

Improving the morphofunctional state of female students from different health groups through strength athletics during the academic year

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Abstract:

Developing innovative methods for university students' physical education is a key focus for physical education specialists. **Purpose.** The objective of this study is to enhance physical education methods by incorporating elements of strength athletics, aiming to improve the physical condition and functional reserves of girls with somatic health disorders. **Materials and methods.** The improved methods were tested at a technical university in Irkutsk, Russia, involving 65 female students aged 17.6 ± 0.5 years. The participants were randomly assigned to a control group (CG, $n = 30$) and an experimental group (EG, $n = 35$). Both groups attended physical education classes twice a week for 90 min. For the EG participants, the main portion of each session included 35–40 min of strength athletics exercises. The training incorporated various exercise machines and equipment, including dumbbells, barbells, medicine balls, and skipping ropes. Additionally, exercises on apparatus such as wall bars, gymnastic benches, parallel bars, and horizontal bars were used, along with bodyweight exercises. A comprehensive assessment of functional indicators, physical performance, and motor skill development was performed using motor tests. **Results.** At the end of the academic year, positive results in the physical education of female students were observed in both groups. These results were reflected in improved functional reserves of the cardiorespiratory system, strength, physical performance, and motor skills. However, the EG, which used strength athletics, demonstrated the most significant improvements in functional indicators, physical performance, and physical fitness compared to the CG. **Conclusions.** The testing of the innovative methodology incorporating strength athletics into the physical education of girls with somatic diseases demonstrated its high effectiveness. These results support its recommendation for implementation in other educational institutions.

Keywords: physical education, female students, functional indicators, motor qualities, power athletics

Introduction

The application of physical education tools and methods to correct and enhance human health offers considerable advantages over pharmacological approaches to treating pathologies (Guseva & Zhukova, 2021; Wu et al., 2024). Consequently, the ongoing exploration and improvement of physical exercise strategies to promote and enhance the population's health, particularly among young people, represent a vital and relevant direction in physical education and health technologies (Marsigliante et al., 2024; Griban et al., 2024; Martusevich et al., 2024). Improving the health of the younger generation is particularly critical given its impact on the labor and intellectual potential of modern society (Carl et al., 2024). This need is amplified by the declining health indicators among student populations in many countries (Almhdawi et al., 2021; Zhao et al., 2024; Landman & Tagari, 2024; Metalnikov et al., 2024) and the increasing prevalence of metabolic disorders among young people (Kalka et al., 2019; Alwashmi, 2023).

The decline in the health of children and adolescents often begins during their school years (Ruan & Tang, 2024). According to C. Li et al. (2024), a steady decrease in cardiorespiratory endurance and an increase

in body mass index have been observed in Chinese children over the past three decades. A similar decline in endurance has been noted in French children (Vanhelst et al., 2024; Kolokoltsev et al., 2021), raising concerns among researchers. This trend is particularly alarming because cardiorespiratory endurance is a key indicator of both current and future health for children and adolescents. Experts suggest that significant academic and extracurricular workloads, along with stress factors (Herbert, 2022; Kolokoltsev et al., 2022) and the widespread use of information and communication technologies (Genc & Pirincci, 2024), contribute to the deterioration of students' health. Additionally, the disregard for healthy lifestyle principles (Jürgensen et al., 2024) and the pronounced low physical activity among young people (Khatrı & Sharma, 2024) play a considerable role in this decline.

Each year, the number of students unable to fully engage in physical activity owing to physical or somatic health issues increases. As a result, a special medical group is formed from these students (Glazkova et al., 2020), where physical education incorporates medical and pedagogical elements and requires special attention from teachers (Momot et al., 2020).

Young people often underestimate the importance of physical activity, leading to physical inactivity and the development of somatic diseases (Kellner & Faas, 2022; Bocharin, et al., 2021). A decline in student motivation for traditional forms of physical education has been observed. The use of monitoring observations of the physical status of female students and the improvement of physical education methods remain crucial issues (Romanova et al., 2023; Esposito et al., 2024). This approach enables teachers to adjust the educational process, thereby enhancing the effectiveness of modified technologies (Prontenko et al., 2019; Bocharin et al., 2023; Daniels & Howie, 2024).

