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THE DIFFERENTIATED TRAINING AND ITS IMPACT ON THE FUNCTIONAL STATE OF THE CARDIOVASCULAR SYSTEM AND THE LEVEL OF ENDURANCE DEVELOPMENT OF 13–15-YEAR-OLD PUPILS

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Zróźnicowany trening i jego wpływ na stan funkcjonalny układu sercowo-naczyniowego oraz poziom rozwoju wytrzymałości u uczniów w wieku 13–15 lat

Streszczenie

Zastosowanie zróźnicowanego treningu w procesie wychowania fizycznego w celu poprawy stanu funkcjonalnego młodzieży szkolnej jest istotnym zagadnieniem. Badano skuteczność zasto-

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sowania zróżnicowanego treningu na lekcjach wychowania fizycznego, uwzględniając wskaźniki funkcjonalnego stanu układu sercowo-naczyniowego oraz poziom rozwoju wytrzymałości uczniów w wieku 13–15 lat. Przebadano 226 uczniów w wieku 13–15 lat (107 chłopców i 119 dziewcząt). Utworzono trzy grupy eksperymentalne i trzy grupy kontrolne. Na początku badania stwierdzono: niżej niż przeciętny poziom regulacji układu sercowo-naczyniowego; przeciętny poziom reakcji układu sercowo-naczyniowego na standardowe obciążenie fizyczne; niski poziom rozwoju wytrzymałości u uczniów w wieku 13–15 lat. Po wdrożeniu systemu ćwiczeń opartych na zróżnicowanym treningu, ukierunkowanych na podniesienie poziomu przygotowania funkcjonalnego, zaobserwowano pozytywne zmiany wskaźników układu sercowo-naczyniowego ($p < 0,05$ – $0,001$) oraz istotny statystycznie wzrost wyników rozwoju wytrzymałości w grupach eksperymentalnych ($p < 0,001$). W grupach kontrolnych nie odnotowano istotnych zmian w żadnym z badanych parametrów ($p > 0,05$). W rezultacie stan funkcjonalny układu sercowo-naczyniowego wzrósł z poziomu poniżej przeciętnego do przeciętnego, a poziom rozwoju wytrzymałości – z niskiego do poniżej przeciętnego w grupach eksperymentalnych.

Słowa kluczowe: zróżnicowanie, zdrowie, sprawność fizyczna, lekcje.

Abstract

The application of differentiated instruction in physical education to improve the functional state of school-aged youth is a relevant issue. This study investigated the effectiveness of using differentiated instruction in physical education classes, taking into account indicators of the cardiovascular system's functional state and the endurance level of students aged 13–15. A total of 226 students aged 13–15 (107 boys and 119 girls) were examined. Three experimental and three control groups were formed. The baseline assessment revealed a below-average level of cardiovascular regulation, an average response level of the cardiovascular system to standard physical load, and a low level of endurance development among 13–15-year-old students. Following the implementation of a system of differentiated instruction exercises aimed at improving functional readiness, positive changes in cardiovascular system indicators were observed ($p < 0.05$ – 0.001), along with a statistically significant improvement in endurance development results in the experimental groups ($p < 0.001$). In the control groups, no significant changes were found in any of the studied parameters ($p > 0.05$). As a result, the functional state of the cardiovascular system improved from below average to average, and the level of endurance development increased from low to below average in the experimental groups.

Keywords: differentiation, health, physical fitness, lessons.

Introduction

The economic, social and spiritual development of any country and Ukraine in particular, is impossible without a healthy nation. Health is the main value of a person, a healthy population is the value of the state, and a healthy younger generation is an investment now and a prospect for the development of the state in the future. However, research findings (Bala & Masliak, 2011; Bala, 2012; Azhippo et al., 2016; Maslyak, et al., 2016; Mameshyna, 2016; Platonova, A, Podrigalo, L, et al., 2018) show that the health of the younger generation is deteriorating significantly, especially among school-age children. It has been

found that 80% of pupils have various diseases, 60% have a low level of physical development, and only 20% of children are practically healthy (Moskalenko & Yelisieieva, 2016; Kryvoruchko & Masliak, 2016; Bala et al., 2017; Petrova & Bala, 2020). This situation, according to the authors, is directly related to insufficient physical activity, which results in a decrease in the functional state of the body's major systems, the level of development of physical qualities, and deterioration of health (Platonova, Podrigalo, & Sokol, 2013).

