

Assessment of the effects of low-intensity external resistance exercises on strength indicators of students aged 12–13 under conditions of wartime stress

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Abstract

Background and Study Aim

Under conditions of wartime stress, the daily routine and patterns of physical activity of students undergo significant changes, creating prerequisites for a decline in physical functioning. Limited access to habitual forms of movement, prolonged stays in shelters, and disruption of the stable educational process form an environment in which the maintenance of strength qualities becomes challenging. Although various forms of physical activity are used to compensate for these adverse effects, their relative effectiveness in maintaining and developing strength in adolescents remains of practical interest. The aim of the study was to analyze changes in strength indicators of students aged 12–13 resulting from low-intensity external resistance exercises under conditions of wartime stress.

Material and Methods

The study involved students aged 12–13 who were assigned to an experimental group and a control group. The duration of the intervention was eight weeks, with a training frequency of three sessions per week. The program for the experimental group included low-intensity external resistance exercises performed under conditions of restricted physical activity caused by the wartime stress environment. Strength indicators were assessed before and after the intervention using standardized tests, including push-ups, squats, trunk raises, plank hold, and standing long jump. Statistical data processing was carried out using comparative analysis methods within and between groups.

Results

Following the eight-week intervention, students in the experimental group demonstrated improvements in strength indicators. In boys, the number of push-ups increased from 20.5 ± 7.5 to 23.0 ± 7.25 , plank holding time increased from 98.5 ± 24.25 to 104.37 ± 25.62 , and standing long jump performance improved from 155.0 ± 21.25 to 157.62 ± 21.03 . In girls, the improvements were moderate: the number of push-ups increased from 16.0 ± 1.2 to 17.2 ± 1.84 , plank holding time increased from 80.4 ± 12.48 to 82.4 ± 14.88 , and standing long jump distance increased from 131.4 ± 2.32 to 132.6 ± 3.12 . Statistically significant improvements ($p < 0.05$) were observed mainly in tests reflecting strength endurance and static strength, whereas no substantial changes were identified in the control group.

Conclusions

The results obtained demonstrated that low-intensity external resistance exercises can contribute to the maintenance and moderate improvement of strength indicators in students aged 12–13 under conditions of restricted physical activity caused by the wartime stress environment. The most pronounced changes were observed in tests for strength endurance and static strength, with the dynamics of improvement differing in magnitude and nature between boys and girls. The findings highlight the practical value of dosed strength training as an accessible means of maintaining physical fitness in students under external restrictions.

Keywords:

adolescents, physical fitness, strength endurance, adaptive loads, stress environment, functional status

Introduction

The living conditions of students during wartime stress are accompanied by changes in their usual activity patterns and limitations in performing daily physical tasks. Constant external stressors, reduced overall mobility, and irregular physical practice create a set of factors that can affect the physical condition of adolescents. The interaction of these factors creates prerequisites for variability in the

physical fitness indicators of students.

The results of studies examining the living conditions of children in Ukraine during wartime indicate significant changes in the structure of their daily activities and the characteristics of physical load. The combination of stress factors, disruption of habitual routines, and restrictions on performing physical actions has been shown to affect the overall condition of the child population and to create altered conditions for bodily functioning [1, 2]. According to reports from international

organizations, a substantial proportion of children are forced to spend prolonged periods in shelters, experience irregular physical activity, and adapt to a modified structure of the school day [3]. Regional studies report a decline in physical activity levels among adolescents and changes in physical condition indicators in students aged 12–13 [4, 5]. These findings are associated with restrictions in motor routines, a reduction in the volume of active movements, and the impact of prolonged stress exposure. Hozak et al. emphasize the effect of reduced opportunities for organized and leisure-time physical activity [6], which, according to the authors, creates new conditions for maintaining the functional state of children and adolescents. Another study presents pedagogical approaches aimed at compensating for motor and educational losses in younger age groups [7].

