

**DIFFERENTIATION OF THE CONTENT OF PHYSICAL EDUCATION  
LESSONS TAKING INTO ACCOUNT INDICATORS OF THE STATE OF  
THE CARDIORESPIRATORY SYSTEM OF PUPILS IN THE SECONDARY  
SCHOOL**

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**Purpose:** to study the dynamics of the cardiorespiratory system indicators of 13 - 14-year-old pupils under the influence of the differentiated content of physical education lessons.

**Material and methods:** 103 pupils of the comprehensive school No. 150 of Kharkov took part in the research. The methods were used in the research: theoretical analysis and synthesis of scientific-methodological literature; biomedical methods (tonometry, pulsometry, and spirometry); pedagogical experiment; methods of mathematical statistics.

**Results:** the level of functioning of the cardiorespiratory system in 13 - 14-year-old pupils is below average. Taking into account the indicators of the functional state of the cardiovascular and respiratory systems of 13 - 14-year-old pupils, the content of physical education lessons is differentiated; the development and implementation of physical exercise complexes aimed at increasing the above indicators.

**Conclusions:** as a result of the introduction of the developed physical exercise complexes in indicators characterizing the state of cardiovascular and respiratory

systems of pupils of experimental groups, there were reliable positive changes in all the studied parameters ( $p < 0,05 - 0,001$ ). As a result, the state of the cardiorespiratory system of 13-14-year-old pupils increased from below average to average.

**Keywords:** physical health, cardiovascular system, respiratory system, physical education, 13 - 14-year-old pupils.

## **Introduction**

Today a serious problem is the preservation of the health of the younger generation. This issue is particularly acute for the modern school, as researches indicate that their physical health levels are deteriorating significantly during the school years [10, 19, 24]. The intensity of the educational process and the growth of mental burden; indifferent and sometimes negative attitudes towards physical culture; a sedentary lifestyle is a determining factor in the deterioration of the physical health of school-age children [16, 17, 21, 26].

Physical education is the main factor in the formation of a healthy personality. It was proved that adequate physical activity, rationally constructed motor activity contributes to improving the functional potential of the main systems of the body, mental and physical performance; is an effective factor in creating positive emotions, contributing to the child's health [1, 18, 25, 27].

However, leading experts point to the insufficient effectiveness of the physical education system in educational institutions and attribute this to the fact that mainly meaningful content of classes remains typical [20]; lesson forms are based on standard normative approach [12]; many schools don't carry out extracurricular physical education work [6]; only a small number of teachers implement innovative technologies [11], etc. Therefore, the system of physical education requires qualitative changes.

The analysis of scientific literature revealed that one of the current directions of optimization of the physical education process of children of different ages and sexes is a differentiated approach, providing for taking into account the individual typological characteristics of each child [2, 4, 8]. To solve this problem successfully,

researchers propose taking into account indicators of physical development [2], physical health [23], motor fitness [20], etc.

However, it should be noted that the issue of expanding the functional potential of the main systems of the body of pupils of the secondary school by differentiating the content of physical culture lessons remains unexplored.

**The purpose of the research** is to study the dynamics of the cardiorespiratory system indicators of 13 - 14-year-old pupils under the influence of the differentiated content of physical education lessons.

### **Material and Methods of research**

The research was carried out based on of secondary school No. 150 in Kharkiv. It was attended by 103 pupils, of which 2 experimental and 2 control groups were formed. So, the first experimental group included 13-year-old pupils (18 boys and 33 girls), the second - 14-year-old pupils (29 boys and 23 girls). Control groups were formed accordingly: the first - 10 boys and 17 girls, the second - 16 boys and 12 girls. The pupils participating in the research were almost healthy. Consents were obtained from parents to participate in the research.

The quantitative evaluation of the functioning of the cardiorespiratory system of the research contingent was carried out according to Robinson index, which characterizes the state of the cardiovascular system; Ruffier index - characterizes the response of the cardiovascular system to standard physical activity; Skibinski Index - characterizes the functionality of the respiratory system and the body's resistance to hypoxia. To calculate these indices, the following were determined: blood pressure (BP), heart rate (HR) at rest and after physical exertion (30 squats in 45 s), vital capacity of lungs (VCL), breath retention time (Stange test). The obtained average indicators were compared with the evaluation scale proposed by S. D. Polyakov and co-authors [14].