Physical education is the main and effective factor in compensating for the lack of physical activity. At the same time, Krutsevych et al. (2016); Kolumbet & Dudorova (2016); Moskalenko et al. (2019) point out that standard content, generally accepted methods, and template forms of physical education in educational institutions do not provide the necessary health-improving effect.

Therefore, representatives of the science and practice of physical education are looking for new innovative ways to solve this problem. Thus, to improve the effectiveness of physical education of pupils, Maslyak, et al., 2016, proposes the introduction of a set of special exercises aimed at improving the functional state of the vestibular analyzer; Alexandr Aghyppo, et al., 2018, to improve the functions of the motor analyzer; Tetiana Bala, et al., 2018, cheerleading exercises; Marchenko & Taranenko, 2020, basic elements of Kyokushinkai karate. It should be noted that a differentiated approach remains one of the most relevant areas for improving the effectiveness of physical education. According to experts, a differentiated approach makes it possible to take into account not only the gender and age of the child, but also other informative indicators (Bodnar & Stefanyshyn, 2016; Bondarchuk, 2016).

The analysis of scientific and methodological literature has revealed a number of studies on this issue. For example, a differentiated approach to the physical health of children with different somatotypes is advocated by Delbani Hassan, 2014; Mysiv et al., 2016, taking into account the constitutional identification of primary pupils in Lebanon. Differentiated teaching of 13–15-year-old pupils taking into account physical health is advocated by Masliak & Mameshyna, 2018; differentiation of the content of physical education classes taking into account the indicators of physical fitness of pupils - Mameshyna, 2020.

However, the issue of application of differentiated training in physical education lessons taking into account indicators of functional state of cardiovascular system and level of endurance development of 13–15-year-old pupils remains unexplored.

In our view, the modernization of physical education lessons through the application of differentiated instruction—based on grouping students into homogeneous subgroups according to their identified individual characteristics significant to the learning process—and the supplementation of the variable section of the curriculum with functional training exercises will contribute to im-

proving the functioning of the cardiovascular system and increasing the level of endurance development in adolescents.

This assumption determined the purpose of the research - to test experimentally the effectiveness of differentiated training in physical education lessons, taking into account the indicators of the functional state of the cardiovascular system and the level of endurance development of 13–15-year-old pupils.

Methods

Participants. The study was conducted at General Secondary Education Institution No. 150 in Kharkiv, Ukraine. A total of 226 pupils aged 13–15 years took part in the research (107 boys and 119 girls). Three experimental groups and three control groups were formed.

The study involved pupils from both the main and preparatory medical groups. All participants were in generally good health and were under regular supervision by the school physician. Written informed consent for participation was obtained from the pupils' parents.

Study Design. The research methodology included theoretical analysis and synthesis of scientific and methodological literature, biomedical methods (heart rate and blood pressure monitoring), a pedagogical experiment (comprising ascertaining and formative stages), and methods of mathematical statistics.

Assessment Tools. The functional potential of the cardiovascular system was assessed using the Robinson Index, which reflects the regulatory efficiency of the cardiovascular system, and the Ruffier Index, which evaluates tolerance to standardized physical load. To calculate these indices, heart rate (HR) at rest and after a standard load (30 squats in 45 seconds), as well as arterial blood pressure (BP), were measured. The Robinson Index was calculated as follows: $HR \text{ (beats/min)} \times \text{systolic BP (mmHg)} / 100$. The Ruffier Index was calculated using the formula: $[4 \times (P_1 + P_2 + P_3) - 200] / 10$. Where P_1 is the heart rate for 15 seconds at rest, P_2 is the heart rate during the first 15 seconds of recovery after the load, and P_3 is the heart rate during the last 15 seconds of the first recovery minute. The constants 4, 200, and 10 are fixed values in the formula.

The obtained results were compared against evaluation tables developed by Mameshyna and Masliak (2020), which provided point-based assessments.

Physical Fitness Assessment. The level of general endurance development among the pupils was determined using the standard motor test "Jumping out from a squatting position with deflection" (maximum number of repetitions), which has a reliability coefficient greater than 0.6.

