ORIGINAL ARTICLE

CONTENTS

Improving physical working capacity of high school students in the process of their functional training

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ABSTRACT

Aim: To investigate the effectiveness of functional training implementation for improving the physical working capacity of high school students in physical education.

Materials and Methods: The research, which was conducted in 2024-2025, involved 176 high school students aged 16, of whom the experimental (EG) and the control (CG) groups were formed. Functional training was introduced into the physical education classes of the EG, while the CG high school students studied according to the existing program. The following indices were used to assess high school students' physical working capacity: Rufier index, Kerdo vegetative index, circulatory efficiency coefficient, Stange and Genchi tests.

Results: During the research period the EG revealed a significant ($p \leq 0.05$-0.001) improvement in the Rufier index by 0.8 c. u. in boys and by 0.6 c. u. in girls, the Kerdo index – by 0.8 c. u. in boys and by 0.9 c. u. in girls, circulatory efficiency coefficient – by 175.8 c. u. in boys and 189.3 c. u. in girls, the Stange test – by 6.7 seconds in boys and 5.8 seconds in girls, the Genchi test – by 4.3 seconds in boys and 3.9 seconds in girls. At the end of the experiment, the EG high school students had all studied indicators significantly better than the CG's.

Conclusions: The results of the conducted experiment prove the effectiveness of functional training implementation in physical education of high school students to improve their physical working capacity.

KEY WORDS: physical working capacity, functional training, high school students, physical education, cardiovascular system, respiratory system, health

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INTRODUCTION

In today's living conditions in Ukraine, schooling harms children's health. At the same time, innovative educational institutions often accumulate the disadvantages of traditional schools, exacerbating this impact. The intensification of the educational process, permanent stress during martial law causes an increase in the load on the functional state of the high school students' bodies, resulting in changes characterized by a decrease in the functional reserve of the heart, deterioration of mental and physical working capacity, and a limitation of the body's adaptation and adjustment capabilities to motor activity. Excessive study loads, insufficient motor activity during the educational process, and violation of the day and sleep regime during air raids harm the bodies of high school students, whose formation is not yet complete [1-3].

In the context of the implementation of developmental learning technology, a significant number of high school students experience signs of fatigue, which is accompanied by a decrease in working capacity and an increase in morbidity [4, 5]. In recent years, education reforms have been accompanied by the emergence of innovative educational institutions (gymnasiums, lyceums), which are characterized by increased intellectual workload, increased mental stress, decreased motor activity, and intensified learning. At the same time, the volume of high school students' academic workload has increased to such an extent that the resulting limitations of muscle effort and increased neuropsychological stress cause various diseases, deterioration of physical condition, in particular physical working capacity [6, 7].

A high physical working capacity indicates good health; vice versa, a low level is a risk factor. Physical working capacity is associated with motor activity and lower morbidity, including cardiovascular diseases, which are among the leading causes of morbidity among children and youth [8-10]. Thus, the importance

of physical working capacity for the younger generation's health actualizes the search for and application of new, effective physical education and health-improving methods and technologies in school physical education.

AIM

The aim is to investigate the effectiveness of functional training implementation for improving the physical working capacity of high school students in physical education.

MATERIALS AND METHODS

PARTICIPANTS

The research involved 176 high school students aged 16 (89 girls and 87 boys), of whom the experimental (EG) and the control (CG) groups of the general secondary education institution Lyceum No. 17 "Kyrylivskyi" in Kyiv were formed. The groups of high school students for the study were formed randomly. The EG included 85 high school students (41 girls and 44 boys) from two tenth grades (A and B), and the CG included 91 high school students (48 girls and 43 boys) from the other two tenth grades (C and D). Functional training was introduced into the main part of physical education classes in the EG, while the CG high school students studied according to the existing program. The EG and the CG with girls and boys were homogeneous ($p > 0.05$), which is confirmed by the absence of a significant difference between the studied indicators at the beginning of the experiment. The experiment lasted for 9 months in the academic year 2024-2025 (September-May), was open, and the high school students were informed about its aim and tasks, which contributed to increased interest in the classes.

