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# THE EFFECTIVENESS OF THE INFLUENCE OF THE PHYSICAL EDUCATION PROGRAM ON THE DYNAMICS OF CHANGES IN ADDITIONAL PARAMETERS OF CARDIOSPIRATORY AND VASCULA FUNCTIONING IN CHILDREN WITH SCOLIOSIS

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*The article is devoted to studying the physical education program's effectiveness on the dynamics of changes in additional parameters of the cardiorespiratory and vascular systems functioning in children with scoliosis aged 11-14 years. The study has found that exercises complex in children with scoliosis aged 11-14 years has a positive effect on the functioning of the body the cardiorespiratory and vascular systems, which is manifested by an increase in left ventricular capacity and minute blood volume with exercise, increased oxygen pulse, reduced shock Brelov's index, increase in specific resistance of vessels. A characteristic difference is the increased load on the cardiovascular and vascular systems of girls aged 11-14 years with scoliosis. This fact can be explained by an earlier growth "jump", and therefore the underlying disease progression in girls compared to boys, as well as different exercise tolerance levels by girls and boys in this age group.*

**Key words:** *schoolchildren, scoliosis, cardiorespiratory and vascular system, physical education.*

**The connection of the publication with planned research works.** The study is a fragment of the research project "Study of the organism adaptive reactions, which are formed under various factors of nature and society influence", state registration № 0115U003314.

**Introduction**. Scoliotic disease, which limits motor activity, is quite common among the world's population, its progression leads to changes in the chest and pelvis shape, functional disorders of the cardiovascular, respiratory, neuromuscular, digestive, and urinary systems [1, 2, 3, 4, 5, 6, 7, 8, 9, 10].

Preventing the progression of scoliosis I-II degrees in children during the incomplete growth period is a difficult task to solve. Currently, doctors and the scientific community do not have a single point of view on the treatment of this patients group. The used methods are not unambiguously evaluated by different authors and often give unsatisfactory results. The good results have achieved during treatment are sometimes lost completely, as there are breaks in treatment due to the lack of relationship between the stages of recovery and changes in stabilization [1, 2, 3, 4, 5, 6, 7, 8, 9, 10].

Considering that one of the first body systems which are affected negatively, working with increased stress in scoliosis, are cardiovascular and respiratory, it is extremely important to determine the functionality, functional reserves, early decompensation signs of these systems [1, 2, 3, 4, 5, 6, 7, 8, 9, 10].

One of the most important points in assessing the physical rehabilitation effectiveness in children with scoliosis is the dynamics of the cardiorespiratory and vascular system's functioning.

**The aim of the study** was to determine the effectiveness of the developed physical education program on the dynamics of additional parameters changes in the functioning of the cardiorespiratory and vascular systems of school-age children with scoliosis aged 11-14 years.

**Object and methods of research.** The research base was specialized general sanatorium boarding school № 13 for children with scoliosis in Oleksiyevo-Druzhkivka, Donetsk region.

The study has conducted on 19 children with scoliosis aged 11-14 years (9 boys and 10 girls). It has developed a physical exercise comprehensive program for the long-term rehabilitation of school-age children with spinal defects (scoliosis). The study was based on the impact results of a comprehensive program of developed exercise technology on the leading indicators of physical performance, absolute and relative heart volume, stroke volume, and minute blood circulation; cardiac index by PWC; MOC by heart volume; blood flow rate. The cardiovascular and respiratory system's response to the physical education results was assessed by left ventricular capacity, oxygen pulse, minute blood volume, arteriovenous difference, Brelov's shock index, and vascular resistance.

The research was conducted by the provisions of the Council of Europe Convention on the Protection of Human Rights and Dignity in Biomedicine (1997), Ethical Principles of Medical Research with Human involvement, adopted by the 52nd Assembly of the World Medical Association (2000). Universal Declaration on Bioethics and Human Rights ", adopted by the UNESCO General Conference (2005), the principles of the Declaration of Helsinki (1964), and in compliance with current regulatory requirements of Ukraine. Parents of all children have given informed written consent to conduct a survey of their children and use the data that was obtained in scientific work.