Testing Procedure. The test began from the initial position: the participant assumed a squatting stance with feet slightly apart and fingertips touching the

ground or floor. At the signal, the pupil performed consecutive vertical jumps using both legs. In the final phase of the jump, the torso had to extend into a backward arch, with arms swinging upward to accompany the movement. After landing, the pupil returned to the initial position. The jumps were performed continuously, without pauses. *Outcome measure:* the result was defined as the maximum number of correctly performed repetitions. The data were evaluated using a point-based scale developed by Serhienko (2010).

Study Stages. The research was conducted over several phases throughout the academic year.

At the first stage, a diagnostic (ascertaining) experiment was carried out to assess the baseline condition of the cardiovascular system and the level of endurance development in the participating pupils. No statistically significant differences were found between the experimental and control groups at this stage.

Based on the results of the ascertaining experiment, the pupils in the experimental groups were further divided into homogeneous subgroups, taking into account individual characteristics relevant to the educational process.

The pupils who received low scores (1–2 points) for the Robinson and Ruffier indices—indicating insufficient functional capacity of the cardiovascular system—were assigned to *subgroup A*. The pupils with low scores (1–2 points) for the Skibinski index—indicating limited respiratory system function—were assigned to *subgroup B*. The pupils who demonstrated poor development of speed and strength were placed in *subgroup C*, while those with low scores in coordination and flexibility were assigned to *subgroup D*. The pupils with reduced endurance were generally included in subgroup A, with priority given to the lower of the two cardiovascular indices (Robinson or Ruffier).

To enable differentiated instruction, the physical education curriculum was divided into two components—*core* and *optional* (Figure 1).

The *core component* included mandatory motor activities such as technical-tactical exercises from basic sports (basketball, volleyball, football, athletics), as well as general physical training exercises.

The *optional component* was differentiated based on the pupils' individual typological characteristics and was structured into two blocks: the first focused on *functional training*, while the second addressed *physical conditioning*.

Each homogeneous subgroup received a tailored system of differentiated exercises aimed at enhancing the functional state of major physiological systems and improving the development of physical qualities.

At the second stage, the developed differentiated training program was implemented into the physical education curriculum for the pupils in the experimental groups.

Lesson Structure and Implementation. The structure of the physical education lesson was standard, while the implementation of the developed instruc-

tional content and pupil organization followed a customized authorial framework. The *preparatory part of the lesson* lasted 10 minutes and included exercises aimed at preparing the body for the main workload (drill exercises, various types of walking and running, general developmental exercises).

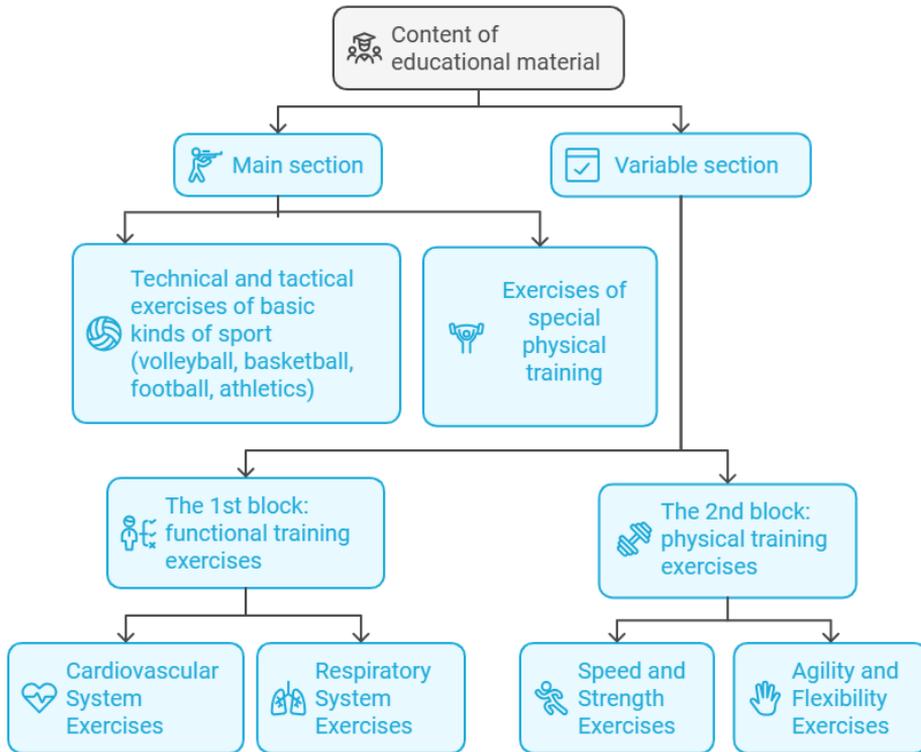


Figure 1

Content of educational material for differentiated learning in physical education lessons