Research methods include the analysis and generalization of literary sources, medical and biological methods, and statistical methods. The analysis and generalization of literary sources were employed to substantiate the theoretical problem (20 sources from the scientometric databases MedLine, Scopus, and Web of Science were analyzed). The medical and biological methods allowed us to assess the high school students' physical working capacity indicators.

Rufier index (RI, c. u.) was used to assess physical working capacity by the functional state of the cardiovascular system of high school students. The method of its measurement is as follows: after five minutes of rest, in a sitting position, the subject's pulse was counted for 15 seconds. After that, the high school student performed 30 squats with arms extended forward for 45 seconds. At the end of the squats, the pulse was counted for the first 15 seconds of the first minute of recovery and for the last 15 seconds of the first minute of recovery. The assessment of the functional capabilities of the cardiovascular system was calculated by the formula: $RI = 4 \times (P1 + P2 + P3) / 10$, where: P1 is pulse for 15 seconds at rest; P2 is pulse for the first 15 seconds of the first minute of recovery; P3 is pulse for the last 15 seconds of the first minute of recovery. The level of functional heart reserve and adaptive capacities of an organism to motor loads in 16-year-old high school students was determined taking into account five gradations: less than 3 c. u. – high level; 4-6 c. u. – above average (good); 7-9 c. u. – average; 10-14 c. u. – below average (satisfactory); more than 15 c. u. – low.

Kerdo vegetative index (KI, c. u.) characterizes myocardial blood flow and was calculated by the formula: $KI = (1 – (DBP / HR)) \times 100$, where: DBP is diastolic blood pressure, mm Hg; HR is heart rate at rest, beats per minute. An increase in the KI indicates a weakening of the reserve functions of blood circulation regulation, which leads to a decrease in the body's aerobic capacity, and its positive value means an increase in sympathetic tone. A negative value of the KI indicates a predominance of parasympathetic influences in the studied groups. Its significant negative growth indicates an increase in the reserves of the circulatory regulation function and increases the body's aerobic capacity.

Circulatory efficiency coefficient (CEC, c. u.) is intended to assess the functioning of the cardiovascular system and was calculated by the formula: $CEC = (SBP – DBP) \times HR$, where SBP is systolic blood pressure, mm Hg; DBP is diastolic blood pressure, mm Hg; HR is resting heart rate, beats per minute. The normal value of the CEC indicator is 2600-3600 c. u., which corresponds to a healthy person. If the value exceeds this indicator, it may indicate a cardiovascular system malfunction. An increase in the CEC indicates an increase in energy consumption for the movement of blood through the body, a decrease in the CEC indicates an increase in the potential capabilities of the hemocirculatory system, a decrease in energy consumption for the movement of blood through the body.

The functional state of the respiratory system was determined by the Stange test (arbitrary breath holding on inhalation) and the Genchi test (breath holding on exhalation). The results of the tests were compared with the norms. For the Stange test, these norms are: more than 40 seconds – good; 35-39 seconds – satisfactory; less than 34 seconds – unsatisfactory; for the Genchi test, respectively: 50-60 seconds – excellent; 39-45 seconds – good; 20-34 seconds – satisfactory; 10-19 seconds – poor; less than 10 seconds – very poor.

Table 1. Average indicators of cardiovascular and respiratory system functioning in 16-year-old high school students (n = 176), X ± m

Boys (n = 87)	Girls (n = 89)
RI, c. u.	
9.2 ± 0.15	7.8 ± 0.13
KI, c. u.	
4.8 ± 0.16	7.7 ± 0.18
CEC, c. u.	
3442.0 ± 45.55	3158.1 ± 46.71
Stange test, sec	
45.5 ± 1.81	40.0 ± 1.69
Genchi test, sec	
23.2 ± 0.89	23.1 ± 0.75

Legend: X is the arithmetic mean; m is the standard error of the arithmetic mean
Source: compiled by the authors of this study

Table 2. Dynamics of indicators of the functional state of the cardiovascular system of high school students of the EG (n = 85) and the CG (n = 91) during the pedagogical experiment, X ± m