Statistical processing of the obtained results was performed according to well-known methods of variable statistics with the determination of mean values (M) and standard error (±m). The reliability of the data for independent samples is calculated by the Student's t-test. The difference was considered significant at $P>0.05$

**The research results and their discussion.** The effectiveness of exercise on the additional results dynamics of the cardiovascular and respiratory system's functions by the tests of physical performance in school-age children with scoliosis aged 11-14 years are shown in the **table**.

Determination of left ventricular capacity in children with scoliosis aged 11-14 years has shown that the use of a physical exercises complex in girls statistically significantly has exceeded the corresponding values in boys (p<0.05). At the same time under load, there has been an increase in the power of the left ventricle in boys (0.68±0.15 vs. 0.48±0.22) and girls (0.83±0.02 vs. 0.52±0.02; p<0,05). There has been a decrease in left ventricular capacity to background values during the first and second rest **(table)**.

The gender difference in the distribution of the indicator has disappeared (p>0.05) after the physical education program. There have noticed a general trend – an increase in the left ventricular myocardium capacity during exercise and its gradual decrease during rest.

Stable values in children with scoliosis aged 11-14 years before exercise were without significant gender difference (p>0.05) during the oxygen pulse determining, with a slight increase in the value of oxygen pulse during exercise (10.61±0.06 vs. 9,29±0.05 in boys; p>0.05, 9.44±1.63 against 8.69±0.15 in girls, p<0.05).

After a complex of physical exercises, there has been a statistically significant increase in oxygen pulse at rest in both boys (12.24±0.06 vs. 9.29±0.05) and girls (13.06±0.04 vs. 8.69±0.15) compared with the "background" value before the application of physical exercises (p<0.05). Oxygen heart rate in children also has exceeded the corresponding values before the use of exercise (p<0,05) during exercise and rest.

A study of minute blood volume in children with scoliosis aged 11-14 years has shown that it did not differ statistically significantly in girls and boys, increased with exercise, and decreased to baseline at rest before treatment.

After the physical education program, the minute blood volume in boys was statistically significantly lower than the corresponding indicator before exercise (8.07±2.49 vs. 13.04±0.01; p<0.05), while as in girls – this one increased on the background of exercise (14.09±0.21 vs. 12.72±0.06; p<0.05). At the age of 7-10 years the minute volume of blood was statistically significantly more intense during the load, compared to the corresponding indicators before physical education in girls (24.11±0.40 vs. 19.65±0.02), but not in boys

**Table – The impact of exercise on the additional results dynamics of the cardiovascular and respiratory systems function by tests of physical performance in children with scoliosis aged 11-14 years**

