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Original Article

Organization of student physical education using the innovative CrossFit training system

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Abstract:
Optimizing the physical education curriculum for students is a timely and essential task for specialists in the fields of physical education and sports. **Purpose:** To develop, analyze, and assess the effectiveness of the CrossFit methodology in physical training sessions for university students. **Materials and Methods**: The study involved twenty male university students from the Northeastern Federal District, Russia. Participants were randomly assigned to either a control group (CG, n = 10) or an experimental group (EG, n = 10). Both groups attended Applied Physical Education classes twice weekly, with each session lasting 90 min. For the CG, physical education was performed according to the standard course curriculum approved by the university. For the EG, a training methodology was developed that incorporated CrossFit elements into the main portion of the physical education classes. In designing the EG programs, three key principles were applied: performing exercises without a time limit, applying maximal loads in a set interval, and completing a fixed volume of exercises in the shortest possible time. To evaluate the effectiveness of the physical training programs, all participants underwent benchmark physical fitness testing. Body composition was assessed using the bioimpedance method, while overall health was evaluated through the bioimpedance phase angle. Cardiorespiratory capacity during physical activity was measured using the Ruffier index. **Results:** The advantages of the new methodology were clear, reflected in a significant and reliable improvement in all basic physical qualities and skills. Participants in the EG showed an increase in the bioimpedance phase angle, indicating improved performance, metabolism, and overall health. Bioimpedance analysis also revealed positive changes in body composition, including a significant decrease in lipid content and an increase in skeletal muscle mass. By the end of the observation period, the EG participants demonstrated a significant improvement in cardiovascular reserve capacity, as measured by the Ruffier index. **Conclusions:** The positive results obtained in the EG support the recommendation of the CrossFit methodology for student physical training at other universities. The reliable and significant improvements demonstrated through testing indicate that this approach can be effectively implemented in physical education programs across higher education institutions. Moreover, the CrossFit method has the potential to improve students' physical fitness and health over the long term throughout their years of study.
Key Words: **physical education, physical training, motor abilities, body composition, CrossFit, social life**

Introduction

Current observations of youth health indicate a decline in health indicators in many countries worldwide (Zhao et al., 2024; Landman, & Tagari, 2024; Metalnikov et al., 2024), with particularly low levels recorded among university students (Ruan, & Tang, 2024; Li et al., 2024). At the same time, students demonstrate weak motivation for engaging in physical activity (Biino et al., 2020; Romanova et al., 2022). Researchers and specialists report deterioration across all aspects of health in young people, especially physical health, as

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evidenced by long-term studies tracking youth health across generations (Syamsudin et al., 2021; Vanhelst et al., 2024). Poor health among students negatively affects academic performance, career development, and overall quality of life (Kolokoltsev et al., 2020; Mischenko et al., 2021).

Collectively, these trends contribute to a decline in the development of the workforce and the socioeconomic strength of the state (Bocharin et al., 2023; Hermassi et al., 2024). Therefore, maintaining and improving the health of the younger generation remains a critical focus of public policy worldwide (Alalawi et al., 2024; Ituen et al., 2025).

It is well established that one of the key approaches to improving human health is the use of physical education tools and methods. This drug-free strategy has proven effective and, when properly implemented, can lead to significant health benefits. Incorporating such tools and methods in the physical education curriculum plays an important role in enhancing both the physical and mental capacities of students (Zurita-Ortega et al., 2019; Zhang et al., 2019). Educators, in collaboration with researchers, continually refine the health-promoting aspects of physical education, thereby increasing students' physical activity levels (Porter et al., 2024). However, interventions in the curriculum aimed at improving the health of children and adolescents are not always successful, which can negatively affect their overall health outcomes (Kurnaz et al., 2024; Noordstar et al., 2025; Bocharin et al., 2023). Therefore, there is a growing need to integrate innovative, health-promoting activities into physical education programs. Research has demonstrated that the use of modern technologies can enhance student motivation and, in turn, improve physical health outcomes (Romanova et al., 2023; Esposito et al., 2024). In particular, physical education practices have increasingly incorporated sports-training-based technologies, which have been shown to significantly improve the effectiveness of health improvement interventions (Clemente et al., 2023; Stojanović et al., 2023; Kurnaz et al., 2024). As a result, sports training has become an integral component of contemporary physical education classes (Barba-Martín et al., 2020; Snezhitsky et al., 2022).

