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<sup>1</sup>Dychko D. V., <sup>1</sup>Dychko O. A., <sup>1</sup>Klymenko Yu. S., <sup>2</sup>Kushakova N. I., <sup>1</sup>Kaznacheyev A. V., <sup>1</sup>Dychko V. V.**DYNAMICS OF THE CARDIOVASCULAR SYSTEM ACCORDING TO PHYSICAL ABILITY TESTS IN SCHOOL-AGED CHILDREN WITH SCOLIOSIS**<sup>1</sup>State higher educational institution "Donbas State Pedagogical University" (Sloviansk/Dnipro, Ukraine)<sup>2</sup>Donetsk National Medical University (Kropyvnytskyi, Ukraine)[v.v.dichko@ukr.net](mailto:v.v.dichko@ukr.net)

*The article is devoted to the study of the dynamics of the cardiovascular system based on physical performance tests in children at the age of 11-14 with scoliosis. 24 adolescents with scoliosis (9 boys and 10 girls) and 24 practically healthy peers (12 boys and 12 girls) were studied. As a result of the study, it was established that in school-age children with scoliosis, the function of the cardiovascular and autonomic systems is destabilized, which is mostly expressed in such indicators as a decrease in pulse pressure at rest by 16.90%, and on the contrary, it increases by 49.55% during exercise. % and increases after the first and second rest, respectively by 8.02% and 5.24%, increase in systolic blood volume.*

*Scoliosis in boys leads to a decrease in the average aortic pressure at rest by 18.45%, during exercise – by 17.24%, after the first rest – by 20.56%, and after the second rest – by 19.90%. In girls with scoliosis at the age of 11-14, multidirectional changes in the indicators of the cardiovascular system function were formed, with slight changes in the maximum aerobic power and relative maximum aerobic power by 2.11 times and 2.31 times, and the largest deviations in the indicators of children's physical performance were found in girls with scoliosis.*

*The latter may be due to delayed puberty in boys compared to female patients. The maximum growth spurt, and therefore the progression of scoliotic disease in adolescents occurs during puberty, so it is quite logical that the worst indicators are noted in girls.*

**Key words:** children at the age of 11-14 years, scoliosis, cardiorespiratory system, vascular system.

**Connection of the publication with planned research works.**

The research work was carried out within the framework of the dissertation work in accordance with the plan of the State Educational Institution «DSPU». The research is a fragment of the SRW «Study of adaptive reactions of the organism that are formed under the influence of various factors of nature and society», state registration № 0115U003314.

**Introduction.**

A person's ability to adapt physically and socially is complex and diverse. It is determined by many factors, including the somatic condition, the ability to tolerate physical and psycho-emotional loads, the degree of training, etc. [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14]. In maintaining homeostasis and its regulation, the most important role belongs to the interactions of the cardiovascular, nervous, muscular, respiratory and immune systems, endocrine glands, sensory organs, as well as the hypothalamic-pituitary and limbic systems of the brain [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14]. One of the severe types of maladjustment leading to a social defect, social insufficiency, is a disease (MSS – musculoskeletal system).

Scoliosis seriously affects the physical and mental health of children and adolescents. During the period of intensive growth and development, scoliosis deformity develops faster, which in the future, in the absence of treatment, can lead to numerous violations of many body systems, one of which is the cardiorespiratory and vascular systems [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14].

Taking into account the peculiarities of the development of children with scoliosis, as well as taking into account the causes of their pathology, there is a problem of proper education of such a contingent of children / teenagers in order to prevent possible secondary deviations in the emotional and intellectual spheres, physical development, as well as early disability

**The aim of the study.**

To study the peculiarities of the work of the cardiovascular system according to tests of physical performance in children at the age of 11-14 years old with scoliosis in comparison with their practically healthy peers from secondary school.