Among young people, power athletics has become a popular form of physical activity, particularly among girls and women, as a means of promoting health and fitness (Zainullin et al., 2020). The use of power athletics for effective body shaping is important (Eliane Aparecida Franco et al., 2021). Power fitness, such as "Hot Iron," is commonly used to enhance strength endurance and reduce body weight. This form of exercise involves a system of physical activities using mini-bars of various weights (Nenenko, Maksimova, 2018). Despite the existing scientific literature on the role of power athletics in maintaining students' health, the use of this approach among female students categorized as belonging to a special medical group owing to health conditions remains underexplored. We believe that investigating this issue will enable more effective physical education classes for these students, ultimately contributing positively to their physical health.

Research aim. The aim of this research is to enhance the physical status and functional reserves of girls with somatic health disorders by improving the physical education methodology through the integration of strength athletics elements.

Materials and methods

To test the proposed methodology, 65 girls aged 17–19 (17.6 ± 0.5 years) were selected. These students, enrolled at Irkutsk National Research Technical University (Siberian Federal District, Russia), had somatic pathologies and participated in physical education in a special medical group. The study was carried out jointly by scientists from the departments of physical education and pedagogy at various universities in Russia, Kyrgyzstan, and Kazakhstan. The scientific work that was performed adhered to the principles of the Helsinki Declaration of 2008.

The girls were randomly assigned to a control group (CG, $n = 30$) and an experimental group (EG, $n = 35$). In both groups, physical education classes were performed twice a week for 90 min. For the girls in the EG, the main part of the classes included 35–40 min of strength athletics exercises. Various exercise machines and equipment (dumbbells, barbells, medicine balls, and skipping ropes) were used, along with exercises on apparatus (wall bars, gymnastic benches, parallel bars, and horizontal bars) and bodyweight exercises.

Strength exercises were performed using a continuous method aimed at increasing both dynamic and isometric strength indicators. The training also focused on developing strength endurance in all muscle groups. The physical exercises started with the arm muscles, followed by the trunk, and ended with the lower limbs. The physical load was alternated between the extensor and flexor muscles. Static exercises were incorporated either in the middle or at the end of the strength training sessions.

A comparative analysis of the effectiveness of the proposed technique was performed at the beginning of the experiment (September) and at its end (May).

To assess the functional indicators of the body, the following parameters were studied: heart rate at rest (bpm), hypoxic tests of Stange and Genchi (s), hand dynamometry for both hands (kg), and the calculation of the strength index ($SI = \text{hand strength, kg} \times 100 / \text{body weight, kg, \%}$). The physical performance of the girls was evaluated using the Gardard step test index (arbitrary units). Physical fitness was assessed using motor tests, and the dynamic strength of the lower limb muscles was measured using the "standing long jump" test (cm). Speed–strength qualities were determined using the "number of torso lifts in 30 s" test (number of repetitions), the "jumping rope in 30 s" test (number of repetitions), and the "flexion and extension of arms in support" test (number of repetitions). Static endurance was assessed using the "holding straight legs at an angle of 45° in a supine position" test (s). Overall endurance was evaluated using the Cooper test (m).

The digital data were processed using standard parametric statistical methods (arithmetic mean, error, and standard deviation). Reliability was determined using Student's t-test. Differences with a p-value of less than 0.05 were considered statistically significant.

Results

The results of the study on functional indicators and physical performance in girls from both groups at the beginning and end of the school year are presented in Table 1.

Table 1. Threshold values of functional indicators and physical performance in girls from the CG and EG, $M \pm m$

No	Indicators	CG, n= 30		EG, n= 35	
		September	May	September	May
1.	Heart rate at rest, bpm	88.2±4.37	86.2±4.17	88.8±4.22	79.4±4.12*
2.	Stange test	36.2±3.63	43.8±3.97*	35.7±3.52	47.3±3.89*
3.	Genchi test	28.7±2.34	30.5±2.33	29.8±2.32	36.5±3.57*
4.	Left hand strength, kg	24.4±1.65	27.3±1.94	23.2±1.39	28.9±1.46*
5.	Right hand strength, kg	26.1±1.73	29.5±2.19	25.4±1.33	35.6±3.44*
6.	Strength index of the left hand, %	43.6±3.23	46.2±3.54	42.5±3.16	55.3±4.32*
7.	Strength index of the right hand, %	46.8±3.57	52.4±3.12	44.6±2.87	59.3±3.78*
8.	Harvard step test index, arbitrary units	66.3±4.34	87.4±5.46*	65.5±4.23	98.5±6.73*