One effective approach to physical education and health improvement is the CrossFit system (Klimek et al., 2018). This system is based on a circuit training method that incorporates a diverse range of physical exercises, including weightlifting, gymnastics, strength training, running, rowing, swimming, and specialized movements such as rope climbing, rock climbing, and kettlebell lifting. This variety allows individuals to select exercises that are most suitable for their abilities and goals. The diverse exercises in CrossFit promote the development of endurance, flexibility, speed, balance, agility, and motor coordination. Workouts are designed to combine aerobic and anaerobic muscle activity efficiently (Franchini et al., 2019). By developing a wide spectrum of motor skills, the CrossFit system demonstrates strong potential for implementation across various educational institutions. The CrossFit system is an optimal tool for promoting motivated academic and extracurricular physical activity among young students (Petrova et al., 2022; Han et al., 2022). However, its practical implementation in university physical education programs remains insufficiently studied. There is a lack of comprehensive data in the scientific literature regarding the instrumental monitoring of CrossFit's effectiveness in student physical education, particularly using bioimpedance analysis. This gap in knowledge limits the potential for enhancing youth health through physical education. Therefore, further research is needed to implement the CrossFit methodology in the curriculum and systematically evaluate its effectiveness.

Research objective: To develop, examine, and assess the effectiveness of the CrossFit methodology in physical training sessions for university students.

Materials and Methods

The experimental study was performed from September to May of the 2023–2024 academic year at a pedagogical university in the Northeastern Federal District of Russia. Twenty male students aged 18–21 years (mean age 19.4 ± 1.5 years) were randomly assigned to either a control group (CG, n = 10) or an experimental group (EG, n = 10). All participants were generally healthy and classified in the primary medical group. The study was performed in accordance with the 2008 Declaration of Helsinki, which outlines the ethical principles for research involving human subjects. Researchers and specialists from multiple universities in Russia, Kyrgyzstan, and Kazakhstan collaborated on this project.

Students in both groups attended "Applied Physical Education" classes twice weekly, with each session lasting 90 min. For the CG, physical education was performed according to the university-approved curriculum, incorporating elements of general physical training, active games, track and field, skiing, and elective sports.

For the EG, a modified methodology was implemented, integrating elements of the CrossFit system into the main portion of each class. High-intensity interval training and a variety of functional exercises were tailored to the individual capabilities of the students. The EG training programs were designed based on three key principles: performing exercises without a time limit, applying maximum load in a defined time interval, and completing a fixed volume of work in the shortest possible time.

The classes in the experiment were structured according to three models.

Model 1: Exercise time was not recorded.

Model 2: Participants performed the maximum number of exercises within a fixed time interval.

Model 3: Participants completed a predefined volume of work in the shortest possible time.

The training programs included various types of running, general developmental exercises, and specific functional movements such as pull-ups, push-ups, squats, burpees, abdominal exercises, as well as standard CrossFit workouts such as Barbara, Kelly, and Cindy. Rest periods were individualized and determined based on heart rate. Each training model was applied twice weekly for four weeks, after which the subsequent model was introduced. In later phases, mixed training modes were used, which increased student motivation while promoting the development and improvement of multiple physical qualities and skills.

The program was structured according to the principle of sequential mastery of the material. Initially, the focus was on learning and refining the techniques of various exercises. Subsequently, the curriculum incorporated the development of kettlebell lifting, weightlifting, powerlifting, bodyweight exercises, and cyclical physical activities. This approach contributed to the improvement of students' overall physical fitness and increased the reserve capacity of their functional systems for physical activity.