According to the results obtained, the content of physical culture lessons was corrected taking into account the individual capabilities of pupils.

So, the content component of the curriculum is white divided into two sections: *basic and variable*. The main section contained the educational material of the basic

modules: athletics, basketball, volleyball and football. We differentiated the content of the *variable section* taking into account the identified individual capabilities of pupils. Thus, complexes of physical exercises aimed at improving the functional state of the cardiovascular and respiratory systems were developed for each formed typological subgroup. The physical exercise complexes included the basic movements of CrossFit cardio training – “BURPEE” (transition from a standing position to a lying position); “WALKING LUNGES” (lunge-walk); jumping up, jumping through a racecar (single, double, and triple); aerobic exercises (fast and dosed walking, fast running); breathing exercises with an emphasis on deep breathing and forced exhalation, with holding breathing and exercises of breathing gymnastics A. M. Strelnikova [15] – “Palms”, “Square one’s shoulders”, “Head turns”, “Ears”, etc. These exercises were performed by pupils of experimental groups in the main part of the lesson, after mastering the technical and tactical actions of the planned modules. The number of repetitions and intensity of exercise was gradually changed. Exercises were carried out in the aerobic mode, the intensity wasn’t exceeded 60 - 70 %, by heart rate – 170 – 180 bpm<sup>-1</sup>, breath frequency – 16 – 20 cycles per min<sup>-1</sup>. The developed physical exercises were introduced into the content of independent classes, organized individual classes, and offered as differentiated homework. The permission to change the program was received from the school administration.

Pupils of control groups, during the school year, were engaged in the educational program for general educational institutions “Physical culture for the 5<sup>th</sup>-9<sup>th</sup> grades” [13]. Athletics, volleyball, basketball, and football lessons were held; the structure of the lessons and the pedagogical aspects of the organization of the educational process was typical.

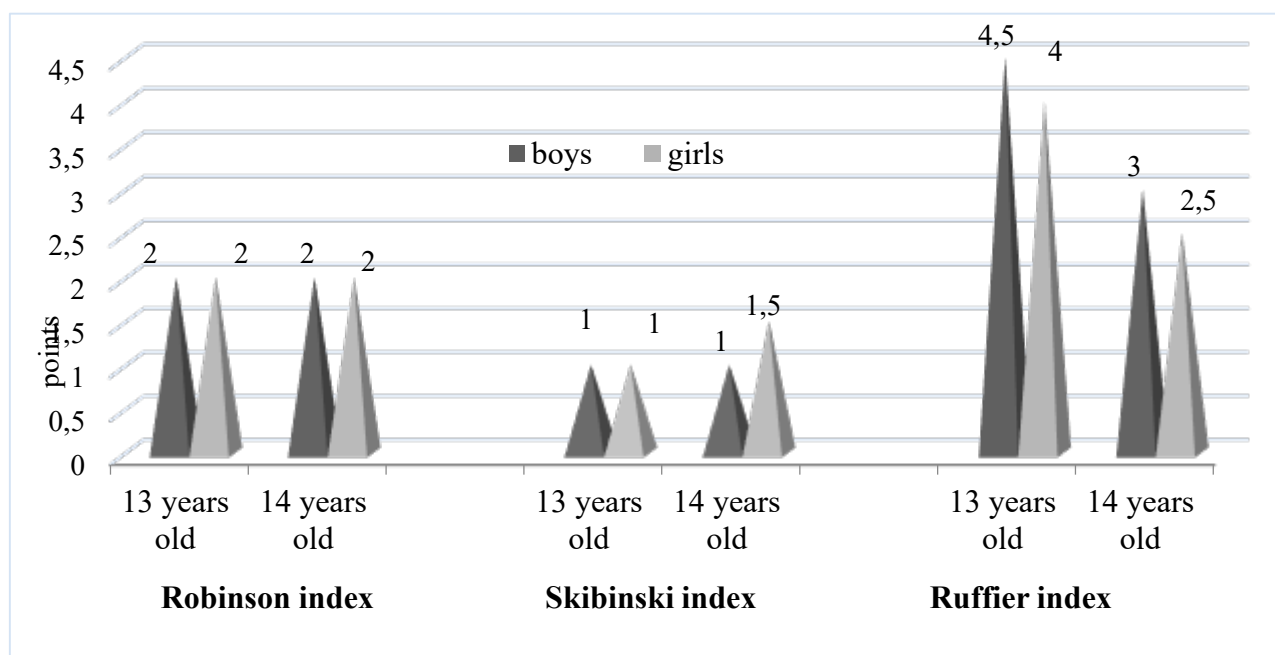
During the research, the following methods were applied: theoretical analysis and synthesis of scientific and methodological literature; biomedical methods (tonometry, pulsometry, spirometry); pedagogical experiment (ascertaining, molding); methods of mathematical statistics.