| Indicators | | Units of measurement | After research | | | Before research | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Boys (n=9) | Girls (n=10) | P | Boys (n=9) | Girls (n=10) | P | $P_1$ | $P_2$ |
| Left ventricular power | no-load | Watt | 0,36±0,03 | 0,43±0,03 | >0,05 | 0,48±0,01 | 0,52±0,02 | <0,05 | <0,01 | <0,05 |
| | load | Watt | 1,10±0,04 | 1,11±0,06 | >0,05 | 0,68±0,02 | 0,83±0,02 | <0,01 | <0,01 | <0,01 |
| | 1 rest | Watt | 0,36±0,02 | 0,44±0,02 | <0,05 | 0,54±0,03 | 0,39±0,01 | <0,01 | <0,01 | >0,05 |
| | 2 rest | Watt | 0,39±0,03 | 0,45±0,03 | >0,05 | 0,52±0,01 | 0,67±0,02 | <0,01 | <0,01 | <0,01 |
| Oxygen pulse | no-load | ml/beat | 12,24±0,06 | 13,06±0,04 | <0,01 | 9,29±0,05 | 8,69±0,15 | <0,01 | <0,01 | <0,01 |
| | load | ml/beat | 16,87±1,69 | 16,91±0,87 | >0,05 | 10,61±0,06 | 9,44±1,63 | >0,05 | <0,01 | <0,01 |
| | 1 rest | ml/beat | 13,97±4,71 | 14,07±0,21 | >0,05 | 9,33±0,19 | 9,04±0,02 | >0,05 | >0,05 | <0,01 |
| | 2 rest | ml/beat | 14,19±3,51 | 14,89±0,10 | >0,05 | 9,89±0,11 | 9,21±0,03 | <0,01 | >0,05 | <0,01 |
| Minute blood volume | no-load | l/min | 8,07±2,49 | 14,09±0,21 | <0,05 | 13,04±0,01 | 12,72±0,06 | <0,01 | >0,05 | <0,01 |
| | load | l/min | 17,03±4,00 | 24,11±0,49 | >0,05 | 18,66±0,15 | 19,65±0,02 | <0,01 | >0,05 | <0,01 |
| | 1 rest | l/min | 8,03±3,03 | 15,11±0,09 | <0,05 | 13,85±0,04 | 10,18±0,01 | <0,01 | >0,05 | <0,01 |
| | 2 rest | l/min | 9,11±3,30 | 15,21±0,07 | >0,05 | 13,73±0,06 | 13,53±0,01 | <0,01 | >0,05 | <0,01 |
| Arteriovenous difference | no-load | ml/l | 0,47±0,05 | 0,30±0,03 | <0,05 | 0,25±0,01 | 0,24±0,02 | >0,05 | <0,01 | >0,05 |
| | load | ml/l | 0,22±0,02 | 0,17±0,02 | >0,05 | 0,18±0,01 | 0,22±0,01 | <0,05 | >0,05 | <0,05 |
| | 1 rest | ml/l | 0,44±0,03 | 0,30±0,03 | <0,01 | 0,26±0,02 | 0,30±0,02 | >0,05 | <0,01 | >0,05 |
| | 2 rest | ml/l | 0,45±0,03 | 0,31±0,02 | <0,01 | 0,25±0,02 | 0,24±0,02 | >0,05 | <0,01 | <0,05 |
| Brelov's shock index | no-load | U | 0,55±0,01 | 0,61±0,05 | >0,05 | 1,18±0,01 | 1,22±0,06 | >0,05 | <0,01 | <0,01 |
| | load | U | 0,81±0,04 | 0,79±0,02 | >0,05 | 1,43±0,07 | 1,53±0,01 | >0,05 | <0,01 | <0,01 |
| | 1 rest | U | 0,54±0,04 | 0,59±0,05 | >0,05 | 1,23±0,02 | 0,96±0,02 | <0,01 | <0,01 | <0,01 |
| | 2 rest | U | 0,56±0,03 | 0,61±0,03 | >0,05 | 1,16±0,01 | 1,19±0,02 | >0,05 | <0,01 | <0,01 |
| Specific vascular resistance | no-load | U | 8,00±0,03 | 6,15±0,03 | <0,01 | 5,54±0,02 | 5,94±0,02 | <0,01 | <0,01 | <0,01 |
| | load | U | 5,75±2,15 | 3,07±0,04 | >0,05 | 4,18±0,01 | 4,49±0,03 | <0,01 | >0,05 | <0,01 |
| | 1 rest | U | 8,01±0,17 | 6,12±0,14 | <0,01 | 5,62±0,01 | 7,25±0,02 | <0,01 | <0,01 | <0,01 |
| | 2 rest | U | 8,17±0,19 | 6,37±0,20 | <0,01 | 5,51±0,04 | 6,52±0,01 | <0,01 | <0,01 | >0,05 |

**Notes: P** – the reliability degree of development between boys and girls in groups before and after rehabilitation activities; **$P^1$** – the degree of difference between boys after rehabilitation in comparison with boys before rehabilitation; **$P^2$** is the degree of difference between girls after rehabilitation in comparison with girls before rehabilitation.

(17.03±4.00 vs. 18.66±0.15), which may indicate both the positive effect of exercise on the cardiovascular system of children with scoliosis aged 11-14 years and the increased load that the body of a teenage girl with scoliosis may undergo **(table).**

The arteriovenous difference did not statistically significantly differ in girls and boys before the physical education program. There did not find gender differences in the distribution of the indicator during exercise and at rest (p>0.05).

After a complex of physical exercises, the rate of arteriovenous difference in girls was statistically significantly lower compared to the corresponding value of boys no-load, during exercise, and at rest (p<0.05). It is another indication of the increased load of exercise on the body of girls aged 11-14 years with scoliosis.

There did not find a gender difference in the distribution of values of the Brelov shock index no-load, during exercise, at rest before and after a complex of exercises (p>0.05). At the same time, when we are comparing the values of the index before and after the physical education program, it was found a statistically significant decrease in the shock index in boys (0.55±0.01 vs. 1.18±0.01) and girls (0.60±0.05 vs. 1.22±0.06; p<0.05).