The effectiveness of the physical training programs was evaluated using milestone testing to assess the development of physical qualities in both groups. The following motor tests were used: speed–strength endurance was measured as the maximum effort on a Concept 2 rowing machine for 10 s (W); speed was assessed with a 100-m sprint (s); endurance was measured using the 12-min Cooper test (m); strength and coordination were evaluated by the maximum number of Turkish get-ups performed in 3 min using a 10 kg dumbbell; accuracy was assessed by throwing a 4 kg medicine ball against a wall from alternating distances of 2.5, 3, and 3.5 m from a full squat, with the number of successful throws recorded; flexibility was assessed using the "bridge" test (cm), and body balance was evaluated by measuring the time maintaining balance on a platform with closed eyes (s). A dynamometer was used to determine trunk muscle strength in the deadlift (kg). Cardiovascular reserve capacity was assessed using the Ruffier index (points). Body composition was analyzed via bioimpedance, and health status was evaluated based on the bioimpedance phase angle. All bioimpedance measurements were performed using an ABC-01 Medass analyzer (MEDASS Scientific and Technical Center, Russia).

The data were processed using the Statistica 10.0 software package and Microsoft Excel 2016. For numerical data that did not follow a normal distribution, the Mann–Whitney U-test was applied. Results were considered statistically significant at $p < 0.05$.

Results

The benchmark values for physical fitness testing in young men from the CG and EG groups are presented in Table 1.

Table1.

Benchmark values for motor performance testing in young men in the experimental groups, M ± m

Tests	CG (n = 10)		EG (n = 10)	
	At the beginning of the study	At the end of the study	At the beginning of the study	At the end of the study
Concept 2 rowing machine exercise, W	178.1 ± 5.24	179.8 ± 5.34	178.8± 5.56	206.3 ± 7.43*
100 m run, s	13.6 ± 0.25	13.7 ± 0.27	13.6 ± 0.23	12.7 ± 0.18*
Cooper 12-minute test, m	1900.0 ± 48.2	1887.0 ± 44.2	1898.5 ± 50.23	2177.0 ± 61.3*
Turkish get-up, number of repetitions	9.7 ± 1.53	10.1± 1.76	10.1 ± 1.45	18.3 ± 2.43*
Throwing a 4 kg medicine ball against a wall, number of repetitions	21.1 ± 2.87	22.4± 2.94	21.1 ± 2.23	29.7 ± 3.76*
Bridge, cm	155.5 ± 4.42	155.7 ±5.36	155.4 ± 5.43	147.4 ± 4.32
Maintaining balance on a platform with eyes closed, s	60.3 ± 3.34	61.4 ± 4.59	60.6 ± 3.42	108.0 ± 6.87*
Deadlift, kg	93.4 ± 4.36	96.4 ± 4.34	93.3 ± 4.34	121.1 ± 7.46*

*Note: *Significant difference in test scores at the end of the pedagogical observation period ($p < 0.05$)*

Analysis of the data presented in Table 1 showed that at the initial stage of the experiment, there were no significant differences in physical fitness levels between the groups ($p \geq 0.05$), indicating a comparable baseline and sample homogeneity. By the final stage of the study, positive improvements were observed in the physical fitness indicators for participants in both groups. However, only the students who followed the experimental methodology demonstrated a statistically significant increase in motor test scores ($p < 0.05$). These results highlight the effectiveness of the proposed student physical education program incorporating the CrossFit methodology compared to the traditional curriculum. The percentage increase in motor test scores is shown in Figure 1.