Functional indices	Groups	Stages of the experiment		The difference	Reliability of the difference (t, p)
		Before	After		
		Boys			
RI, c. u.	CG	9.1 ± 0.16	8.9 ± 0.15	-0.2	t = 0.91; p > 0.05
	EG	9.0 ± 0.15	8.2 ± 0.14**	-0.8	t = 3.90; p ≤ 0.001
		Girls			
RI, c. u.	CG	7.7 ± 0.13	7.6 ± 0.12	-0.1	t = 0.57; p > 0.05
	EG	7.8 ± 0.14	7.2 ± 0.13*	-0.6	t = 3.14; p ≤ 0.01
		Boys			
KI, c. u.	CG	4.9 ± 0.15	4.7 ± 0.15	-0.2	t = 0.94; p > 0.05
	EG	4.7 ± 0.16	3.9 ± 0.14**	-0.8	t = 3.76; p ≤ 0.001
		Girls			
KI, c. u.	CG	7.8 ± 0.19	7.5 ± 0.17	-0.3	t = 1.18; p > 0.05
	EG	7.7 ± 0.18	6.8 ± 0.17**	-0.9	t = 3.64; p ≤ 0.001
		Boys			
CEC, c. u.	CG	3446.6 ± 44.97	3398.1 ± 45.14	-48.5	t = 0.76; p > 0.05
	EG	3441.4 ± 45.11	3265.6 ± 44.24*	-175.8	t = 2.78; p ≤ 0.05
		Girls			
CEC, c. u.	CG	3158.2 ± 46.39	3102.3 ± 46.51	-55.9	t = 0.85; p > 0.05
	EG	3156.7 ± 46.82	2977.4 ± 45.73*	-189.3	t = 2.89; p ≤ 0.05

Legend: X – the arithmetic mean; m – the standard error of the arithmetic mean t – Student's t-test value, p – statistical significance indicator; *, ** – reliability of the difference between the EG and the CG at the end of the research at the level of p ≤ 0.05, p ≤ 0.01
Source: compiled by the authors of this study

STATISTICAL METHODS

At the beginning of the pedagogical experiment, the homogeneity of all indicators of the EG and the CG high school students was determined, i.e., the absence of a significant difference in the studied indicators (p > 0.05), and it was found that the distributions of the EG and the CG are normal, which allowed us to assess the reliability of the results using Student's t-test. The reliability of the difference was set at p ≤ 0.05. All statistical analyses were performed using SPSS software. The results were presented as X ± m, where X is the arithmetic mean and m is the standard error of the arithmetic mean.

ETHICAL STANDARDS

The process of research implementation is built following the requirements of scientific ethics. The Academic

Table 3. Dynamics of indicators of the functional state of the respiratory system of high school students of the EG (n = 85) and the CG (n = 91) during the pedagogical experiment, X ± m

Functional indices	Groups	Stages of the experiment		The difference	Reliability of the difference (t, p)
		Before	After		
		Boys			
Stange test, sec	CG	45.5 ± 1.84	46.2 ± 1.82	+ 0.7	t = 0.27; p > 0.05
	EG	45.4 ± 1.79	52.1 ± 1.83*	+ 6.7	t = 2.62; p ≤ 0.05
		Girls			
Stange test, sec	CG	39.9 ± 1.68	40.4 ± 1.69	+ 0.5	t = 0.21; p > 0.05
	EG	40.1 ± 1.70	45.9 ± 1.75*	+ 5.8	t = 2.38; p ≤ 0.05
		Boys			
Genchi test, sec	CG	23.2 ± 0.91	24.0 ± 0.93	+ 0.8	t = 0.61; p > 0.05
	EG	23.0 ± 0.88	27.3 ± 0.92*	+ 4.3	t = 3.38; p ≤ 0.01
		Girls			
Genchi test, sec	CG	22.9 ± 0.74	23.5 ± 0.77	+ 0.6	t = 0.56; p > 0.05
	EG	23.0 ± 0.76	26.9 ± 0.79**	+ 3.9	t = 3.56; p ≤ 0.01

Legend: X – the arithmetic mean; m – the standard error of the arithmetic mean t – Student's t-test value, p – statistical significance indicator; *, ** – reliability of the difference between the EG and the CG at the end of the research at the level of p ≤ 0.05, p ≤ 0.01
Source: compiled by the authors of this study

Ethics Commission of the Ukrainian State Dragomanov University approved the research. Also this research followed the regulations of the World Medical Association Declaration of Helsinki – ethical principles for medical research involving human subjects. The participants were informed about the aim and tasks of the research, and they voluntarily participated in it.