**Object and research methods.**

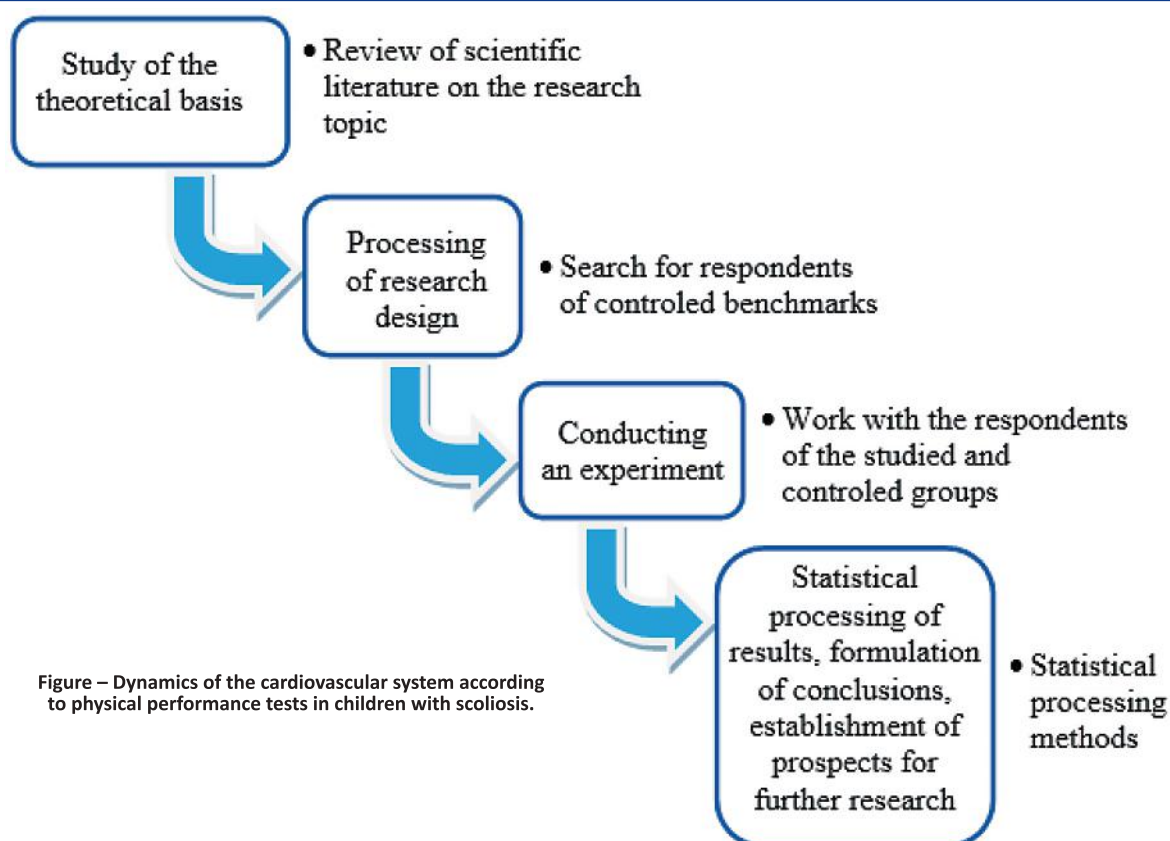
**1. The general research methodology is described in fig.**

**2. Selection of research respondents.** The respondents of the study are the teenagers with scoliosis and conditionally healthy boys and girls in the age category of 11-14 years. Two groups of respondents are formed: studied and controled.

The studied group includes 19 children (9 boys and 10 girls) of the Oleksiievo-Druzhkivskoi general educational sanatorium and boarding school of I-III degrees № 13 for children with scoliosis.

The controled group includes 24 children (12 boys and girls each) of secondary school № 17.

**3. Setting benchmarks.** In order to develop an adequate complex of adaptive physical exercises, we conducted research in two groups (studied and controled) of physical capacity, including and in the dynamics, tolerance to physical exertion, as well as certain parameters of the cardiovascular (CVS) and



autonomic nervous systems (ANS), maximal oxygen consumption (MOC) in children with scoliosis and practically healthy children of the same age.

**4. Statistical processing of results.** The statistical processing of the obtained results is carried out according to well-known methods of variable statistics with the determination of average values (M) and standard error of the arithmetic mean value ( $\pm m$ ), the reliability of data for independent samples is calculated according to the Student t-criterion. The difference is considered significant at  $p < 0.05$ .

**5. Ethical criteria.** The work is carried out in accordance with the provisions of the Council of Europe Convention «On the Protection of Human Rights and Dignity in the Aspect of Biomedicine» (1997), «Ethical Principles of Medical Scientific Research Involving Human Subjects» adopted by the 52nd Assembly of the World Medical Association (2000), «General declaration on bioethics and human rights», adopted by the resolution of the UNESCO General Conference (2005), the principles of the Helsinki Declaration (1964) and in compliance with the current regulatory requirements of Ukraine.