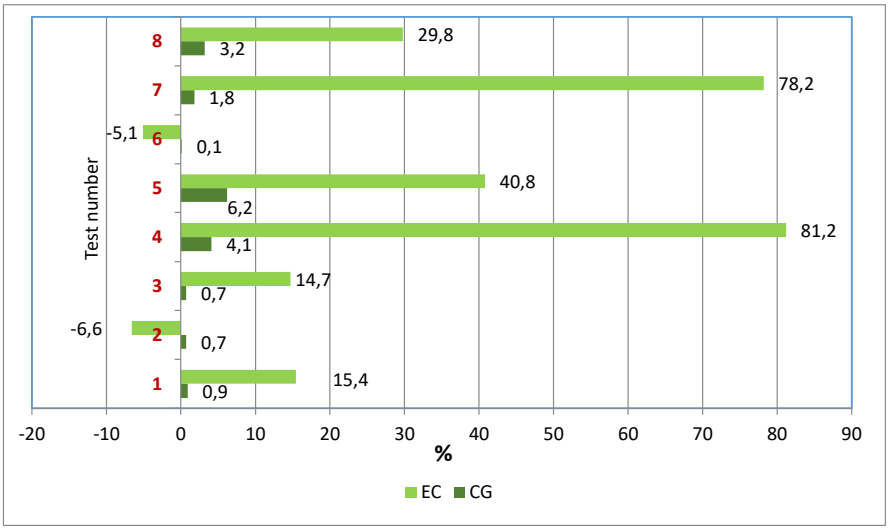

Fig. 1. Final gains in physical fitness indicators for young men

At the end of the experiment, improvements in all motor tests were greater for participants in the EG compared to the CG. The largest gain in the EG was observed in Test No. 4 (the "Turkish Get-Up"), with an increase of 81.2%. Significant improvements were also noted in Test No. 7 (Balance on a Platform with Eyes Closed), which exceeded 70%, and in Test No. 5 (Throwing a 4 kg Medicine Ball Against a Wall), which increased by more than 40.8%. In contrast, gains for participants in the CG were substantially smaller, at 4.1%, 1.8%, and 6.2% for the same tests, respectively.

The pedagogical experiment had a positive effect on cardiovascular exercise tolerance in the EG, as evidenced by a significant 32.3% decrease in the Ruffier index (from 9.6 ± 0.92 to 6.5 ± 0.72 points, $p < 0.05$) compared to baseline. This indicates an improvement in physical performance among the young men and helps explain their higher motor test scores. In contrast, the CG showed a negative trend, with a 2.1% increase in the Ruffier index, reflecting a decline in physical performance.

During physical education classes, changes in component composition, anthropometric parameters, and phase angle were observed in the young men participating in the program. These changes are supported by the results of the bioimpedance analysis (Table 2).

Table 2. Benchmark values of anthropometric parameters, body composition, and bioimpedance phase angle in young men from the experimental groups, M ± m

Indicator	CG (n=10)		EG (n=10)	
	At the beginning of the study	At the end of the study	At the beginning of the study	At the end of the study
Body length, cm	179.0 ± 5.32	179.2± 6.34	179.2 ± 5.43	179.5±7.65
Body weight, kg	75.4 ± 5.87	73.7 ±4.98	75.7 ± 5.88	72.2± 6.88
Phase angle, deg	7.9 ± 0.57	8.0 ± 0.65	7.9 ± 0.54	8.7 ± 0.67*
Body mass index, kg/m^2	23.5 ± 1.22	23.0± 1.20	23.6 ± 1.26	22.4 ± 1.30
Fat mass, kg	10.4 ± 0.35	10.7 ± 0.43	10.2 ± 0.33	8.3 ± 0.35*
Lean mass, kg	64.9 ± 1.82	62.4 ± 1.46	64.8 ± 1.83	69.5 ± 1.12*
Active cell mass, kg	40.9 ± 1.56	38.5 ± 1.22	40.8 ± 1.54	47.2 ± 1.65*
Skeletal muscle mass, %	34.9 ± 2.69	33.3 ± 2.64	34.8 ± 2.64	41.5 ± 2.82*
Skeletal muscle mass proportion, %	53.6 ± 6.47	53.5 ± 6.38	53.8 ± 6.48	65.5 ± 6.93

*Note: *Significant difference in test score values at the end of the study ($p < 0.05$)*

At the initial stage of the experiment, no significant differences were observed between the groups in the results of instrumental analyses ($p \geq 0.05$). By the final stage, significant changes occurred in body composition indicators and the bioimpedance phase angle, particularly among participants in the EG. Specifically, the bioimpedance phase angle increased by 10.1% (from 7.9 ± 0.54 to 8.7 ± 0.67 degrees, $p < 0.05$), indicating improved physical performance and metabolic processes in students following the experimental physical education program. In contrast, the CG showed only a slight increase of 1.3% in the bioimpedance phase angle (Fig. 2).