RESULTS

Physical working capacity was determined in the process of assessing the functional state of the cardiovascular system of the 10th-grade high school students by Rufier, Kerdo indices, and circulatory efficiency coefficient, as well as by indicators of the functional state of the respiratory system by Stange and Genchi tests before and after the pedagogical experiment. The average group data of the cardiovascular and respiratory systems functioning of 16-year-old boys and girls are presented in Table 1.

Comparison of the obtained data characterizing physical working capacity in blood circulation and respiration with age norms showed that they correspond to the average level.

During the pedagogical experiment, functional training was introduced into the physical education of the EG high school students. Functional training is one of the modern physical culture and health technologies characterized by high intensity of muscle work and involvement of all muscle groups. The peculiarity of functional exercises is the strengthening and development of deep stabilizing muscles that support the spine and joints from daily loads and injuries, emphasis on the core muscles through movements with body weight and external resistance: squats, dynamic lunges, lifts, presses, burpees, bends, jumps, isometric exercises to hold the body position and their combination with various movements, etc. Functional training combines elements of gymnastics, aerobics, cardio, and strength exercises. Functional training is characterized by the following features: organization of motor activity with musical accompaniment; a wide range of physical exercises and their combinations, which allow for the development of various motor skills; absence of direct load on the skeleton and joints; possibility of easy regulation of motor loads following the gender and age characteristics and level of fitness of high school students; high dynamism and emotionality of classes. Given that physical working capacity is characterized by the potential ability to perform static, dynamic, and mixed muscle work based on the functional capabilities of the cardiorespiratory system in different modes of energy supply, the priority task in the process of functional training was to develop different types of endurance and strength.

Physical education classes based on functional training were conducted according to a structure that includes three parts: preparatory, main, and final (recovery). The preparatory part solved the following tasks: organizing high school students and activating their attention; creating an appropriate psychological attitude and positive emotional state; preparing the

body for future motor activity. The classes began with an aerobic part, including a general developmental exercise warm-up. The duration of the preparatory part is 20 % of the training time. The structure of the main part of the lesson depended on the tasks set. If the task was to promote the development of general endurance, the aerobic long protocol was used, which involved 1-5 minutes of work and more, depending on the level of high school students' fitness. If the task was to promote the development of strength and anaerobic endurance, the aerobic short protocol was used, which provided 30-60 seconds of work. At the same time, strength exercises were used to develop the muscles of the abdominal press, trunk, shoulder girdle, muscles of the legs, and arms. The pace of the exercises was chosen as intensive (as many repetitions of the exercise as possible) or extensive (performing the exercise at an individual pace). At an intensive pace, a relatively complete rest was planned (90-120 seconds), at an extensive pace – a rigid rest between series of exercises was planned (until incomplete recovery 60 seconds). The duration of the main part is 70 % of the training time. After each series of strength exercises, exercises to stretch the working muscles were performed. The final part made up 10 % of the training time and involved the use of stretching exercises (elements of stretching, Pilates); restorative breathing exercises (elements of breathing exercises); relaxation exercises (elements of yoga).

Depending on the targeted focus of classes with high school students, the level of their motor and functional abilities, and other factors, the generalized structure of functional training had different variations. Special equipment was used in physical education classes: fitballs, rubber balls, jump ropes, expander-loops, weighting cuffs, dumbbells of different weights, which allowed for diversifying classes and more purposefully influencing the body of high school students to increase their physical working capacity. From this point of view, we considered functional training a highly effective system of health-improving classes aimed at improving physical conditions, health promotion, and harmonious physical development of high school students.