At the beginning of the study, the parents of all children gave informed written consent to the examination of their children and the use of the obtained data in scientific work.

#### Research results and their discussion.

The cardiovascular system of the human body plays an important role in the care of children with spinal defects, which prompted us to study indicators that characterize the activity of the cardiovascular system.

The results of similar studies of the work of the cardiovascular system based on tests of physical

performance of children at the age of 11-14 years with spinal pathology are shown in the **table**.

In boys at the age of 11-14 years with scoliosis, the pulse pressure at rest decreases by 16.90%, while during exercise, on the contrary, it increases by 49.55% and increases after the first and second rest, respectively, by 8.02% and 5.24%. Systolic blood volume at rest decreases by 40.39% and increases by 49.68% during standard exercise, but after the first and second rest, the systolic volume in boys with scoliosis is reduced by 33.33% and by 31.75% respectively.

Boys at the age of 11-14 years with scoliosis have reduced maximum and relative aerobic power at rest by 35.02% and 46.81%, respectively, and when loaded, on the contrary, levels have been increased by 34.16% and 18.30% respectively. The maximum and relative aerobic power remains reduced in boys with scoliosis even after the first and second rest. The maximum aerobic power becomes reduced by 20.70% and by 18.44%, respectively, and the relative power – by 38.25% and 37.82%, respectively. The pulse limit of tolerance at rest in boys with scoliosis increased by 11.46%, during exercise, on the contrary, it decreased by 5.02%. The pulse limit of tolerance after the first and second rest becomes increased by 10.47% and by 21.44%. Scoliosis in boys at the age of 11-14 years leads to a decrease in the average aortic pressure at rest by 18.45%, during exercise – by 17.24%, after the first rest – by 20.56%, and after the second rest – by 19.90%.

In girls at the age of 11-14 years with scoliosis, multidirectional changes in indicators of the function of the cardiovascular system were formed. The pulse pressure of girls with scoliosis at rest is lower by 38.75% than that of practically healthy girls, and during exercise it is higher by 84.58% and it remains elevated after

Table – Dynamics of work (function) of the cardiovascular system according to physical performance tests in children with scoliosis aged 11-14 years