Baj-Korpak et al. indicate that the physical fitness of children and adolescents reflects characteristics of their functional state and changes under the influence of various environmental factors [8]. In this context, the level of physical fitness in childhood demonstrates a certain degree of stability during the transition to later developmental stages and is associated with indicators of somatic health [9]. A systematic review by França et al. reports that strength-oriented exercises should be considered as one of the means for maintaining and modifying physical fitness parameters in youth [10]. Conceptual syntheses also highlight the role of resistance-based loads in the development and stabilization of muscular characteristics in adolescents, particularly under conditions of restricted physical activity [11].

Applied research examining the effects of strength programs on the physical condition of children and adolescents demonstrates a consistent trend toward the use of external resistance exercises as a means of targeted influence on indicators of muscular functionality. Systematic reviews indicate that regular strength-oriented training contributes to changes in physical fitness parameters in students, including strength development and improvements in performance in motor tests [12, 13]. The findings of Moreno-Torres et al. confirm that structured programs delivered under professional supervision can lead to changes in strength levels and related characteristics in children and adolescents, provided that principles of safety and appropriate load dosage are observed [14]. Other studies emphasize the physiological foundations of strength exercise application at a young age and describe practical approaches to their implementation in educational settings [15, 16]. In applied school-based interventions, a combination of strength and endurance components is used, which is considered one option for organizing adolescents' physical activity and may result in changes in a range of physical and cognitive parameters [17].

An analysis of research findings indicates that strength exercises and programs involving external resistance can influence physical fitness indicators in children and adolescents, including parameters related to muscular functionality. Authors of various studies emphasize that the effectiveness of such interventions depends on the conditions under which exercises are performed, characteristics of the movement environment, and age-specific features of the participants. It is also highlighted that changes in physical activity caused by external restrictions introduce additional factors that may affect the strength characteristics of students. At the same time, there remains a need to investigate how different forms of external resistance exercises manifest under conditions of uneven physical load and altered activity patterns. This gap complicates the clarification of the specific effects of low-intensity strength interventions on physical condition indicators in students and determines the necessity for further analytical research on this issue.

The aim of the study was to analyze changes in strength indicators of students aged 12–13 resulting from low-intensity external resistance exercises under conditions of wartime stress.

Materials and Methods

Participants

The study involved 32 students aged 12–13 attending a general secondary school in Kharkiv, Ukraine. The total sample consisted of 16 boys and 16 girls. All participants were generally healthy, had no medical contraindications to physical exercise, and attended physical education classes as part of the school curriculum.

The sample was formed on the basis of voluntary participation of students who met the age criteria and regularly attended school. According to the study design, participants were assigned to two groups: an experimental group ($n = 16$) and a control group ($n = 16$). Each group included 8 boys and 8 girls, ensuring comparability between groups in terms of sex distribution.

The participants had not undergone specialized sports training and had a similar level of motor experience, which allowed the experimental and control groups to be considered relatively homogeneous in terms of basic physical characteristics at the baseline stage of the study.

The study was conducted in accordance with the principles of the Declaration of Helsinki and the current regulatory requirements for conducting research involving minors. Prior to the start of the study, written informed consent was obtained from the parents or legal guardians of the students, as well as verbal consent from the participants themselves for voluntary participation. All children

were informed in advance about the expected nature of the exercises and testing procedures. In addition, participation in the study did not involve any interventions exceeding age-appropriate levels of physical activity.

The study did not include the use of potentially injurious loads, in line with the principles of risk minimization for minors. Personal data of the participants were not collected or recorded in an identifiable form; the results are presented in an aggregated manner that precludes the identification of individual students. The conduct of the study also complied with the requirements of the educational institution where the activities were carried out.

Study Design

The study was conducted at the extracurricular education institution of the “Olymp” sports club in Kharkiv and lasted eight weeks. Training sessions were held three times per week with a fixed duration of 45 minutes. All training sessions were conducted indoors, ensuring stable and safe conditions for exercise during the period of external stress.

