near the thumb and gently presses the artery to the bone or places her hand on the carotid artery (it is comfortable to do this on the right side). Upon the instructor's command and simultaneous start of the stopwatch, the counting begins for 15 seconds with further recalculation for 1 minute.

Stange test (voluntary inspiratory breathhold). The test was used to assess the respiratory system activity.

Equipment required. Stopwatch. The participant stands and does several deep breathing cycles. After a full inhale, she closes her mouth (tightly closes her lips) and pinches the wings of her nose with the thumb and index finger. The stopwatch determines the time from the moment of breathhold to its recovery. The respiratory system activity was assessed by the indicator of breathhold duration:

more than 90 s – excellent;
from 60 to 90 s – good;
from 30 to 60 s – satisfactory;
less than 30 s – bad (unsatisfactory).

Genchi test (expiratory breathhold). The test was used to assess the respiratory system activity. After several breathing cycles, the subject fully exhales, closes her mouth and pinches her nose with her fingers. The stopwatch records the time of breathhold. The respiratory system activity was assessed by the indicator of breathhold duration:

more than 50 s – excellent;
from 35 to 50 s – good;
from 20 to 35 s – satisfactory;
less than 20 s – bad (unsatisfactory).

Statistical analysis

The study results were processed using the method of mathematical statistics. The study calculated: arithmetic mean (x), error in calculating the arithmetic mean (s); significance of difference between means (t). The significance of difference between statistical indicators (t) was evaluated using the Student's t-test.

Results

Table 1 shows the results of analysis of the cardiovascular and respiratory systems of the 1st-5th year female students. As a result of comparison of the indicators of heart rate and breathhold tests, the study determined average indicators characterizing the peculiarities of the cardiovascular and respiratory systems in women aged 18-22 years.

At 19, there is a significant deterioration in the results of breathhold in the Stange test (49 s) and the Genchi test (38 s) ($P < 0.05$). The Ruffier index, heart rate indicators f0, f1, f2 do not change.

At the age of 19-20 (2nd-3rd years of study), no changes are observed in all indicators.

At the age of 21, there is a decrease in the Ruffier index (12.4 – "satisfactory") and the average heart rate after exercise (f1 = 34.7), while there is a decrease in heart rate (f2 = 25.8) after a standard recovery pause ($P < 0.05$). This indicates that during this period there occur the most successful compensatory processes of cardiovascular activity.

At 21-22 (4th-5th years of study), there is an increase in heart rate before exercise (f0) and improvement in the indicators of the Stange test. The Ruffier index, the number of pulses after exercise, the heart rate recovery response, and the Genchi test do not change. This indicates that with age there are characteristic signs of heterochrony and sensitivity of the functional state of the female body.

The obtained Ruffier index and the results of comparative analysis of the functional fitness for cardiovascular assessment show that with age the number of female students with a "satisfactory" Ruffier index increases (59.4%), and a "good" heart indicator decreases (15.6%).

Table 1. Results of testing of the functional fitness of 1st-5th year female students

No.	Test	1st year (n = 44)		2nd year (n = 38)		3rd year (n = 42)		4th year (n = 44)		5th year (n = 32)		t_{1-2}	t_{2-3}	t_{3-4}	t_{4-5}
		X	s	X	s	X	s	X	s	X	s				
1	Ruffier index	12.59	0.57	13.62	0.84	14.91	0.80	12.44	0.66	13.33	0.79	1.02	1.11	2.39	0.90
2	f_0	20.61	3.26	21.11	5.43	21.69	0.87	20.52	0.49	22.70	0.68	0.49	0.47	0.17	2.68
3	f_1	34.41	5.34	35.74	6.42	37.81	1.35	34.73	1.23	35.90	0.98	1.01	1.21	2.47	0.99
4	f_2	26.45	3.91	27.21	4.79	27.79	0.93	25.84	0.61	24.80	0.89	0.78	0.47	1.75	1.08
5	Stange test (s)	57.19	15.97	48.79	17.92	50.90	2.58	47.50	2.39	54.10	1.88	2.22	0.54	0.97	1.78
6	Genchi test (s)	45.53	12.66	37.55	13.78	13.76	1.80	40.80	2.63	37.90	1.21	2.71	0.28	1.25	0.79

Table 2. Ruffier index indicators of 1st-5th year female students

No.	State of the cardiovascular system, %	1st year (18 years)	2nd year (19 years)	3rd year (20 years)	4th year (21 years)	5th year (22 years)
		(n = 44)	(n = 38)	(n = 42)	(n = 44)	(n = 32)
1	"bad" - significant heart insufficiency	27.3	36.8	40.5	22.7	25
2	"satisfactory" - moderate heart insufficiency	50.0	31.6	45.2	50.0	59.4
3	"good" – good heart	20.5	28.9	14.3	22.7	15.6
5	"excellent" – athletic heart	2.2	2.7	0	4.6	0

Discussion

The study assumed that the dynamics of the functional state of the cardiovascular and respiratory systems in women aged 18-22 years has its peculiarities. It was found that with age the number of female students with a "satisfactory" Ruffier index increases (59.4%), and a "good" heart result decreases (15.6%). The age of 19-20 is problematic in the functional fitness of women's cardiovascular and respiratory systems.

