

THE AEROBIC EXERCISE EFFECT ON THE FUNCTIONAL STATE OF ADOLESCENTS WITH IDIOPATHIC SCOLIOSIS

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Abstract. Aerobic exercises are increasingly being included in the rehabilitation process to improve the functional state of the main body systems. Objective: to evaluate the effect of aerobic training on the functional capabilities of adolescents with idiopathic scoliosis. Methods: 6-minute walking test with an assessment of physical activity on the Baseline Dyspnea Index scale; spirometry; heart rate; determination of resistance to hypoxia. The indicators of external respiration (9.1%), general endurance (16.1%) and adaptive reserves of the body (3.2%) of adolescents improved. the improvement of functional capabilities was achieved with moderate physical exertion and a lower respiratory rate (16.4 breaths/min). Aerobic exercise increases the adaptive capabilities of the body and improves the functional performance of children suffering from musculoskeletal system pathologies.

Keywords: idiopathic scoliosis, correction, functional disorders, aerobic exercise, spinal stabilization.

Introduction. Idiopathic scoliosis is a three-dimensional spinal deformity defined by the presence of an arc of curvature with vertebral rotation, where the magnitude of the rotation angle reveals the degree of scoliosis [1, 2]. Scoliosis is a general term including a heterogeneous group of states consisting of changes in the shape and positions of the spine, thorax, and trunk. Despite the set of therapeutic and preventive measures taken, scoliotic deformity remains the most resistant to the effects of the applied methods of therapeutic correction.

The main goal of therapeutic treatment of scoliosis – to decrease the deformity and prevent its further progressing. The main tasks of correction treatment of scoliosis are considered an application of special exercises for spine mobilization and flexibility, of physical therapy measures aimed towards strengthening stabilizing muscles, paravertebral, abdominal, lower limb, and shoulder girdle muscles through isometric contractions in order to stabilize the scoliotic spine [1, 3, 4]. In case of idiopathic scoliosis, there are changes not only in the structures of the vertebral column, but also in the main systems of the body. Changes in the respiratory and cardiovascular system of the body are mostly associated with an increasing degree of spinal curvature [5, 6]. Main signs of such changes include dyspnea as a physiological response to standard physical activity, as well as

sudden fatigue and an inability to perform standard daily work for long periods of time [2, 7]. The aforementioned signs can be noticed among adolescents with degree III and rarely degree II scoliosis, with a curvature of 20 to 45 degrees. These conditions may be caused by restricted ventilation and weak respiratory muscles. These limitations can be corrected through aerobic exercise. Special exercises included in the rehabilitation protocol can affect the physical performance and respiratory function of adolescents with idiopathic scoliosis, significantly improve the adaptive reserves of the cardiorespiratory system and the state of the musculoskeletal system [2, 4].

The aim of the study – to estimate influence of aerobic exercise on the functional capabilities of adolescents with idiopathic scoliosis.

Methods and organization. The study was carried out in the Yudino Therapeutic and Rehabilitation Center located in Moscow. The study period lasted 12 weeks. The observation group included 7 early adolescent children of both genders (according to the WHO classification), average age – 13.1 ± 1.0 years. Taking the radiological findings into account, five adolescents were diagnosed with degree II and two with degree III scoliosis. According to the orthopedist's medical report, aerobic exercise was recommended for all adolescents. The criteria for inclusion in the study were: the presence of idiopathic II-III degree scoliosis

(Cobb angle – 21-34°), parental consent to include the adolescents in the observation group, and the absence of a history of cognitive and physical impairments that would prevent the performance of tests to assess the results.

The main methods of estimating the functional state of adolescents with idiopathic scoliosis are: 6-minute walking test (m) with physical activity assessment according to the BDI – Baseline Dyspnea Index scale (points); spirometry (vital capacity of the lungs – VC, l); HR – heart rate (beats/min); RR – respiratory rate (breaths/min); identifying hypoxia tolerance (breath-holding tests on inhale and exhale, s) [3, 5, 6].

At the beginning, aerobic activity included three 45-minute sessions per week for 4 weeks. Each training session started with a 10-minute warm-up, including low-intensity walking and stretching exercises. In the main part of the 20-25-minute session, children performed aerobic exercises on a treadmill (walking mode) and correction exercises. The load intensity was maintained within 60-70% of the maximum HR, according to the readings from the personal heart rate monitor. This operational control indicator was recorded on the training days before and after exercise. At the end of the study phase, the average HR for each adolescent and the group average were calculated. At the end of the session, all adolescents were offered a 10-minute period of rest and relaxation, including low-energy aerobic exercise such as slow walking and relaxation techniques performed in the supine position with the spine in a relaxed position. The stage control method (spirometry) was implemented to investigate the external respiratory function. Spirometry was performed in the sitting position with a commercial spirometer and a nasal clip. Forced VC was considered as a calculated indicator of spirometry. VC indices were recorded at the beginning and at the end of the study. Hypoxia tolerance testing was performed by measuring the inhalation and exhalation indices. The 6-minute walking test with physical load assessment on the BDI scale (from 0 to 12), where the total number of points can range from 0 (maximum dyspnea severity) to 12 (no dyspnea), was carried out to detect functional disorders of the respiratory organs during exercise. The following was recorded: total

distance travelled in 6 minutes; HR; respiratory rate; dyspnea. In the final 4 weeks, the exercise time increased to 60 minutes, three times a week. The time of the main part of the session was increased by including special correction exercises. At the final stage, the repeated testing of the studied indices was carried out to compare the results obtained.