Baseline and post-intervention assessments of the participants were performed under identical conditions, at the same time of day, with a stable indoor temperature and unchanged sports facility equipment. Attendance was recorded throughout the entire study period, allowing for monitoring of participation regularity and ensuring the accuracy of the analysis of changes in the measured indicators.

Equipment

To implement low-intensity external resistance exercises, a set of simple training aids was used, including light-weight dumbbells, resistance bands, and TRX suspension straps. All equipment was selected with consideration of the age-specific characteristics of students aged 12–13 and allowed for controlled additional loading without exceeding acceptable levels of exertion.

Light-weight dumbbells (0.5–1 kg) were used to create minimal external resistance when performing exercises aimed at activating the muscles of the upper limbs and shoulder girdle. Their use allowed for variation of the load without increasing movement intensity.

Resistance bands provided elastic resistance that varied depending on the degree of band elongation. They were used to perform exercises targeting the muscles of the back, shoulder girdle, and lower limbs and enabled regulation of load magnitude by modifying the range of motion.

TRX suspension straps were applied in exercises using body weight as resistance. Changes in body inclination angle and support point positioning allowed adjustment of the level of external resistance while maintaining low exercise intensity. The use of suspension straps enabled the performance of stabilization and supportive exercises with a

controlled level of load.

The combination of the equipment used made it possible to create conditions for performing exercises with low-intensity, dosed external resistance without the need for heavy or specialized training machines.

Exercise Program

The training program was designed for eight weeks and included three sessions per week, each lasting 45 minutes. Each session had a fixed structure consisting of a warm-up, a main part, and a final block of recovery exercises. The content of the sessions was adapted to the age-specific characteristics of students aged 12–13 and involved the use of low-intensity external resistance exercises.

Session Structure

1. *Warm-up (8–10 minutes)*. The warm-up included simple general conditioning exercises aimed at preparing the musculoskeletal system, activating major muscle groups, and increasing joint mobility.
2. *Main part (30 minutes)*. The main part consisted of a set of exercises performed using light-weight dumbbells, resistance bands, and TRX suspension straps. The exercises were selected to provide dosed loading of the major muscle groups without exceeding low-intensity thresholds.
3. *Cool-down (5 minutes)*. The final part included relaxation exercises, breathing exercises, and stretching, facilitating a gradual reduction of muscle tension.

Exercise Selection and Objectives

Low-Intensity Dumbbell Exercises

Dumbbell curls. The exercise was performed in a standing position with the dumbbells held alongside the body. Elbow flexion was executed through the activation of the arm muscles without trunk swinging. The elbows remained fixed relative to the torso, and the range of motion was controlled.

Dumbbell triceps extensions. The starting position involved a slight forward inclination of the torso. The upper arm was kept close to the body, and the movement was performed through elbow extension. The trunk remained stabilized, and the movement was slow and controlled.

Squats with light-weight dumbbells. The dumbbells were held alongside the body. Squats were performed to a comfortable depth while maintaining a neutral spine position. The knees followed the line of the feet, and postural stability was preserved throughout the movement.

Objective. The objective of these exercises was to provide light external resistance to activate the muscles of the upper and lower limbs while maintaining a safe load level appropriate for students aged 12–13.

Resistance Band Exercises

Resistance band row to the chest. The resistance band was fixed at chest level. The participant performed a pulling movement by flexing the arms and retracting the shoulder blades. The trunk remained stationary, and the movement was executed at a controlled speed.

Lateral arm raises with a resistance band. The starting position involved slightly flexed arms with the resistance band held in front of the body. The arms were abducted to shoulder level with a controlled trajectory. The movement was smooth and performed without elbow hyperextension.

Backward leg extension with a resistance band. The resistance band was fixed at the level of the lower leg or foot. The participant maintained an upright trunk position and slowly extended the leg backward while preserving stability of the supporting leg. The range of motion was controlled, and the pelvis remained in a neutral position.

Objective. The objective of these exercises was to develop the muscles of the back, shoulder girdle, and gluteal region using elastic resistance, allowing movements to be performed within an accessible range of motion and at a safe level of exertion.