| Indicators, units of measurement         |        | Controlled group |                 |       | Researched group |                  |       |                |                |
|------------------------------------------|--------|------------------|-----------------|-------|------------------|------------------|-------|----------------|----------------|
|                                          |        | Sex              |                 |       | Sex              |                  |       |                |                |
|                                          |        | Boys<br>(n=12 )  | Girls<br>(n=12) | P     | Boys<br>(n=9)    | Girls<br>(n=10 ) | P     | P <sub>1</sub> | P <sub>2</sub> |
| Pulse pressure,<br>mm Hg                 | rest   | 45,85±11,85      | 47,30±6,47      | >0,05 | 39,22±4,25       | 34,09±7,71       | >0,05 | >0,05          | >0,05          |
|                                          | load   | 45,29±5,66       | 41,90±4,93      | >0,05 | 67,33±7,19       | 77,34±5,47       | >0,05 | <0,05          | <0,01          |
|                                          | 1 rest | 52,42±10,98      | 52,90±6,25      | >0,05 | 48,53±4,64       | 55,79±3,25       | >0,05 | >0,05          | >0,05          |
|                                          | 2 rest | 51,80±11,33      | 51,39±5,79      | >0,05 | 49,22±3,26       | 56,56±2,96       | >0,05 | >0,05          | >0,05          |
| Systolic blood volume,<br>ml / unit      | rest   | 57,25±6,25       | 62,79±7,79      | >0,05 | 40,78±4,91       | 42,48±3,68       | >0,05 | <0,05          | <0,05          |
|                                          | load   | 37,28±5,89       | 34,59±7,51      | >0,05 | 55,80±8,89       | 66,10±9,30       | >0,05 | >0,05          | <0,05          |
|                                          | 1 rest | 62,13±6,48       | 61,85±7,88      | >0,05 | 46,60±4,98       | 55,25±5,45       | >0,05 | >0,05          | >0,05          |
|                                          | 2 rest | 61,13±8,85       | 60,60±5,93      | >0,05 | 46,40±5,02       | 52,71±5,09       | >0,05 | >0,05          | >0,05          |
| Maximum aerobic power, watts             | rest   | 196,80±9,70      | 207,33±7,89     | >0,05 | 148,10±6,76      | 98,25±9,20       | <0,01 | <0,01          | <0,01          |
|                                          | load   | 194,40±8,23      | 183,90±7,38     | >0,05 | 260,80±7,29      | 231,40±4,12      | <0,01 | <0,01          | <0,01          |
|                                          | 1 rest | 226,20±8,43      | 231,70±6,82     | >0,05 | 187,40±8,00      | 166,50±5,60      | <0,05 | <0,01          | <0,01          |
|                                          | 2 rest | 225,40±8,70      | 227,70±7,53     | >0,05 | 190,30±9,38      | 172,00±5,80      | >0,05 | <0,05          | <0,01          |
| Relative maximum aerobic<br>power, watts | rest   | 4,83±3,40        | 5,13±2,36       | >0,05 | 3,29±1,48        | 2,22±0,74        | >0,05 | >0,05          | >0,05          |
|                                          | load   | 4,70±2,57        | 4,51±2,41       | >0,05 | 5,56±2,84        | 5,08±2,10        | >0,05 | >0,05          | >0,05          |
|                                          | 1 rest | 5,53±3,70        | 5,71±1,96       | >0,05 | 4,00±1,33        | 3,74±2,73        | >0,05 | >0,05          | >0,05          |
|                                          | 2 rest | 5,43±1,36        | 5,61±1,99       | >0,05 | 3,94±1,30        | 3,73±2,72        | >0,05 | >0,05          | >0,05          |
| Pulse limit of tolerance, beats<br>/ min | rest   | 31,40±8,83       | 32,50±12,92     | >0,05 | 35,00±8,22       | 37,33±4,46       | >0,05 | >0,05          | >0,05          |
|                                          | load   | 63,85±11,38      | 62,40±10,47     | >0,05 | 60,80±6,04       | 70,10±3,70       | >0,05 | >0,05          | >0,05          |
|                                          | 1rest  | 33,13±5,73       | 33,79±5,16      | >0,05 | 36,60±7,69       | 40,17±3,80       | >0,05 | >0,05          | >0,05          |
|                                          | 2 load | 34,42±5,88       | 34,39±5,39      | >0,05 | 41,80±3,33       | 47,48±2,38       | >0,05 | >0,05          | <0,05          |
| Average aortic pressure, mm<br>Hg.       | rest   | 132,90±4,40      | 135,10±5,77     | >0,05 | 112,20±7,33      | 103,90±3,30      | >0,05 | <0,05          | <0,01          |
|                                          | load   | 172,70±18,02     | 170,50±7,00     | >0,05 | 147,30±7,16      | 150,30±4,56      | >0,05 | >0,05          | <0,05          |
|                                          | 1 rest | 147,20±7,30      | 146,00±4,00     | >0,05 | 122,10±5,42      | 127,00±6,40      | >0,05 | <0,05          | <0,05          |
|                                          | 2 rest | 148,20±8,47      | 147,00±3,33     | >0,05 | 123,60±5,42      | 130,40±4,36      | >0,05 | <0,05          | <0,01          |

Notes: P is a reliable difference between practically healthy boys and girls with scoliosis. P1 is a reliable difference between practically healthy boys and boys with scoliosis. P2 is a reliable difference between practically healthy girls and girls with scoliosis.

the first and second rest by 5.46% and by 10.06% in accordance. The systolic blood volume in girls with scoliosis at rest is reduced by 47.81%, and during exercise it increases by 91.10% and decreases by 11.19% after the first rest, and by 14.97% after the second rest.

The maximum and relative maximum aerobic power at rest is reduced by 2.11 times and 2.31 times, during exercise it becomes higher by 25.83% and by 12.64%, respectively; after the first rest it turns out to be decreased by 39.16% and 52.67%, respectively, and after the second rest – by 32.38% and 50.40%, respectively. The pulse tolerance limit in girls with scoliosis at rest increased by 14.86%, when loaded – by 12.34%, after the first rest – by 18.88%, and after the second – by 38.06%, respectively. The average aortic pressure in girls at the age of 11-14 years with scoliosis at rest is also

reduced by 30.91%, during exercise – by 13.44%, after the first rest it is also reduced by 14.96% and after the 2d rest – by 12, 73% respectively.

#### Conclusions.

Thus, the girls at the age of 11-14 with scoliosis, like boys, have disorders of the cardiovascular system. To improve the indicators of its function, it is advisable to carry out a set of physical exercises. Their implementation should improve not only physical performance, but also the quality of life.