Mathematical and statistical processing of the actual material was carried out to interpret the results of the pedagogical experiment using the computer program

STATISTICA 10.0. The arithmetic mean ( $\bar{X}$ ) was determined to characterize the population according to individual parameters; error of mean value (m) - for determination of deviation of arithmetic mean from corresponding parameters of the general population; reliability of differences (p) - was determined to establish the degree of changes in the average values of the analyzed parameters after the experiment. The validity of the differences was determined according to the probability of Student's distribution (t) at a level of at least  $p < 0,05$ .

### **Results of the research**

The results of the constant experiment show that there are no statistically significant differences between the control and experimental groups for all the indices studied ( $p > 0,05$ ). As a result of a comprehensive study of the state of the cardiorespiratory system according to the indicators of Robinson, Skibinski, Ruffier indexes, it is determined below the average level of functioning of the cardiorespiratory system in 13 - 14-year-old pupils of both study groups (Fig. 1).



**Fig. 1.** The assessment of the functional state of the cardiorespiratory system of 13 - 14-year-old pupils before the experiment

The analysis of the repeated data characterizing the state of cardiovascular regulation (Robinson index) obtained after the experiment (Table 1-2) determined a reliable decrease in AP and HR indicators both in boys and girls of experimental

groups ( $p < 0,001$ ). Significant changes weren't observed in the control group pupils after the experiment ( $p > 0,05$ ).

The comparison of the repeated data of the Robinson index with the assessment scale [14] indicates that as a result of the introduction of the developed physical exercise complexes taking into account typological features, in 13 - 14-year-old pupils of experimental groups, the level of regulation of the cardiovascular system below the average (2 points) increased to the average (3 points). Significant changes weren't detected on the assessment scale pupils of the control group, as a result of which the level of regulation of the cardiovascular system didn't change (below average).

*Table 1*

**Cardiorespiratory system of functional status indicators of boys of experimental groups before and after the experiment**

Indicators	Before the experiment	After the experiment	t	p	
	$\bar{X} \pm m$				
<b>13 years old (n=18)</b>					
ЧСС (bpm <sup>-1</sup> )	83,11±2,99	75,17±0,95	3,87	<0,01	
AP syst' (mmHg)	113,28±2,24	103,33±1,93	9,91	<0,001	
AP diast' (mmHg)	73,83±1,76	68,06±1,35	5,77	<0,001	
HR for 15 s (number of times)	P <sub>1</sub>	16,00±0,61	16,33±0,54	1,52	>0,05
	P <sub>2</sub>	27,89±1,12	29,94±0,57	3,08	<0,05
	P <sub>3</sub>	17,89±0,72	18,28±0,51	1,18	>0,05
VCL (ml)	2016,67±65,11	2472,22±65,40	19,09	<0,001	
Breath retention time (s)	30,33±1,00	44,17±1,23	10,81	<0,001	
<b>14 years old (n=29)</b>					
ЧСС (bpm <sup>-1</sup> )	88,00±3,10	76,14±1,06	5,08	<0,001	
AP syst' (mmHg)	120,38±2,16	102,34±1,24	11,98	<0,001	
AP diast' (mmHg)	77,07±1,71	68,76±0,68	6,59	<0,001	
HR for 15 s (number of times)	P <sub>1</sub>	20,86±1,13	18,28±0,30	3,21	<0,01
	P <sub>2</sub>	31,93±1,16	32,76±0,53	1,59	>0,05
	P <sub>3</sub>	25,03±1,27	20,86±0,32	6,34	<0,001
VCL (ml)	2124,14±71,37	2544,83±57,94	16,20	<0,001	
Breath retention time (s)	32,41±1,85	41,21±1,70	11,08	<0,001	