After a complex of physical exercises, there was a statistically significant increase in vascular resistance both no-load and during exercise and rest (p<0.05). At the same time, the indicator was statistically significantly higher in boys than the corresponding indicators in girls of this age group both no-load and during exercise and rest (p<0.05).

**Conclusions.** Thus, a special program of physical education for children with scoliosis aged 11-14 years has a positive effect on the functioning of the cardiorespiratory system by the definition of left ventricular capacity and oxygen pulse. Determination of vascular-specific resistance allowed to show the same gender distribution of the indicator before physical education activities (p>0.05). Thus, under load, the resistivity of the vessels has decreased and then increased again to the appropriate «background» values.

**Prospects for further research.** It was shown multidirectional dynamics changes of additional parameters of the functioning of the cardiorespiratory and vascular systems that require to development of individual exercise programs to improve the physical performance of children aged 15-17 with scoliosis.

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**ЕФЕКТИВНІСТЬ ВПЛИВУ ПРОГРАМИ ФІЗИЧНОГО ВИХОВАННЯ НА ДИНАМІКУ ЗМІН ДОДАТКОВИХ ПАРАМЕТРІВ ФУНКЦІОНУВАННЯ КАРДІОРЕСПІРАТОРНОЇ І СУДИННОЇ СИСТЕМ У ДІТЕЙ ЗІ СКОЛІОЗОМ**

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**Резюме.** Одним з найважливіших моментів в оцінці ефективності фізичного оздоровлення у дітей і сколіозом є динаміка показників функціонування кардіореспіраторної і судинної системи.

*Мета роботи:* дослідження полягала у визначенні ефективності впливу розробленої програми фізичного виховання на динаміку змін додаткових параметрів функціонування кардіореспіраторної і судинної систем у дітей шкільного віку зі сколіозом віком 11-14 років

*Об'єкт і методи дослідження.* Базами для дослідження виступили: спеціалізована загальноосвітня санаторна школа-інтернат № 13 для дітей зі сколіозом м. Олексієво-Дружківка Донецької області.

Дослідження проведено у 19 дітей віком 11-14 років зі сколіозом (9 хлопчиків і 10 дівчаток). Розроблена комплексна програма фізичних вправ для тривалої реабілітації дітей шкільного віку, які мають дефекти хребта (сколіоз). В основу дослідження були покладені результати впливу комплексної програми розробленої технології фізичних вправ на провідні показники фізичної працездатності, на абсолютний і відносний обсяг серця, ударний об'єм крові і хвилинний обсяг кровообігу; серцевий індекс за PWC; МСК за обсягом серця; швидкість кровотоку. Відповідь серцево-судинної і респіраторної систем на отримані результати фізичного виховання оцінювали за показниками потужності лівого шлуночка, кисневого пульсу, хвилинного об'єму крові, артеріовенозної різниці, шокового індексу Брелова і питомого опору судин.

*Результати.* Програма фізичного виховання позитивно впливає на функціонування кардіо-респіраторної системи, згідно з визначенням показників потужності лівого шлуночка у дітей зі сколіозом віком 11-14 років показало, що показники у дівчат статистично значимо перевищували відповідні значення у хлопчиків, при

цьому відмічалася загальна тенденція: підвищення потужності міокарду лівого шлуночка при навантаженні та її поступове зниження за відпочинку, також відбувалося статистично значиме підвищення кисневого пульсу в спокої як у хлопчиків (12,24±0,06 проти 9,29±0,05), так і у дівчат (13,06±0,04 проти 8,69±0,15) порівняно із «фоновим» значенням до застсування фізичних вправ. Хвилинний об'єм крові у хлопчиків був статистично значимо нижчим за відповідний показник до використання фізичних вправ, в той час як у дівчат – хвилинний об'єм крові зростав на фоні фізичних вправ, показник артеріовенозної різниці у дівчат виявився статистично значимо нижчим в порівнянні з відповідним значенням хлопчиків в спокої, при навантаженні і під час відпочинку, також після проведення фізичних вправ відбувалося статистично значиме збільшення питомого опору судин як в стані спокою, так і при навантаженні і відпочинку. При цьому показник у хлопчиків статистично значимо перевищував відповідні показники у дівчат цієї вікової групи як в стані спокою, так і при навантаженні і відпочинку.