#### Prospects for further research.

The results of the research can be used in the assessment of the mutual influence of spine pathologies and the state of the immune system of adolescents. It is promising to conduct similar studies with a larger number of respondents.

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## ДИНАМІКА РОБОТИ КАРДІОВАСКУЛЯРНОЇ СИСТЕМИ ЗА ТЕСТАМИ ФІЗИЧНОЇ ПРАЦЕЗДАТНОСТІ У ДІТЕЙ ШКІЛЬНОГО ВІКУ ЗІ СКОЛІОЗОМ

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**Резюме.** Здатність людини до фізичної та соціальної адаптації складна й різноманітна. Вона визначається багатьма факторами, в тому числі соматичним станом, здатністю переносити фізичні і психоемоційні навантаження, ступенем тренуваності тощо. У підтримці гомеостазу та його регуляції найважливіша роль належить взаємодіям серцево-судинної, нервової, м'язової, дихальної та імунної систем, залоз внутрішньої секреції, органам відчуттів, а також гіпоталамо-гіпофізарної і лімбічної систем мозку. Одним з важких видів порушення адаптації, що призводять до соціального дефекту, соціальної недостатності, є захворювання (ОРА – опороухового апарату).

**Мета** нашого дослідження полягала у вивченні особливостей роботи кардіоваскулярної системи за тестами фізичної працездатності у дітей 11-14 років хворих на сколіоз в порівнянні з їх практично здоровими однолітками із загальноосвітньої школи.

**Об'єкт і методи дослідження.** Респондентами дослідження виступили підлітки зі сколіозом та умовно здорові хлопчики та дівчатка у віковій категорії 11-14 років. Було сформовано 2 групи респондентів: досліджувана та контрольна, допершої групи увійшли 19 дітей (9 хлопчиків та 10 дівчаток) загальноосвітньої санаторної школи-інтернату I-III ступенів для дітей, хворих на сколіоз, до контрольної групи увійшли 24 дитини (по 12 хлопчиків та дівчаток).

З метою розробки адекватного комплексу адаптивних фізичних навантажень нами проведено дослідження у двох групах (досліджуваній та контрольній) фізичної працездатності в т.ч. і в динаміці, толерантності до фізичних навантажень, а також окремих параметрів серцево-судинної (ССС) і вегетативної нервової системи (ВНС), максимального споживання кисню (МСК) у дітей зі сколіозом і практично здорових, ідентичних за віком дітей.

**Результати дослідження та їх обговорення.** У хлопчиків віком 11-14 р. із сколіозом знижується пульсовий тиск у спокої на 16,90%, а при навантаженні, навпаки підвищується і знижується після I і II відпочинку.

Пониженими у хлопчиків із сколіозом є максимальна і відносна аеробна потужність у спокої а при навантаженні, навпаки мають підвищені рівні. Максимальна і відносна аеробна потужність залишається пониженою у хлопчиків із сколіозом і після I та II відпочинку.

У дівчаток із сколіозом у віці 11-14 років сформовані різнонаправлені зміни показників функції кардіоваскулярної системи. Пульсовий тиск у дівчаток із сколіозом у спокої нижчий на 38,75%, ніж у практично здорових дівчаток, а за навантаженням – вищий на 84,58% і залишається підвищеним після I і II відпочинку на 5,46% і на 10,06% відповідно. Систолічний об'єм крові у дівчаток із сколіозом у спокої понижений на 47,81%, а при навантаженні підвищується на 91,10% і понижується на 11,19% після I відпочинку, а після II – на 14,97%.

Максимальна і відносна максимальна аеробна потужність у спокої понижена у 2,11 рази та у 2,31 рази, при навантаженні вона стає вищою на 25,83% і на 12,64% відповідно; після I відпочинку виявляється пониженою на 39,16% і на 52,67% відповідно, а після II відпочинку – на 32,38% і на 50,40% відповідно. Пульсова межа толерантності у дівчаток із сколіозом у спокої підвищена на 14,86%, при навантаженні – на 12,34%, після I відпочинку – на 18,88%, а після II – на 38,06% відповідно. Середній аортальний тиск у дівчаток віком 11-14 років із сколіозом у спокої також понижений на 30,91%, при навантаженні – на 13,44%, після першого відпочинку він також понижений на 14,96% і після II відпочинку – на 12,73% відповідно.