P<sub>1</sub> – HR for 15 s at rest, P<sub>2</sub> – HR for the first 15 s of the recovery period after load, P<sub>3</sub> – HR for the last 15 s of the first minute of recovery

Examining the repeated data of Skibinski index, characterizing the functional capabilities of the respiratory system, the body's resistance to hypoxic phenomena

(Table 2-3), the increase in VCL and respiratory retention time (Stange sample) in pupils of experimental groups was revealed and these distinctions are reliable ( $p < 0,01$ ;  $0,001$ ).

Analyzing similar indicators of pupils of control groups obtained after the experiment, insignificant positive changes were established for all the studied parameters ( $p > 0,05$ ).

A repeated comparison of Skibinski index indicators with the assessment scale [14] indicates that after the introduction of special physical exercises, the level of functional capabilities of the respiratory system in boys of experimental groups from low (1 point) increased to lower (2 points), in girls from low to average (3 points).

Positive changes in Skibinski index indicators were established, both in boys and girls of control groups on the rating scale didn't significantly affect and their level remained at the starting position (low and lower than the average, respectively).

Table 2

**Cardiorespiratory system of functional status indicators of girls of experimental groups before and after the experiment**

Indicators	Before the experiment		t	p	
	$\bar{x} \pm m$				
<b>13 years old (n=18)</b>					
ЧСС (bpm <sup>-1</sup> )	81,55±2,43	76,15±1,08	4,00	<0,01	
AP syst' (mmHg)	115,42±1,96	101,55±1,14	9,97	<0,001	
AP diast' (mmHg)	75,42±1,24	66,42±1,10	7,97	<0,001	
HR for 15 s (number of times)	P <sub>1</sub>	15,36±0,45	16,55±0,49	2,42	<0,05
	P <sub>2</sub>	27,15±0,68	30,33±0,68	5,73	<0,001
	P <sub>3</sub>	17,79±0,51	18,79±0,57	1,91	>0,05
VCL (ml)	1703,03±63,04	2300,00±61,40	12,65	<0,001	
Breath retention time (s)	30,52±0,92	39,97±0,78	13,36	<0,001	
<b>14 years old (n=29)</b>					
ЧСС (bpm <sup>-1</sup> )	90,91±3,50	76,48±1,15	5,62	<0,001	
AP syst' (mmHg)	122,22±2,03	104,26±1,37	12,83	<0,001	
AP diast' (mmHg)	77,70±1,45	68,83±0,73	8,44	<0,001	
HR for 15 s (number of times)	P <sub>1</sub>	18,09±0,79	17,26±0,32	2,00	>0,05
	P <sub>2</sub>	30,78±1,27	32,43±0,54	2,36	<0,05
	P <sub>3</sub>	21,61±1,07	19,61±0,32	3,09	<0,01
VCL (ml)	2113,04±75,60	2504,35±61,15	9,28	<0,001	
Breath retention time (s)	32,61±2,50	42,83±1,84	10,06	<0,001	

P<sub>1</sub> – HR for 15 s at rest, P<sub>2</sub> – HR for the first 15 s of the recovery period after load, P<sub>3</sub> – HR for the last 15 s of the first minute of recovery