Note. * reliability of the difference in indicator values for female students at the end of the academic year, $p < 0.05$

At the beginning of the school year, no significant difference in the values of functional parameters was found between the girls in both groups, $p > 0.05$.

Physical education classes throughout the school year enhanced the body's reserve capacity, as evidenced by the higher values of functional characteristics and physical performance parameters in the girls from both groups.

A significant increase in the values of all functional test parameters was observed in the girls from the EG, $p < 0.05$. The EG incorporated strength exercises into the physical education process. In the CG, the indicator value increased significantly only in the Stange test (Table 1). The increase in indicator values for girls in both groups at the end of the observation period is shown in Figure 1.

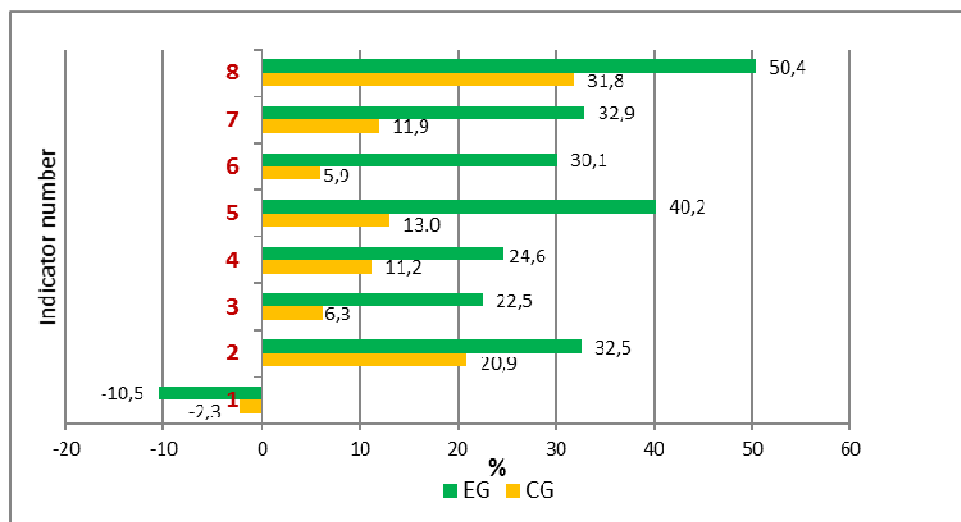


Fig. 1. Dynamics of functional characteristics and physical performance values in girls at the end of the observation period

A greater increase in the parameters was observed in the girls from the EG compared to those from the CG. The results indicate significant adaptation of the cardiovascular and respiratory systems to physical activity in the girls from the EG, as reflected by a greater decrease in heart rate at rest (-10.5 bpm) compared to the girls from the CG (-2.3 bpm). By the end of the school year, the girls from the EG demonstrated higher hypoxic resistance, as evidenced by better results in the Stange and Genchi tests compared to the results in these tests for the girls from the CG.

The implementation of strength-oriented exercises in physical education had a significant impact on the strength training of girls from the EG. They showed a greater increase in the strength indicators of both hands and the strength index compared to girls from the CG. Physical performance was also higher at the end of the observation, as indicated by the final values of the Harvard step test index. The increase in physical performance for the girls from the EG was 50.4%, which is 1.56 times greater than the result in CG, where it was 31.8%. The results of the study on the physical fitness of girls in both groups are presented in Table 2.