**Висновки.** Таким чином, у дівчаток віком 11-14 років із сколіозом як у хлопчиків має місце порушення функції кардіоваскулярної системи. Для покращення показників її функції доцільно провести комплекс фізичних вправ. Виконання їх повинно покращити не тільки фізичну працездатність, а також й якість життя.

**Перспективи подальших досліджень.** Результати досліджень можуть бути використані при оцінці взаємного впливу патологій хребта та стану імунної системи підлітків. Перспективним є проведення подібних досліджень з більшою кількістю респондентів.

**Ключові слова:** діти віком 11-14 років, сколіоз, кардіореспіраторна система, судинна система.

## DYNAMICS OF THE CARDIOVASCULAR SYSTEM ACCORDING TO PHYSICAL ABILITY TESTS IN SCHOOL-AGED CHILDREN WITH SCOLIOSIS

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**Abstract.** A person's ability to adapt physically and socially is complex and diverse. It is determined by many factors, including the somatic condition, the ability to tolerate physical and psycho-emotional loads, the degree of

training, etc. In maintaining homeostasis and its regulation, the most important role belongs to the interactions of the cardiovascular, nervous, muscular, respiratory and immune systems, endocrine glands, sensory organs, as well as the hypothalamic-pituitary and limbic systems of the brain. One of the severe types of maladjustment leading to a social defect, social insufficiency, is a disease (MSS – musculoskeletal system).

*The purpose of our research is to study the peculiarities of the work of the cardiovascular system according to tests of physical performance in children at the age of 11-14 years old with scoliosis in comparison with their practically healthy peers from secondary school.*

*Objects and methods of research.* The respondents of the study are the teenagers with scoliosis and conditionally healthy boys and girls in the age category of 11-14 years. 2 groups of respondents are formed: researched and controlled. The researched group included 19 children (9 boys and 10 girls) of the Oleksiievo-Druzhkivskoi general educational sanatorium and boarding school of I-III degrees № 13 for children with scoliosis. The controlled group included 24 children (12 boys and girls each).

In order to develop an adequate complex of adaptive physical exercises, we conducted research in two groups (studied and controlled) of physical capacity, including and in the dynamics, tolerance to physical exertion, as well as certain parameters of the cardiovascular (CVS) and autonomic nervous systems (ANS), maximal oxygen consumption (MOC) in children with scoliosis and practically healthy children of the same age.

*Research results and their discussion.* In boys at the age of 11-14 years with scoliosis, pulse pressure at rest decreases by 16.90%, while during exercise, on the contrary, it increases and stabilizes after the first and second rest.

Boys with scoliosis have reduced maximum and relative aerobic power at rest, and when loaded, on the contrary, have increased levels. Maximum and relative aerobic capacity remains reduced in boys with scoliosis even after the first and second rest

In girls with scoliosis at the age of 11-14 years, multidirectional changes in indicators of the function of the cardiovascular system were formed. The pulse pressure of girls with scoliosis at rest is lower by 38.75% than that of practically healthy girls, and during exercise it is higher by 84.58% and remains elevated after the first and second rest by 5.46% and by 10.06% in accordance. The systolic blood volume in girls with scoliosis at rest is reduced by 47.81%, and during exercise it increases by 91.10% and decreases by 11.19% after the first rest, and by 14.97% after the second.

The maximum and relative maximum aerobic power at rest is reduced by 2.11 times and 2.31 times, during exercise it becomes higher by 25.83% and by 12.64%, respectively; after the first rest it turns out to be decreased by 39.16% and 52.67%, respectively, and after the 2nd rest – by 32.38% and 50.40%, respectively. The pulse tolerance limit in girls with scoliosis at rest increased by 14.86%, when loaded – by 12.34%, after the first rest – by 18.88%, and after the second – by 38.06%, respectively. The average aortic pressure in girls at the age of 11-14 years with scoliosis at rest is also reduced by 30.91%, during exercise – by 13.44%, after the first rest it is also reduced by 14.96% and after the second rest – by 12, 73% respectively.

*Conclusions.* Thus, the girls at the age of 11-14 with scoliosis, like boys, have disorders of the cardiovascular system. To improve the indicators of its function, it is advisable to carry out a set of physical exercises. Their implementation should improve not only physical performance, but also the quality of life.

*Prospects for further research.* The results of the research can be used in the assessment of the mutual influence of spine pathologies and the state of the immune system of adolescents. It is promising to conduct similar studies with a larger number of respondents.

**Key words:** children at the age of 11-14 years, scoliosis, cardiorespiratory system, vascular system.

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