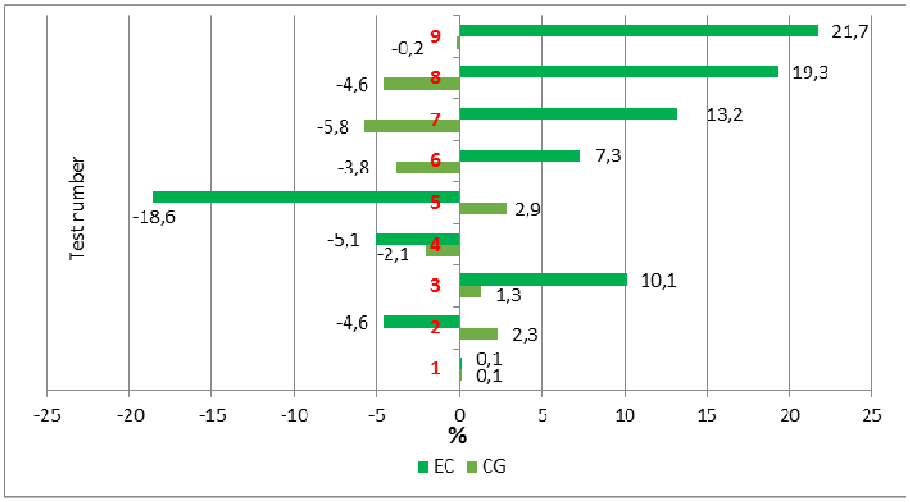

Fig. 2. Final changes in bioimpedance values in young men at the end of the experiment

An important result of implementing the experimental CrossFit methodology in physical education classes was a reduction in fat mass and an increase in the proportion of skeletal muscle mass. These changes occurred alongside a 4.6% decrease in body weight among EG students (from 75.7 ± 5.88 to 72.2 ± 6.88 kg) and a 5.1% reduction in body mass index. Body fat content in the EG decreased by 18.6% (from 10.2 ± 0.33 to 8.3 ± 0.35 kg, $p < 0.05$), while the proportion of skeletal muscle mass increased by 19.3% (from 34.8% ± 2.64% to 41.5% ± 2.82%, $p < 0.05$). The increase in skeletal muscle mass and the reduction in fat mass contributed to a 7.3% increase in lean body mass among EG students (from 64.8 ± 1.83 to 69.5 ± 1.12 kg, $p < 0.05$), whereas the CG exhibited a decrease in this parameter. Additionally, students in the EG following the CrossFit methodology demonstrated a 15.7% increase in active cell mass (from 40.8 ± 1.54 to 47.2 ± 1.65 kg, $p < 0.05$).

This positive change in body composition and bioimpedance phase angle suggests high levels of motor development and good health in students in the EG. In contrast, students in the CG showed no significant changes in bioimpedance parameters ($p \geq 0.05$).

Discussion

The introduction of technologies from various sports into physical education has demonstrated significant health benefits for students (Clemente et al., 2023; Stojanović et al., 2023; Kurnaz et al., 2024). The use of the CrossFit system in training across many sports has demonstrated high effectiveness in improving athletes' physical fitness (Klimek et al., 2018; Kolokoltsev et al., 2021). Therefore, researchers have attempted to use CrossFit in physical education for students (Petrova et al., 2022; Han et al., 2022).

The results of using the CrossFit system in physical education classes at secondary schools have been adequately studied. However, issues related to the implementation of the CrossFit system in university physical education remain understudied. There is little information in the scientific literature on evaluating the effectiveness of the CrossFit system using instrumental methods for monitoring students' bodies. Specifically, there is a lack of information on the dynamics of changes in the component composition and phase angle parameters in students' bodies based on bioimpedance analysis. Studying these issues will allow the obtained data to be used in the educational process of physical training for students, thereby enhancing the health benefits of physical activity in physical education classes.