The obtained data confirm that the third year is a problematic period in physical education of students (Chernenko, Iermakov, Oliinyk, & Dolynnyi, 2018; Chernenko, Jagiello, Ivashchenko, Khudolii, & Pashkevich, 2021).

Decreased indicators of the functional fitness of the cardiovascular and respiratory systems in women aged 19-20 testify to insufficient physical load in the process of physical education of students and complement the data on the need for additional introduction of more intensive forms of training to the system of physical education of students (Solohubova et al., 2020; Amin et al., 2019; Choi et al., 2021), and on the importance of motor activity in the educational process of students (Lynch & Sargent, 2020; Tohmea et al., 2020; Hovey et al., 2020).

The obtained data point to prognostic significance of heart rate and a tendency towards an increase in resting heart rate of students (1st-5th years of study), which confirms the study on the influence of resting heart rate on deterioration of the functional fitness of the human cardiovascular system (Baevskii, 1979; Amosov, & Bendet, 1989).

Thus, the Ruffier index, the Stange test, and the Genchi test can be used to assess the functional fitness of 1st-5th year female students.

Conclusions

The results of comparative analysis show that with age the number of female students with a "satisfactory" result of the Ruffier index increases (59.4%), and a "good" heart result decreases (15.6%). The age of 19-20 is problematic in the functional fitness of women's cardiovascular and respiratory systems.

Decreased indicators of the functional fitness of the cardiovascular and respiratory systems in women aged 19-20 testify to insufficient physical load, their low motor activity and point to the need for additional introduction of more intensive forms of training to the system of physical education of students.

The Ruffier index, the Stange test, and the Genchi test can be used to assess the functional fitness of 1st-5th year female students.

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Conflict of interest

The authors declare that there is no conflict of interest.

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ВПЛИВ ФІЗИЧНОГО ВИХОВАННЯ НА ОСОБЛИВОСТІ ФУНКЦІОНАЛЬНОГО СТАНУ СЕРЦЕВО-СУДИННОЇ ТА ДИХАЛЬНОЇ СИСТЕМИ СТУДЕНТОК 18-22 РОКІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 5 с., 2 табл., 23 джерела.

Мета дослідження – визначити вікові особливості функціонального стану серцево-судинної та дихальної системи студенток 1-5 курсів вищої школи.

Матеріал і методи. У дослідженні взяли участь 200 студенток: 1-го курсу (n = 44); 2-го курсу (n = 38); 3-го курсу (n = 42); 4-го курсу (n = 44); 5-го курсу (n = 32). Для вирішення поставлених завдань були застосовані наступні методи дослідження: аналіз науково-методичної та медичної літератури, педагогічне спостереження, метод індексів, медико-біологічні методи, констатуючий експеримент та методи математичної статистики.

Результати. У дослідженні встановлено, що у 19 років спостерігається значне погіршення результатів затримки дихання проби Штанге (49 с) та Генче (38 с) ($P < 0,05$). У віці 21 рік відбувається зменшення індексу Руф'є (12,4 – «задовільно») та середнього значення пульсу після навантаження (f_1 = 34,7), одночасно спостерігається зменшення серцевих скорочень (f_2 = 25,8) після стандартної паузи відновлення ($P < 0,05$). Це вказує, що у цей період найбільш успішно відбуваються компенсаторні процеси серцево-судинної діяльності. У 21-22 роки (4-5 курс) простежується збільшення ударів пульсу до навантаження (f_0), покращується показник проби Штанге.

Висновки. За результатами порівняльного аналізу спостерігається з віком збільшення кількості студенток з результатом оцінювання індексу Руф'є «задовільно» (59,4%), а також зменшується показник «добре» серце (15,6%). У 21 рік жінки демонструють кращі показники ЧСС, а у 22 роки мають кращі результати у затримці дихання в умовах гіпоксії.

Ключові слова: жінки, індекс Руф'є, частота серцевих скорочень, проба Штанге, Генчі.

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