Table 2. Threshold values of physical fitness indicators for girls from the CG and EG, $M \pm m$

No.	Tests	CG, n= 30		EG, n= 35	
		September	May	September	May
1.	Standing long jump, cm	174.6 $\pm$ 4.56	179.5 $\pm$ 4.85	173.3 $\pm$ 4.12	186.7 $\pm$ 5.23*
2.	Number of torso lifts in 30 s, number of repetitions	21.5 $\pm$ 1.87	26.6 $\pm$ 2.34*	21.0 $\pm$ 1.56	32.7 $\pm$ 2.63*
3.	Jumping rope in 30 s, number of repetitions	56.8 $\pm$ 2.23	66.7 $\pm$ 3.54*	55.5 $\pm$ 2.12	75.4 $\pm$ 4.52*
4.	Maintaining straight legs at a 45° angle in a supine position, s	35.8 $\pm$ 3.65	43.3 $\pm$ 4.76	36.7 $\pm$ 3.25	58.3 $\pm$ 4.76*
5.	Arm extension in support, number of repetitions	19.7 $\pm$ 2.43	23.40 $\pm$ 2.12	20.4 $\pm$ 2.87	32.5 $\pm$ 3.17*
6.	Cooper test, m	1950.0 $\pm$ 64.5	2045.3 $\pm$ 67.4	1940.5 $\pm$ 63.4	2340.5 $\pm$ 74.7*

Note. * reliability of the difference in indicator values among female students at the end of the academic year, $p < 0.05$

At the beginning of the experiment, no significant differences were observed between the physical fitness indicators of the girls from the CG and EG, $p > 0.05$.

At the end of the school year, higher values of the indicators in the control exercises were observed for girls in both groups. In the CG, the values of the indicators in the two tests increased significantly, while in the EG, all motor test indicators showed significant improvement, $p < 0.05$.

The dynamics of the increase in indicators in motor tests by the end of the experiment are shown in Figure 2.

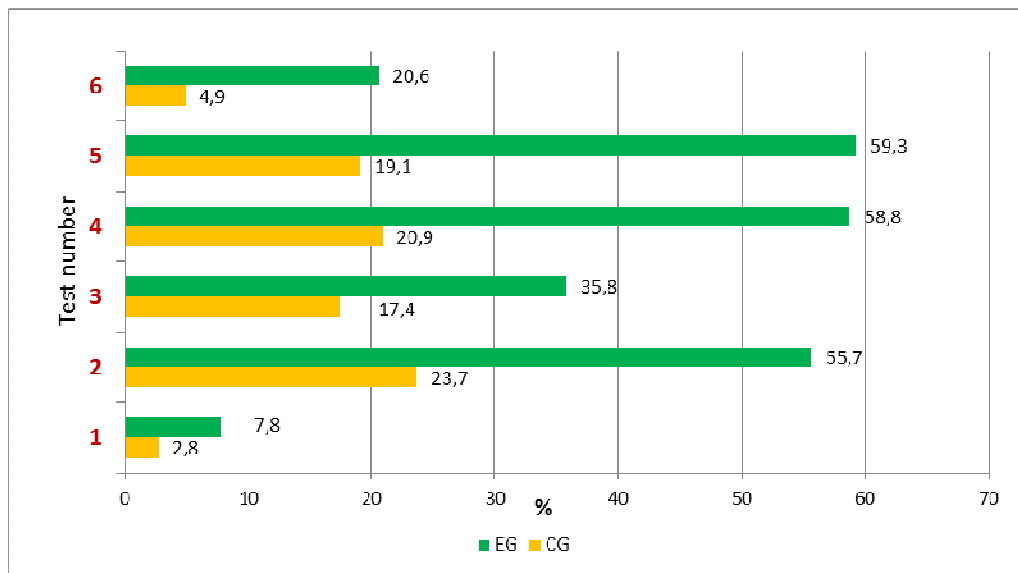


Fig. 2. Changes in the values of motor test indicators at the end of the experiment

At the end of the academic year, the results of testing motor skills showed significantly higher values of all indicators for the girls from the EG compared to those from the CG. The largest increases in motor test indicators for EG girls, exceeding 50%, were recorded in control tests No. 2 (55.7%), No. 4 (58.8%), and No. 5 (59.3%). In the remaining tests, the increase in indicator values for EG girls ranged from 7.8% to 35.8%, all of which were significantly higher compared to the results of CG students.