*Висновки.* Таким чином, спеціальна програма фізичного виховання у дітей зі сколіозом віком 11-14 років позитивно впливає на функціонування кардіо-респіраторної системи, згідно з визначенням показників потужності лівого шлуночка і кисневого пульсу. Визначення питомого опору судин дозволило засвідчити однаковий гендерний розподіл показника до проведення заходів фізичного виховання (p>0,05). Так, при навантаженні питомий опір судин зменшувався, а далі знову зростав до відповідних «фонових» значень.

*Перспективи подальших досліджень.* Наведені різнонаправлені за якістю зміни динаміки додаткових параметрів функціонування кардіореспіраторної і судинної систем, потребують розробки індивідуальних програм фізичних вправ для покращення фізичної працездатності дітей віком 15-17 років із сколіозом.

**Ключові слова:** школяри, сколіоз, кардіореспіраторна і судинна система фізичне виховання.

**THE EFFECTIVENESS OF THE INFLUENCE OF THE PHYSICAL EDUCATION PROGRAM ON THE DYNAMICS OF CHANGES IN ADDITIONAL PARAMETERS OF CARDIOSPIRATORY AND VASCULA FUNCTIONING IN CHILDREN WITH SCOLIOSIS**

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**Abstract.** One of the most important points in assessing the effectiveness of physical rehabilitation in children with scoliosis is the dynamics of the indicators of functioning of the cardiorespiratory and vascular systems. *Purpose of the research:* the scientific research is to study the effectiveness of the developed physical education program on the dynamics of changes in additional parameters of the functioning of the cardiorespiratory and vascular systems in school-age children with scoliosis at the age of 11-14 years. *Materials and methods of the research.* The bases for the research were specialized general sanatorium boarding school № 13 for children with scoliosis in Oleksiyevo-Druzhkivka, Donetsk region.The study was conducted among 19 children at the age of 11-14 years with scoliosis (9 boys and 10 girls). A comprehensive program of physical exercises for long-term rehabilitation of school-age children with spinal defects (scoliosis) has been developed. The research was based on the results of the impact of a comprehensive program of developed exercise technology on the leading indicators of physical performance, absolute and relative heart volume, stroke volume and minute blood circulation; cardiac index by PWC; MSC by heart volume; blood flow rate. The response of the cardiovascular and respiratory systems to the results of physical education was assessed by left ventricular capacity, oxygen pulse, minute blood volume, arteriovenous difference, Brelov's shock index and vascular resistance.

*Results.* The program of physical education has a positive effect on the functioning of the cardio-respiratory system, according to the definition of left ventricular capacity in children with scoliosis at the age of 11-14 years showed that the indicators in girls were statistically significantly higher than in boys. There was a general trend: an increase in the power of the left ventricular myocardium during exercise and its gradual decrease during rest, there was also a statistically significant increase in oxygen pulse at rest as in boys (12.24±0.06 vs. 9.29±0.05), and in girls (13.06±0.04 vs. 8.69±0.15) compared with the "background" value before exercise. Minute blood volume in boys was statistically significantly lower than the corresponding rate before exercise, while in girls – minute blood volume increased on the background of exercise, the rate of arteriovenous difference in girls was statistically significantly lower than the corresponding the importance of boys at rest, during exercise and at rest, as well as after exercise, there was a statistically significant increase in vascular resistance both at rest and during exercise and rest. At the same time, the rate in boys was statistically significantly higher than the corresponding rates in girls of this age group both at rest and during exercise and rest.

*Conclusions.* Thus, a special program of physical education for children with scoliosis aged 11-14 years has a positive effect on the functioning of the cardio-respiratory system, according to the definition of left ventricular capacity and oxygen pulse. Determination of vascular specific resistance allowed to show the same gender distribution of the indicator before physical education activities (p>0.05). Thus, under load, the resistivity of the vessels decreased, and then increased again to the appropriate "background" values.

*Prospects for further research.* The multidirectional in the quality changes in the dynamics of additional parameters of the cardiovascular and vascular systems that have been presented in the research, require the development of individual exercise programs to improve the physical performance of children at the age of 15-17 years with scoliosis

**Key words:** schoolchildren, scoliosis, cardiorespiratory and vascular system, physical education.

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The Authors declare no conflict of interest.

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