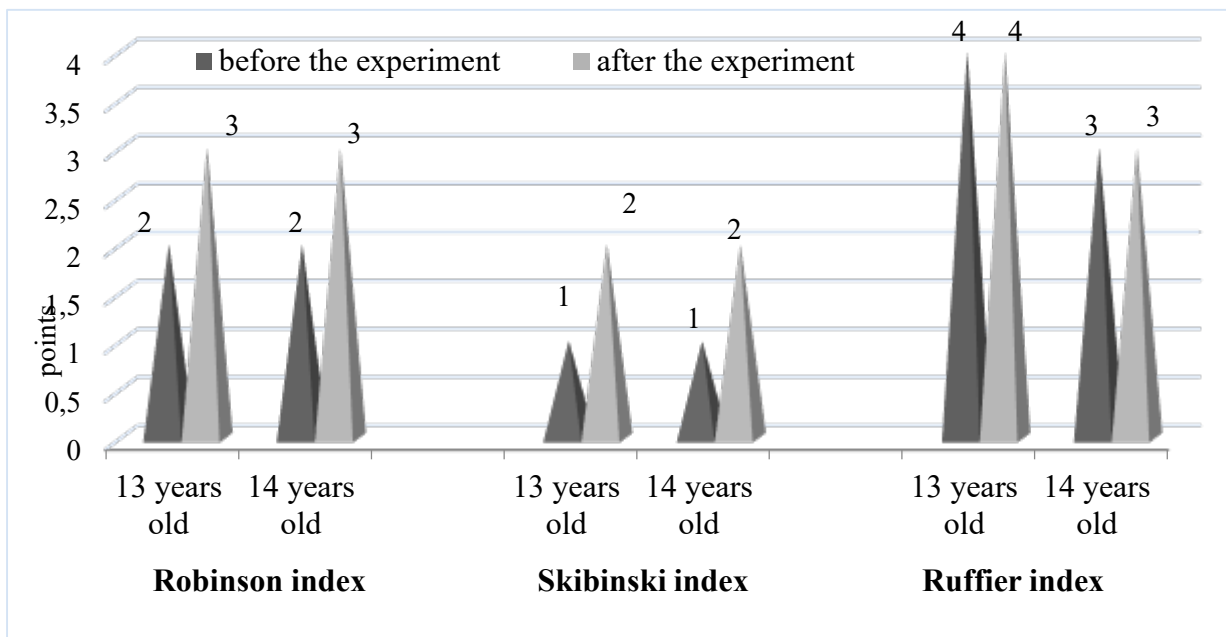
The repeated analysis of Ruffier index data characterizing the degree of response of the cardiovascular system to standard physical activity (Table 1-2) indicates that the functional sample indicators of pupils in experimental groups decreased and these changes are mainly statistically reliable ( $p < 0,05 - 0,001$ ). The exception is the indicators of safety at rest ( $R_1$ ) of 13-year-old boys and 14-year-old girls, the results of HR for the first 15 from the recovery period (R 14 years and for the last 15 from the first minute of recovery (R) of 13 - year-old pupils, for which the results improved, but not significantly ( $p > 0,05$ ). Significant changes weren't found in the control group pupils after the experiment ( $p > 0,05$ ).

The re-comparison of Ruffier index data with the assessment scale [14] found that after the introduction of the developed exercise, in 14-year-old girls of experimental groups, the level of cardiovascular response to standard physical activity increased from the average (3 points) to the highest for the average (4 points). 13-year-old pupils and 14-year-old boys established positive changes at the assessment level didn't affect.