During the pedagogical experiment, the CG high school students studied according to the current physical education curriculum. To determine the effectiveness of functional training at the end of the school year, control measurements of the functional state of the cardiovascular and respiratory systems were conducted in the EG and the CG high school students. As a result of the introduction of functional training into the physical education of high school students, there is a statistically significant ($p \leq 0.05$-0.001) difference between all studied indicators before and after the experiment, both in boys and girls of the EG. The difference between indicators before and after the experiment in the CG was not significant ($p > 0.05$) (Table 2).

The analysis of the RI shows that during the experiment the indicators of the EG high school students significantly ($p \leq 0.01$) improved by 0.8 c. u. in boys and by 0.6 c. u. in girls, in contrast to the CG, where the difference between the initial and final data of the experiment was 0.2 and 0.1 c. u. in boys and girls, respectively ($p > 0.05$). The comparative analysis of the RI in the EG and the CG at the end of the research shows that functional training has a more pronounced positive effect on improving the functioning of the cardiovascular system in 16-year-old high school students compared to the current school curriculum: the indicators of the RI in the EG at the end of the experiment were significantly better than in the CG by 0.7 c. u. in boys ($p \leq 0.01$) and by 0.4 c.u. in girls ($p \leq 0.05$). Analysis of the KI also testifies to the positive influence of functional training classes on the functional state of the cardiovascular system of high school students of the EG: more expressed changes in the indicators of the KI were revealed in the EG than in the CG during the research period. Thus, in the EG boys the value of the KI significantly decreased by 0.8 c. u., and in girls – by 0.9 c. u. ($p \leq 0.001$); in the CG, there was also an improvement in the KI, but the changes were not significant ($p > 0.05$). At the end of the research, the EG indicators were significantly better than in the CG by 0.8 and 0.7 c.u. in boys and girls, respectively ($p \leq 0.01$). The obtained results testify to the strengthening of reserves of the function of blood circulation regulation in the EG high school students, which leads to the growth of aerobic capacities of their organism. The analysis of the CEC indicators confirms our previous conclusions about the effectiveness of functional training on the functioning of the cardiovascular system of the EG high school students. During the research period, the EG boys and girls, in contrast to the CG, had a significant ($p \leq 0.05$) decrease of the CEC values by 175.8 and 189.3 c. u. respectively, which indicates an increase of potential capabilities of hemocirculatory system, decrease of energy expenditures for blood movement through the body. At the end of the research, the CEC indicators in the EG were also significantly better than in the CG, by 132.5 and 124.9 c. u. in boys and girls, respectively ($p \leq 0.05$).

Positive dynamics in both groups' breath samples of high school students during the experiment were also established, but changes were reliable only in the EG (Table 3).

The analysis of the indicators of the Stange and Genchi tests in high school students at the end of the research showed that both the EG boys and girls had

significantly ($p \leq 0.05$-0.01) better indicators than the CG, by 5.9 seconds and 5.5 seconds in the Stange test and by 3.3 seconds and 3.4 seconds in the Genchi test in boys and girls, respectively. This indicates the effectiveness of functional training on improving the functioning of the respiratory system in 16-year-old high school students. Thus, due to the introduction of functional training in the process of physical education of 16-year-old high school students, there is a significant improvement in the activity of their cardiovascular and respiratory systems. In addition, according to the results of attending classes, the developed program improved the level of motivation of high school students to systematic physical exercises.

DISCUSSION

The effectiveness of the educational process in physical education depends on many factors, in particular, on the choice of sports by high school students, the qualifications of the physical education teacher, climatic and geographical conditions, the condition of the equipment, the availability of appropriate equipment, during classes in the gymnasium, swimming pool, playground or outdoor sports ground, stadium, natural environment, and others [11, 12]. At the same time, functional training is considered to be a very promising health-improving technology that is accessible and quite popular among young people, expands opportunities for improving physical fitness, functional capabilities of the body, motivation for motor activity, improving physique, muscle relief, psycho-emotional state, manifestation of high school students' individuality, and diversification of the process of physical education [13, 14].

Functional training consists of aerobics, cardio training and strength training with musical accompaniment, includes a wide range of physical exercises taking into account interests and needs of high school students and their level of fitness, does not require special qualification from physical education teacher, special conditions for classes, sophisticated equipment and inventory, allows to vary motor loads and methods of organization of those engaged (frontal, game, circle) and to engage any number of high school students [15, 16].