The results were analyzed by calculating the mean values ($\bar{X}$) and the standard deviation (σ). The validity of the study results was processed with the Wilcoxon signed-rank test and the Student's t-test as long as $p \leq 0.05$.

Results and discussion. Changes in the cardiorespiratory system indices as a result are presented in table 1.

At the initial stage, the respiratory function tests helped to identify abnormalities, which were manifested by a decreased VC. By the end of the classes, improvements were noted in many aspects of respiratory function. There was a significant improvement (9.1%) in VC (table 1), as well as in breath-holding tests assessing hypoxia tolerance (table 2). The index of the breath-holding test on inhale increased by 10.5%, and that of the breath-holding test on exhale by 19.9%. As a result, hemodynamic changes of HR were also registered. The average index for the group improved by 2.2%, reflecting the adaptation of the cardiovascular system to exercise. Improvement of functional capacity in aerobic exercise was achieved at lower physical activity and lower respiratory rate (16.4 breaths/min). By the end of the rehabilitation course, a 5.3% decrease in HR was registered, reflecting the positive effect of aerobic exercise on the functional state of the cardiovascular and central nervous systems.

Changes in the respiratory function during physical exercise are presented in table 2.

The values of determining the functional state of adolescents with respiratory pathology and the therapy's effectiveness are shown in table 3.

The indices of the 6-minute walking test revealed significant improvement by 3.2%. The distance covered was achieved at a lower respiratory rate, indicating an increased tolerance to physical activity, as well as improved performance of the study participants.

The study of functional disorders on the part of respiratory organs during exercise are presented in table 4.

Table 1

Estimation of the functional state of the cardiovascular system of the adolescents during aerobic exercise, $M \pm \sigma$, $n=7$

Indices	Before the study	After the study	Difference in abs.units	Changes in %	p
HR, beats/min	78.6 $\pm$ 2.6	76.9 $\pm$ 2.0	1.7	2.2	≥ 0.05
RR, breaths/min	17.3 $\pm$ 0.9	16.4 $\pm$ 0.9	0.9	5.3	≥ 0.05
VC, l	2.0 $\pm$ 0.2	2.2 $\pm$ 0.2	0.2	9.1	≤ 0.05

Note: HR – heart rate; RR – respiration rate; VC – vital capacity of the lungs.

Table 2

Hypoxia tolerance study, $M \pm \sigma$, $n=7$

Indices	Before the study	After the study	Difference in abs.units	Changes in %	$P \leq$
Breath-holding test on inhale, s	38.6 $\pm$ 5.9	43.1 $\pm$ 5.1	4.5	10.5	0.05
Breath-holding test on exhale, s	11.3 $\pm$ 1.8	14.1 $\pm$ 1.6	2.8	19.9	0.05

Table 3

Study of tolerance to physical activity, $M \pm \sigma$, $n=7$

Indices	Before the study	After the study	Difference in abs.units	Changes in %	$P \leq$
6-minute walking test, m	496.1 $\pm$ 12.0	512.0 $\pm$ 11.1	15.9	3.2	0.05

Table 4

Study of dyspnea severity according to the modified Baseline Dyspnea Index scale after exercise, $M \pm \sigma$, $n=7$

Indices	Before the study	After the study	Difference in abs.units	Changes in %	Wilcoxon signed-rank test
Dyspnea, points	9.1 $\pm$ 1.2	10.9 $\pm$ 1.0	1.8	16.6	≤ 0.05

The respiratory act normalization is physiologically justified by more intensive lung ventilation achieved by increasing the volume of aerobic exercise. Consequently, positive (16.6%) changes in the dyspnea severity were noted, explaining the improvement of general endurance.

Conclusion. Combined aerobic training is able to improve external respiration (VC – by 9.1%) and hemodynamic parameters (HR – by 2.2%, RR – by 5.3%) of adolescents with idiopathic scoliosis. Improvement in functional capabilities was achieved with moderate exercise

and lower respiratory rate (16.4 breaths/min). The assessment of the load quality and the adequacy of the cardiovascular system response during exercise was reflected in an increase in the external respiratory function indices (breath-holding test on inhale – by 10.5%, breath-holding test on exhale – by 19.9%). The use of aerobic exercise in complex rehabilitation can improve the indices of general endurance (by 16.6%), which determine adaptation to physical activity and functional efficiency (by 3.2%) of children with pathologies of the musculoskeletal system.

Conflict of interest. The authors declare no conflict of interest.

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