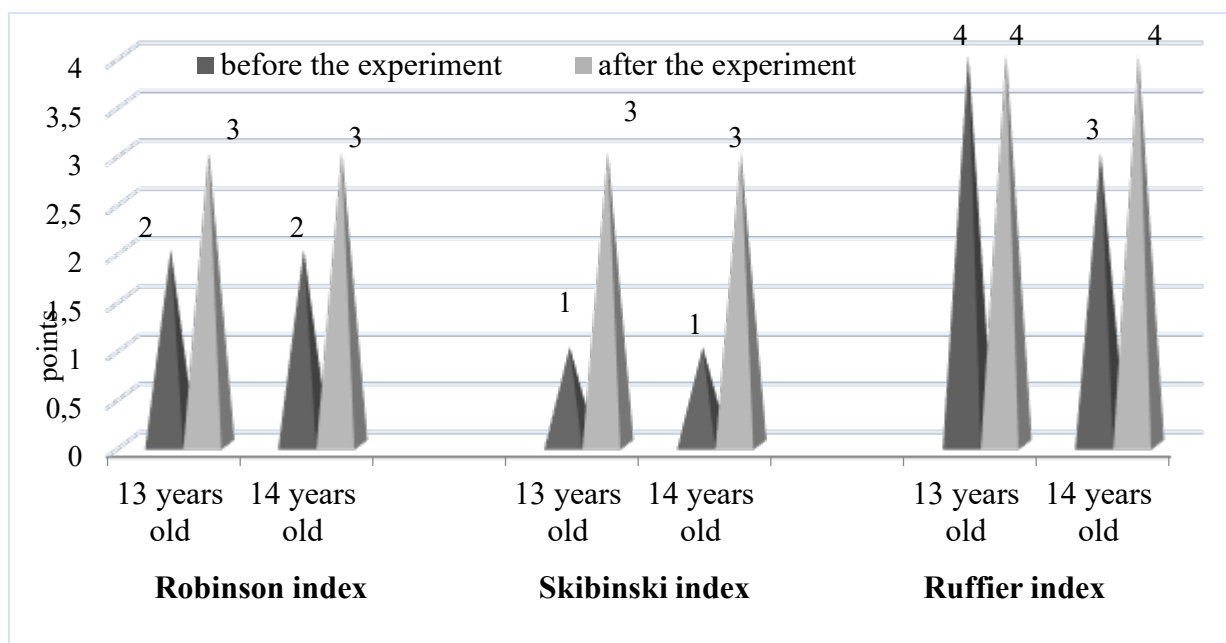
The comparison of similar data of Ruffier index of pupils of control groups with assessment scale [14] shows that insignificant improvement of indicators at the level of the cardiovascular system response to standard physical exercise wasn't affected largely. The exception is the indicators of 14-year-old girls, for which the level from below the average (2 points) increased to the average (3 points).

Examining the general level of functioning of the cardiorespiratory system of pupils of experimental groups, according to the indicators of Robinson, Skibinski, Ruffier indexes, its increase from the lower average (2 points) to the average (3 points) was established (Fig. 2 - 3).





**Fig. 2.** Assessment of the functional state of the cardiorespiratory system of 13 - 14-year-old boys before and after the experiment



**Fig. 3.** Assessment of the functional state of the cardiorespiratory system of 13 - 14-year-old girls before and after the experiment

The analysis of similar indicators of pupils of control groups shows that the level of functioning of the cardiorespiratory system, both in boys and girls, remained at the initial position - lower than the average.

Of this, it is worth differentiating the content of physical education lessons taking into account the individual characteristics of pupils, and introducing special physical exercises effectively affects the functional state of the cardiovascular and respiratory systems of 13-14-year old adolescents.

### **Conclusions / Discussion**

The analysis of scientific developments revealed a number of researches on the mainstreaming of the use of a differentiated approach in physical education of school-age children. The research supplemented data on effectiveness: a differentiated approach using information technologies [3]; differentiated standards of physical fitness [4]; a differentiated approach to health status [5]; multilevel system of physical exercise of differentiated training taking into account physical health indicators [7] and level of development of individual motor abilities [9].

To improve the state of the cardiorespiratory system, it is proposed to differentiate the content of physical education lessons, namely, the variable section of the curriculum, taking into account the typological characteristics of middle-school pupils, and to introduce developed complexes of physical exercises aimed at improving the functional state of the cardiovascular and respiratory systems of 13 - 14-year-old pupils.

As a result of the introduction of the developed physical exercise complexes in indicators reflecting the state of the cardiovascular and respiratory systems of pupils of experimental groups, there were reliable positive changes in all the studied parameters ( $p < 0,05-0,001$ ). As a result, the level of cardiorespiratory systems of 13 - 14-year-old pupils of experimental groups from below average increased to average.

**The prospects for further research** are to determine the effectiveness of differentiating the content of physical education lessons from another age group.

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