Thus, the incorporation of strength athletics into physical education classes for university female students has demonstrated its effectiveness in comparison to the traditional educational approach.

The incorporation of strength athletics elements into the educational process led to increased attendance in physical education classes by EG students. An analysis of the attendance data throughout the academic year revealed that, on average, CG students had an attendance rate of 62%, while EG students had an attendance rate

of 96%, which is 54.8% higher. These findings suggest that EG female students are more motivated to participate in physical education.

Discussion

Improving and modernizing physical education classes for students to increase their effectiveness is a relevant area of physical education (Marsigliante et al., 2024; Griban et al., 2024). This approach to physical education of young people is especially important due to the declining health indicators of children, adolescents and young people, which is observed in many regions (Almhdawi et al., 2021; Zhao et al., 2024; Landman, & Tagari, 2024; Metalnikov et al., 2024). In this regard, a significant number of students have restrictions on physical activity (Glazkova et al., 2020). The increasing physical inactivity of female students, associated with low physical activity and decreased interest in traditional activities, also plays a role. This is reported by a number of authors (Kellner & Faas, 2022; Daniels, & Howie, 2024). Therefore, we believe that the study of issues related to the use of techniques aimed at improving physical health seems important and timely.

Currently, power athletics has become popular among the population of many countries, which is practiced by girls and women, using it as a means of health fitness (Zainullin et al., 2020) and for effective correction of physique (Eliane Aparecida Franco et al., 2021).

One of the areas of physical education of young people is to increase the cardiorespiratory endurance of the body (Sdvizhkova et al., 2021). Aerobic exercises have the most pronounced positive effect on the cardiorespiratory system. The body's tolerance to physical work is assessed by the nature of the pulse at rest or after a dosed load and the Harvard step test index.

Our benchmark testing of functional characteristics and physical performance at the end of the experiment confirms the opinion of a number of authors (Marsigliante et al., 2024) about positive changes in the cardiovascular, respiratory and muscular systems of the girls' body. This is indicated by a slowdown in resting heart rate, an increase in physical performance, strength qualities and hypoxic resistance of the body of girls in the implementation group, where power athletics was used.

An increase in the functional indicators of girls in the experimental group, where power athletics was used, formed a higher physical performance in them. If at the beginning of the study all the girls were classified according to the Harvard Step Test index as a low level of development of this indicator, then at the end of the experiment they were classified as "high".

The use of power athletics in physical education classes allowed to increase the basic motor qualities of female students. At the end of the experiment, they showed a reliable increase in the values of the indicators in all control exercises. The values of the indicator increase in the tests were significantly greater compared to the result in the control group. Similar data were obtained by other authors (Prontenko et al., 2019; Bocharin et al., 2023; Daniels, & Howie, 2024), who used innovative pedagogical methods in the physical education of students. The higher level of physical status of female students in the implementation group is explained not only by the effective impact of power athletics on functional indicators, physical performance and physical qualities, but also by an increase in interest in academic classes. This is indicated by the comparative attendance of physical education classes by girls in the control and experimental groups throughout the academic year. We have found that in the group of girls where power athletics was used, absences from classes without good reason were 1.5 times less frequent compared to the control group where traditional classes were held. We agree with the opinion of other researchers (Romanova et al. 2023; Esposito et al., 2024) that the use of new means and methods of physical education significantly increases the motivational component and the effectiveness of the educational process. while simultaneously improving physical health indicators

Conclusion

To improve the physical status and functional characteristics of girls with various somatic health deviations, a method incorporating power athletics into their physical education curriculum was evaluated. The girls participated in power athletics for 35–40 min during the main part of each physical education lesson throughout the school year. Exercise machines, equipment-based exercises, apparatus-based exercises, and bodyweight exercises were used for the power athletics sessions. At the end of the testing period, the girls from the EG, where power athletics was incorporated, demonstrated higher resistance to physical stress in both the cardiorespiratory and muscular systems, as well as significantly greater physical performance and fitness.

This was supported by reliably significant differences in the indicators between the EG and CG. Additionally, higher motivation for physical education classes was observed among the girls from the EG. Based on these results, power athletics can be recommended for use in the educational process of university students to enhance their physical status and functional characteristics.

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

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