Motor exercises of functional aerobics training include general developmental exercises in sitting and lying position (exercises for feet, exercises for legs in lying position and in kneeling position, exercises for abdominal muscles in lying position on the back, exercises for back muscles in lying position on the stomach and in kneeling position); in a standing position (exercises for arms and shoulder girdle in different directions, exercises for torso and neck, exercises for legs); stretching exercises, basic aerobics steps, types of running in place, jumps, static exercises for holding static positions in a supine position, lying on bent arms, the same supports in combination with accompanying movements [17, 18].

Scientists [19, 20], according to the results of their research, note that when choosing physical exercises for functional training classes, it is necessary to consider the age, gender, and level of physical fitness of those who are engaged. At the same time, the exercises are performed at an intensive and extensive pace and provide for relatively complete and rigid rest options, i.e. until incomplete recovery, which, through the targeted development of strength and various types of endurance, allows for an impact on aerobic working capacity, increasing the physical working capacity of the high school students' bodies. Our research confirms the conclusions of many scientists that functional training has potential for improving the morphological and functional status of the body, increasing the speed of metabolic processes, which contributes to weight loss by burning fat. In addition, the pedagogical effect of using functional training in the process of physical education of 16-year-old high school students is observed since this age is a sensitive period for the development of strength and endurance. Other scientists share a similar opinion [13, 16].

Our results also complement the results of other scientists in terms of the fact that the variability of the content of functional training classes due to a wide range of motor loads and a variety of equipment arouses a keen interest in both boys and girls. The impact on the psycho-emotional state of high school students is achieved through musical accompaniment. In addition, in our opinion, for the first time we have identified the strategic importance of including functional training in rationally organized motor activity of high school students is that it has an impact on the psycho-emotional and physical state of the body, namely, reducing permanent stress of high school students during martial law, improving the functional reserve of the heart, physical working capacity, adaptation and adjustment capabilities of the body to motor loads.

CONCLUSIONS

As a result of the implementation of functional training in the EG high school students, there were recorded reliable positive changes in indicators of the functional state of the cardiovascular and respiratory systems. During the research period in the EG there was a sig-

nificant ($p \leq 0.05$-0.001) improvement of the indicators of the RI by 0.8 c. u. in boys and by 0.6 c. u. in girls, the KI – by 0.8 c. u. in boys and by 0.9 c. u. in girls, the CEC – by 175.8 c. u. in boys and 189.3 c. u. in girls, the Stange test – by 6.7 seconds in boys and 5.8seconds in girls, the Genchi test – by 4.3 seconds in boys and 3.9 seconds in girls. As for the dynamics of physical working capacity of the CG boys and girls according to all studied indicators of the functional state of the cardiovascular and respiratory systems, it is positive, but does not have statistical significance ($p > 0.05$).

At the end of the experiment, all studied indicators in the EG high school students were significantly ($p \leq 0.05$-0.001) better than in the CG. Thus, the indicators of the RI in the EG are better than in the CG by 0.7 and 0.4 c. u. in boys and girls, respectively; the indicators of the KI – by 0.8 and 0.7 c. u. in boys and girls, respectively; the indicators of the CEC – by 132.5 and 124.9 c. u. in boys and girls, respectively; the indicators of the Stange and the Genchi tests by 5.9 and 5.5 seconds and by 3.3 seconds and 3.4 seconds in boys and girls, respectively. This indicates that functional training has a more pronounced positive effect on improving the functioning of the cardiovascular and respiratory systems in 16-year-old high school students compared to the current school curriculum. The results also indicate an increase in the reserves of the circulatory regulation function in the EG high school students, which leads to an increase in the aerobic capacity of their bodies and health improvement.

The results of the conducted pedagogical experiment allow us to assert the effectiveness of functional training for increasing the physical working capacity of 16-year-old high school students in physical education classes.

PROSPECTS FOR FURTHER RESEARCH

Further research will be directed to the determination of the influence of functional training on high school students' somatic and mental health.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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