During the first 15 minutes of the *main part of the lesson*, the pupils in the experimental groups practiced technical elements of the selected sports modules—basketball, volleyball, football, and athletics. After this initial activity, the pupils were divided into four previously formed typological subgroups (A, B, C, D). Each subgroup received printed instructional materials, i.e., each pupil was given an individual task card listing exercises, methodological guidance, and dosage recommendations.

During the subsequent 15 minutes, the pupils in *subgroup A* performed exercises designed to enhance the functional state of the cardiovascular system. The physical exercise program included basic cardio elements from CrossFit training, such as *burpees* (transition from standing to prone position and back), *walking lunges*, single, double, and triple rope jumps, as well as aerobic exer-

cises like brisk walking and fast-paced running. The intensity was gradually increased, not exceeding 60–80% of maximum effort, with a peak heart rate not surpassing 170–180 beats per minute.

The pupils in *subgroup B* focused on exercises aimed at improving the respiratory system. These included intercostal and diaphragmatic strengthening exercises, as well as exercises involving forced inhalation and exhalation.

The pupils in *subgroup C* performed exercises focused on the development of speed (e.g., tempo-varied runs, running between markers) and strength (e.g., resistance exercises, pull-ups, speed-strength combinations).

The pupils in *subgroup D* engaged in exercises designed to improve coordination (e.g., turns of 90°, 180°, and 360°; balance exercises on limited surfaces; rhythmic exercises to music) and flexibility (e.g., springy bends from various positions, leg swings, half-splits, etc.).

The final part of the lesson focused on recovery, incorporating calming activities such as slow walking, breathing, and attention exercises. Each pupil was assigned a differentiated home task based on their individual abilities. This segment lasted 5 minutes.

The content of physical education lessons in the control groups was oriented toward achieving objectives related to technical and specialized physical training within the selected sports modules (volleyball, basketball, football, athletics), and instructional conditions followed a typical organizational model.

Formative Stage. At the third stage, a formative comparative pedagogical experiment was conducted to assess the effectiveness of the author's instructional design. The study focused on evaluating changes in the cardiovascular functional state and endurance levels of 13–15-year-old pupils.

Statistical Analysis

The research data were processed using SPSS software (version 25.0). For each measurement, the mean value and standard error were calculated. The normality of data distribution was assessed using the Kolmogorov–Smirnov test. To determine differences between groups, analysis of variance (ANOVA) was applied. The level of statistical significance was set at $p < 0.05$.

Results

The analysis of baseline results revealed no statistically significant differences between the experimental and control groups across all studied parameters ($p > 0.05$).

A comparison of the mean Robinson index values among 13–15-year-old pupils with reference evaluation tables prior to the experiment indicated a below-

average level (2 points) of cardiovascular system regulation. Similarly, based on the Ruffier index results and their comparison with standard evaluation tables, the pupils demonstrated an average level (3 points) of cardiovascular response to standard physical load.

Assessment of the standing broad jump with arching, compared to normative scales, showed a low level (1 point) of endurance development among the 13–15-year-old pupils.

Following the implementation of the developed system of differentiated physical exercises (Tab. 1 and 2), analysis of the post-intervention data characterizing the functional state of the cardiovascular system (Robinson index) demonstrated improvements in blood pressure and heart rate values among the pupils in the experimental groups. These differences were statistically significant ($p < 0.01$ – 0.001).