The data obtained by the authors of this study demonstrate the significant positive impact of using CrossFit in the physical education process for university students. After completion of the research project, a significantly positive trend in the level of physical fitness was observed in the experimental group of students. The gains in all movement tests were significantly higher than those in the comparison group. The obtained results are consistent with the findings of other researchers regarding the use of CrossFit in physical education classes for students in secondary educational institutions (Franchini et al., 2019; Petrova et al., 2022; Han et al., 2022). Increased physical fitness is typically accompanied by improvements in various functional systems. The most significant changes from physical activity occur in the muscular and cardiovascular systems. Analysis of our results confirms the conclusion about the increase in strength qualities of students in the experimental group. We obtained reliably significant positive data in motor tests and dynamometry of deadlift strength compared to the control group. The increase in cardiovascular reserve capacity was significantly greater in the group that used the experimental method. This is indicated by the positive dynamics of the Ruffier index in students in this group. According to our data, the final cardiovascular testing showed a decrease in the Ruffier index by more than 30%, indicating an increase in systolic work of the heart and, therefore, improved physical performance. In

the control group, a negative trend in the Ruffier index was observed, manifested by an increase in this indicator, indicating a decrease in cardiac reserve capacity.

Using the bioimpedance method to monitor the effectiveness of the proposed CrossFit methodology, we identified reliable changes in body composition and phase angle in the experimental group of young men compared to the control group, where a traditional physical education program was used in the educational process. At the end of the educational experiment, a 10.1% increase in the bioimpedance phase angle was observed, indicating increased physical performance in students in the experimental group and an increase in their metabolic rate. Furthermore, positive dynamics in body composition were observed in this group of subjects. Among the young men in this group, a 19.3% increase in skeletal muscle tissue content and an 18.6% decrease in lipid mass were noted, which led to a 4.6% decrease in body weight. We believe that these dynamics are due to the use of varied and effective physical exercises from the CrossFit system, as reported in the study by S. Klimek et al. (2018). A decrease in body fat and an increase in muscle mass resulted in positive changes in lean body mass and active cell mass. A 7.3% increase in lean body mass and a 15.7% increase in active cell mass were also recorded. The positive changes in bioimpedance are consistent with the results of observations of athletes in various sports (Rossi, 2021; Campa et al., 2021). Such positive changes in bioimpedance parameters indicate improved health. Students in the comparison group showed decreases in all analyzed bioimpedance parameters.

Thus, the significant effectiveness of the CrossFit method in students' physical fitness and positive changes in their body composition and cardiovascular function have been established. This allows us to recommend the use of this innovative technology in physical education for students at higher education institutions. The prospect of a long-term positive effect deserves special attention. The combined use of the CrossFit methodology, designed for students in their second and third years of university, will further enhance the body's adaptation to training loads, improve physical fitness, health, and develop healthy lifestyle skills.

Conclusion

An innovative approach to conducting physical education classes for students, based on the CrossFit methodology and the sequential application of three training models, was developed and tested. This approach involved performing exercises without time limits, applying maximum loads in a set time interval, and completing a fixed volume of exercises in the shortest possible time. Experimental results demonstrated the advantages of this method by the end of the observation period, reflected in a significant and reliable improvement in all basic physical qualities and skills, as well as increased cardiovascular reserve capacity measured by the Ruffier index. Improvements in the bioimpedance phase angle indicated improved overall performance, metabolism, and health. Bioimpedance analysis further revealed positive changes in body composition among students in the EG, including increases in skeletal muscle mass, active cell mass, and lean body mass, alongside reductions in fat mass.

The reliable and significant results obtained from testing the CrossFit method in physical education classes allow us to recommend it for use in other higher education institutions. The CrossFit method has the potential to be used in future years of study to long-term improve the physical fitness and health of students

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

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