TRX Suspension Exercises

TRX horizontal row. The participant held the handles with the body inclined backward at an angle not exceeding 35°. The pulling movement was performed through elbow flexion and scapular retraction. The shoulder girdle was stabilized, and the movement was controlled.

Supported semi-squat with TRX. The participant

held the suspension straps and performed a squat to an approximate knee flexion angle of 60–70°. Body weight was evenly distributed, and the knees did not move beyond the line of the toes. The TRX system was used as a stabilization aid.

TRX plank (modified version). The elbows were positioned under the shoulder joints, and the body was maintained in a straight line. The legs were placed in the TRX straps in a position that minimized the lever arm. The exercise was discontinued at the first signs of technique deterioration.

Objective. The objective of these exercises was to strengthen the core, back, and lower limb muscles through bodyweight-based exercises with adjustable body inclination angles.

The selection of exercises was based on the principles of age appropriateness, the possibility of safely adjusting resistance levels, and the need to maintain motor activity under conditions of external stress exposure. The exercises ensured the involvement of major muscle groups while not requiring high effort and avoiding excessive physical load (Table 1).

Tests

The following test trials were used to assess the strength indicators of the students:

1. *Push-ups* — maximum number of correctly performed repetitions.
2. *Bodyweight squats* — number of repetitions performed using standardized technique.
3. *Trunk raises (sit-ups) in 30 seconds* — number of correctly executed repetitions.
4. *Forearm plank hold* — duration of maintaining the position.

Table 1. Detailed list of exercises

No.	Type of exercise	Equipment	Primary muscle groups	Intensity characteristics
1	Standing arm curls	Dumbbells (0.5–1 kg)	Biceps brachii	Low load, 12–15 repetitions
2	Backward arm extensions	Dumbbells	Triceps brachii	Low load, 12–15 repetitions
3	Resistance band row to the chest	Resistance band	Latissimus dorsi, rhomboids	Light elastic resistance
4	Lateral arm raises	Resistance band	Deltoid muscles	Light resistance, slow execution
5	Backward leg extension	Resistance band	Gluteal muscles	Low load, controlled range of motion
6	Inclined horizontal row	TRX suspension straps	Back muscles, shoulder girdle	Bodyweight resistance, angle < 35°
7	Supported semi-squat	TRX suspension straps	Quadriceps, gluteal muscles	Low load, 10–12 repetitions
8	TRX-supported plank (modified)	TRX suspension straps	Core muscles	Hold for 10–20 s
9	Squat with light-weight dumbbells	Dumbbells	Lower limb muscles	Low load, controlled tempo
10	Forearm flexion with resistance band	Resistance band	Forearm muscles	Light resistance

5. *Standing long jump* – best result from two attempts.

Methods for Assessing Strength Indicators. Strength indicators were assessed twice – before the start of the training cycle and after its completion – using a standardized testing protocol. Prior to each testing session, participants received a brief explanation of the task and a demonstration of the starting position. All tests were performed individually, with monitoring of correct technique and a fixed sequence of test execution.

Manual measurement tools were used to record the results: a stopwatch for measuring the duration of static holds, a measuring tape for assessing standing long jump distance, and recording sheets for counting repetitions. Each attempt was documented in an individual recording form, and the final outcome was defined as the maximum value achieved (time, number of repetitions, or jump distance).

Testing conditions remained unchanged at both assessment points. All tests were conducted at the same time of day, under stable indoor temperature conditions, and using identical sports facility equipment. All measurements were performed by the same specialist, ensuring consistency in technical requirements and reducing variability associated with inter-rater differences.

Training Load Characteristics. The training load was classified as low-intensity strength activity and was regulated through the volume and duration of exercise performance. For dynamic exercises, 10–15 repetitions per set were used, allowing activation of major muscle groups without inducing pronounced fatigue. Static exercises were performed with position holds lasting 10–20 seconds, and execution was terminated at the first signs of technique deterioration.