Table 1

Cardiovascular system indicators of the boys in the experimental and control groups before and after the experiment

Indicators	Group	Before the ex-	After the ex-	ANOVA		
		periment	periment	t	p	
		X±SE	X±SE			
13 years old (n=18) (n=10)						
Heart rate (bpm ⁻¹)	E	83.11±2.99	75.17±0.95	3.87	<0.01	
	C	80.70±2.68	80.50±2.41	0.33	>0.05	
Arterial systolic pressure (mm Hg)	E	113.28±2.24	103.33±1.93	9.91	<0.001	
	C	116.80±4.08	115.40±3.98	1.90	>0.05	
Arterial diastolic pressure (mm Hg)	E	73.83±1.76	68.06±1.35	5.77	<0.001	
	C	77.40±2.39	76.90±1.97	1.07	>0.05	
Heart rate per 15 seconds (number of times)	P ₁	E	16.00±0.61	16.33±0.54	1.52	>0.05
		C	15.30±0.50	15.10±0.51	1.21	>0.05
	P ₂	E	27.89±1.12	29.94±0.57	3.08	<0.05
		C	24.70±1.33	25.50±1.09	2.22	>0.05
P ₃	E	17.89±0.72	18.28±0.51	1.18	>0.05	
	C	17.10±0.69	17.00±0.54	0.25	>0.05	
14 years old (n=29) (n=16)						
Heart rate (bpm ⁻¹)	E	88.00±3.10	76.14±1.06	5.08	<0.001	
	C	84.81±4.90	84.19±3.28	0.35	>0.05	
Arterial systolic pressure (mm Hg)	E	120.38±2.16	102.34±1.24	11.98	<0.001	
	C	124.81±1.22	123.75±1.21	2.00	>0.05	
Arterial diastolic pressure (mm Hg)	E	77.07±1.71	68.76±0.68	6.59	<0.001	
	C	80.13±1.23	78.00±0.75	1.79	>0.05	

Table 1
Cardiovascular system indicators of the boys... (cont.)

Indicators	Group	Before the experiment	After the experiment	ANOVA		
		X±SE	X±SE	t	p	
14 years old (n=29) (n=16)						
Heart rate per 15 seconds (number of times)	P ₁	E	20.86±1.13	18.28±0.30	3.21	<0.01
		C	18.00±0.93	18.06±0.92	0.10	>0.05
	P ₂	E	31.93±1.16	32.76±0.53	1.59	>0.05
		C	30.81±1.11	32.19±1.50	1.01	>0.05
	P ₃	E	25.03±1.27	20.86±0.32	6.34	<0.001
		C	22.00±0.98	20.63±0.86	1.76	>0.05
15 years old (n=19) (n=14)						
Heart rate (bpm ⁻¹)	E	86.37±1.64	76.79±0.68	8.61	<0.001	
	C	85.14±4.07	84.29±3.90	1.60	>0.05	
Arterial systolic pressure (mm Hg)	E	124.26±2.38	109.37±1.68	9.43	<0.001	
	C	129.71±3.30	129.50±3.30	1.83	>0.05	
Arterial diastolic pressure (mm Hg)	E	82.05±1.78	71.05±0.82	7.77	<0.001	
	C	78.00±1.23	77.29±0.94	1.60	>0.05	
Heart rate per 15 seconds (number of times)	P ₁	E	22.84±1.10	19.47±0.76	7.32	<0.001
		C	19.79±1.04	20.29±0.94	1.41	>0.05
	P ₂	E	33.42±1.37	32.00±0.68	2.95	<0.05
		C	30.50±2.20	31.71±1.68	1.60	>0.05
	P ₃	E	25.58±1.01	21.74±0.77	5.57	<0.001
		C	22.36±1.39	23.07±1.03	1.61	>0.05

Abbreviations: E – Experimental group; C – Control group; P₁ – Heart rate over 15 seconds at rest; P₂ – Heart rate during the first 15 seconds of the recovery period after physical activity; P₃ – Heart rate during the last 15 seconds of the first minute of recovery; X – Arithmetic mean; SE – Standard error of the mean; t – Student's t-test value; p – Level of statistical significance.

A repeated comparison of the Robinson index with the evaluation scale showed that the scores increased by 1 point, reaching a value of 3. As a result, the level of cardiovascular system regulation among the pupils in the experimental groups improved from below average to average.

A similar analysis of the control group data (Tab. 1 and 2) revealed no significant changes ($p>0.05$), and therefore, the level of cardiovascular regulation in these groups remained below average.

A repeated analysis of the Ruffier index data, which characterizes the cardiovascular system's response to standard physical exertion (Tab. 1 and 2), demonstrated, for the most part, statistically significant improvements in the studied parameters among the pupils in the experimental groups ($p<0.05$ – 0.001).

Table 2

Cardiovascular system indicators of the girls in the experimental and control groups before and after the experiment

Indicators	Group	Before the ex- periment	After the ex- periment	ANOVA		
		X±SE	X±SE	t	p	
13 years old (n=33) (n=17)						
Heart rate (bpm ⁻¹)	E	81.55±2.43	76.15±1.08	4.00	<0.01	
	C	87.94±2.62	87.59±2.63	1.88	>0.05	
Arterial systolic pressure (mm Hg)	E	115.42±1.96	101.55±1.14	9.97	<0.001	
	C	120.71±2.80	120.53±2.80	1.85	>0.05	
Arterial diastolic pressure (mm Hg)	E	75.42±1.24	66.42±1.10	7.97	<0.001	
	C	77.82±1.70	78.00±1.75	0.47	>0.05	
Heart rate per 15 seconds (number of times)	R ₁	E	15.36±0.45	16.55±0.49	2.42	<0.05
		C	15.76±0.42	16.00±0.34	1.35	>0.05
	R ₂	E	27.15±0.68	30.33±0.68	5.73	<0.001
		C	29.71±1.54	30.94±0.87	2.01	>0.05
	R ₃	E	17.79±0.51	18.79±0.57	1.91	>0.05
		C	18.76±0.26	18.47±0.35	1.82	>0.05
14 years old (n=23) (n=12)						
Heart rate (bpm ⁻¹)	E	90.91±3.50	76.48±1.15	5.62	<0.001	
	C	88.08±2.69	87.83±2.66	1.83	>0.05	
Arterial systolic pressure (mm Hg)	E	122.22±2.03	104.26±1.37	12.83	<0.001	
	C	121.83±3.62	121.17±3.51	2.06	>0.05	
Arterial diastolic pressure (mm Hg)	E	77.70±14.5	68.83±0.73	8.44	<0.001	
	C	79.58±4.08	76.42±1.48	1.13	>0.05	
Heart rate per 15 seconds (number of times)	R ₁	E	18.09±0.79	17.26±0.32	2.00	>0.05
		C	19.17±1.27	20.33±1.38	1.15	>0.05
	R ₂	E	30.78±1.27	32.43±0.54	2.36	<0.05
		C	32.83±0.99	34.25±2.09	1.04	>0.05
	R ₃	E	21.61±1.07	19.61±0.32	3.09	<0.01
		C	24.50±1.12	23.92±1.24	0.60	>0.05
15 years old (n=23) (n=12)						
Heart rate (bpm ⁻¹)	E	86.30±4.22	76.43±1.27	3.63	<0.01	
	C	84.50±3.52	84.25±3.50	1.91	>0.05	
Arterial systolic pressure (mm Hg)	E	121.13±2.52	106.30±1.63	10.99	<0.001	
	C	124.08±3.94	119.42±2.38	2.13	>0.05	
Arterial diastolic pressure (mm Hg)	E	80.57±1.81	70.13±0.99	8.77	<0.001	
	C	83.50±2.14	81.00±2.08	2.01	>0.05	

Table 2
Cardiovascular system indicators of the girls... (cont.)

Indicators	Group	Before the ex- periment	After the ex- periment	ANOVA		
		X±SE	X±SE	t	p	
15 years old (n=23) (n=12)						
Heart rate per 15 seconds (number of times)	R ₁	E	18.30±1.10	17.26±0.54	2.10	<0.05
		C	16.50±1.45	17.50±0.69	1.62	>0.05
	R ₂	E	29.83±1.46	30.00±0.60	0.25	>0.05
		C	29.42±2.66	31.83±1.95	1.86	>0.05
	R ₃	E	23.22±0.84	19.48±0.57	7.54	<0.001
		C	21.08±1.20	22.50±1.16	1.74	>0.05

Abbreviations: E – Experimental group; C – Control group; R₁ – Heart rate over 15 seconds at rest; R₂ – Heart rate during the first 15 seconds of the recovery period after physical activity; R₃ – Heart rate during the last 15 seconds of the first minute of recovery; X – Arithmetic mean; SE – Standard error of the mean; t – Student's t-test value; p – Level of statistical significance.

The exceptions are indicators of resting heart rate for 15 s (P_1) of the boys aged 13 and the girls aged 14; heart rate for the first 15 s of the period of recovery after exercise (P_2) of the boys aged 14 and the girls aged 15; heart rate for the last 15 s of the first minute of recovery (P_3) of the pupils aged 13, where the differences are insignificant ($p>0.05$). Insignificant changes were found in the results of control group the pupils after the experiment ($p>0.05$).

After comparing the Ruffier index data obtained after the pedagogical experiment with the evaluation tables, we found that the results of the girls aged 14 and the boys aged 15 increased by 1 point and began to correspond to a score of 4 and 3 points, respectively.

At the same time, the positive improvement in the scores of the pupils aged 13, the boys aged 14 and the girls aged 15 did not affect significantly the number of points. Thus, during the experiment, the level of cardiovascular system response to standard physical activity increased from average to above average in the girls aged 14, and from below average to average in the boys aged 15. In the pupils aged 13, the boys aged 14 and the girls aged 15, the indicators improved, but their level did not change.

A similar comparison of the data of control group the pupils shows that the slight improvement in results did not affect the level of cardiovascular system response to standard physical activity for the most part. The only exceptions are the results of the girls aged 14 and the boys aged 15 (the girls' level increased from below average (2 points) to average (3 points), the boys' level decreased from average (3 points) to below average (2 points)).

A comparison of the post-experimental data characterizing the functional state of the cardiovascular system in the experimental and control groups revealed that the heart rate and blood pressure indicators of the experimental group the pupils were statistically significantly better than those of the control group ($p < 0.05 - 0.001$).

The analysis of repeated measurements assessing the cardiovascular system's response to standard physical activity showed no statistically significant differences between the experimental and control groups ($p > 0.05$).

However, significant differences ($p < 0.05 - 0.001$) were observed in: the 15-second resting heart rate (P_1) in 14-year-old girls; the heart rate during the first 15 seconds of recovery (P_2) in 13-year-old boys; the heart rate during the last 15 seconds of the first minute of recovery (P_3) in 14–15-year-old girls.

Analysis of the data obtained after the implementation of the differentiated physical exercise program confirmed a statistically significant improvement in endurance performance among 13–15-year-old pupils in the experimental groups ($p < 0.001$).

Thus, the results increased by 6.39 units for the boys aged 13, which is a percentage of (59.07%); 14 years old – by 2.76 (16.64%); 15 years old – by 5.00 (25.43%). The results improved by 4.45 units for the girls aged 13, which is a percentage of (39.90%); 14 years old – by 2.96 (22.67%); 15 years old - by 3.83 (29.01%).

The analysis of repeated indicators of the pupils of control groups shows their insignificant changes ($p > 0.05$). Thus, the results of the boys aged 13 years increased by 0.30 units, which is (2.15%); 14 years – by 0.63 (4.11%); 15 years - by 0.21 (1.10%); the girls – by 0.18 (1.83%); 0.17 (1.16%); 0.25 (1.50%) respectively.

Having compared the repeated data of the performance of jumps with deflection with normative estimates, we found that the indicators of general endurance of the studied contingent increased by 1 point. Thus, the results of the boys aged 13 and 15 began to correspond to the score of 2 points (below average level), the girls aged 13, 15 and the boys aged 14 – to the score of 3 points (average level). The identified significant improvements in the results of the girls aged 14 did not significantly affect the score, and it did not change – 2 points (below average).

The analysis of repeated endurance indicators in the control groups revealed no statistically significant changes ($p > 0.05$). As a result, the level of endurance development among 13–15-year-old pupils in the control groups remained at the baseline level – low (1 point).

By the end of the experiment, the endurance results of the pupils in the experimental groups were found to be statistically significantly higher than those of the control groups in most cases ($p < 0.01$; 0.001). Exceptions included 13-year-old boys and 14-year-old pupils, for whom no statistically significant differences were observed ($p > 0.05$).

Thus, the statistically confirmed positive changes in the studied indicators support the effectiveness of the proposed model of differentiated instruction in physical education classes, which takes into account the individual characteristics of the pupils that are relevant to the learning process.

Discussion

The analysis of the data characterizing the functional state of the cardiovascular system obtained after the pedagogical experiment revealed statistically significant improvements in the indicators of the pupils in the experimental groups ($p < 0.05$ – 0.001). Additionally, a tendency towards reduced blood pressure and heart rate was observed in the study cohort. This indicates that the implementation of specially designed sets of physical exercises for differentiated instruction, taking into account the individual typological characteristics of the pupils, contributed to the development of adaptive mechanisms in the cardiovascular system of the experimental group.

Our findings are consistent with those of other researchers. Positive effects on the cardiovascular system in schoolchildren were reported by Filenko et al. (2013) in rugby-5 sessions; Bala (2012) and Maslyak and Krivoruchko (2016) in cheerleading exercises; Mulyk and Grynova (2015) in walking training; Petrova and Bala (2020) in the variable CROSSFIT module; Petrova et al. (2022) in CrossFit classes; Tsybulska et al. (2024) in health aerobics; and Kyrychenko (2025) in athletic gymnastics.

The comparison of repeated results of the pupils of the control groups did not reveal significant changes in the studied parameters ($p > 0.05$). Thus, our results confirm the effectiveness of differentiated training in physical education lessons for 13–15-year-old pupils.

In the course of the experiment we found a positive dynamics of improvement of the results of the level of endurance development of the studied contingent ($p < 0.001$). The obtained data are consistent with the results of the studies by Skaliy, et al. (2023); Vahitov & Martyanov (2010); Bala et al. (2018), etc. The authors found that under the influence of aerobic exercise, morphological and functional changes occur in the cardiovascular system, on which the manifestation of endurance depends. Our data complement the results of studies by Borisova & Shkarupylo (2017), on the positive impact of capoeira training on the level of endurance development of 15-16-year-old pupils; Dzhangobekov, Vovkanych & Muzyka (2014), on badminton, running and sports dancing; Osipova et al. (2016), on strength cardio training; Mameshina, Masliak & Cherendichenko (2024) – additional support for these findings is provided by studies examining various types of motor activity; Bazilevich et al. (2025) – athletic training methods; Kuzmenko et al. (2025) – ultimate frisbee exercises, among others.

For the first time the author's model of organization of differentiated training at physical education lessons is substantiated, taking into account the indicators of the functional state of the cardiovascular system of 13–15-year-old pupils and, as a result, increasing the level of endurance development of the studied contingent.

Conclusions

The review of the scientific works devoted to the study of this issue revealed a significant number of developments, and as for the criteria for differentiation of physical education, in order to improve physical health and motor fitness of different age groups, it is proposed to take into account not only age and gender, but also body structure, somatotypes, somatic health and indicators of physical qualities development, etc. However, the problem of differentiation of training taking into account the functional state of the cardiovascular system and the level of endurance development of adolescents aged 13–15 years was not raised.

In order to improve the adaptive mechanisms of the cardiovascular system and increase the level of endurance development of 13–15-year-old pupils, the author's model of organizing differentiated training in physical education lessons is proposed; it is recommended to supplement the content of the variable section of the curriculum with physical exercises specifically aimed at increasing the level of functional fitness; differentiated homework is proposed, taking into account the identified individual capabilities of pupils.

Positive changes in the indicators of the functional state of the cardiovascular system (from below average to average) and an increase in the level of endurance development (from low to below average) of 13–15-year-old pupils testify to the effectiveness of the author's development.

To assess the effectiveness of the proposed innovations, it is recommended to implement ongoing, stage-based, and final monitoring. When evaluating students' academic achievements, individual progress should be taken into account, and additional points should be added to the final grade for improvements in the functional state of the main body systems and the level of physical fitness development.

STATEMENT OF ETHICS

This study was conducted in accordance with the World Medical Association Declaration of Helsinki. The study protocol was reviewed and approved by the Ethics Committee of Kharkiv State Academy of Physical Culture (approval number: 2024-11, Kharkiv, Ukraine). All participants provided written informed consent to participate in this study.

DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interests with respect to the research, authorship, and/or publication of the article *The differentiated training and its impact on the functional state of the cardiovascular system and the level of endurance development of 13–15-year-old pupils*.

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AUTHORS' CONTRIBUTIONS

Marharyta Mameshyna: Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft, Writing - Review and Editing, Project administration;

Iryna Masliak: Conceptualization, Methodology, Supervision;

Oleh Olkhovyi: Resources, Supervision;

Iryna Kuzmenko: Investigation, Data Curation, Validation;

Tetiana Bala: Investigation, Resources, Data Curation;

Natalia Bykhun: Investigation, Validation, Writing - Review and Editing;

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