Rest intervals of 45–60 seconds were maintained between sets to ensure adequate recovery. All

exercises were performed at a moderate tempo, with controlled ranges of motion and adherence to proper technique. The training load did not include maximal or submaximal efforts and remained within levels considered safe for students aged 12–13. This regimen corresponded to the principle of dosed and adaptive physical activity under conditions of external stress.

Load Progression. Load progression was achieved through gradual modifications of exercise volume and execution complexity, while the magnitude of external resistance remained unchanged and corresponded to a low-intensity level (Table 2). During the first two weeks, emphasis was placed on mastering proper technique and performing an optimal workload with minimal movement variability. In weeks 3–4, the number of repetitions and the duration of static holds were increased, providing a moderate increase in overall load without altering the nature of resistance.

During weeks 5–6, the number of sets was increased for selected exercises, and minor adjustments to starting positions were introduced, allowing task complexity to increase without raising intensity. In the final weeks (7–8), progression was achieved through improvements in movement quality, moderate increases in execution tempo, and optimization of motor effort while maintaining the required range of motion. This approach ensured a gradual increase in training stimulus and was consistent with the age-related capabilities of students.

Statistical Analysis

Statistical analysis was conducted to evaluate changes in the strength indicators of students at the beginning and at the end of the eight-week training cycle. For each test, mean values and standard deviations were calculated to describe the dynamics of physical fitness indicators. The normality of data distribution was assessed using the Shapiro–

Table 2. Weekly load progression scheme

Week	Type of progression	Main focus
1	Technique acquisition, minimal resistance	Coordination, correct range of motion
2	Technique stabilization, full workload execution	10–12 repetitions, 1–2 sets
3	Increase in number of repetitions	12–15 repetitions, 2 sets
4	Slight increase in static hold duration	+5 s for plank and TRX supports
5	Increase in total session volume	3 sets for simple exercises
6	Increased exercise complexity (not intensity)	TRX angle modification by 5–10°
7	Increased execution speed with maintained technical control	Moderate dynamics
8	Final load stabilization	Repetition of weeks 6–7 conditions

Principle: progression through volume, technique, and holding time, rather than through increased external load.

Wilk test. As measurements were obtained from the same participants at two time points, paired Student's *t*-tests were applied to compare baseline and post-intervention data. The level of statistical significance was set at $p < 0.05$, in accordance with commonly accepted criteria in studies of physical development in students. Statistical data processing was performed using standard Excel software.

Results

The analysis of strength test data obtained from boys in the experimental group at the beginning and at the end of the eight-week training period made it possible to determine the dynamics of performance indicators for each test. A comparison of mean values demonstrated varying magnitudes of change, as presented in Table 3.

An analysis of the data presented in Table 3 showed that most strength indicators in the experimental group demonstrated positive dynamics. Statistically significant differences ($p < 0.05$) were identified in Tests 1, 2, 4, and 5, indicating improvements in parameters associated

with strength endurance and static strength. In Test 3, the slight increase in the mean value did not reach the level of statistical significance ($p = 0.115405$), which may indicate lower sensitivity of this indicator to the applied training loads or a more stable baseline level of preparedness among the participants. Overall, the results demonstrate a tendency toward improved strength characteristics in boys of the experimental group following participation in the eight-week low-intensity external resistance exercise program.

In boys of the control group, strength indicators remained stable throughout the study period (Table 4). Minor increases in mean values did not reach statistical significance in any of the tests ($p > 0.05$), which corresponds to the expected natural variability of indicators in the absence of targeted training intervention.

For girls in the experimental group, changes in strength indicators over the eight-week period were also assessed. Mean values, standard deviations, and the statistical significance of differences are presented in Table 5.

Table 3. Dynamics of strength fitness indicators in boys of the experimental group

Test	January 2024 (Mean ± SD)	May 2024 (Mean ± SD)	<i>p</i>
Test 1	20.5 ± 7.5	23.0 ± 7.25	0.000614
Test 2	56.12 ± 15.34	59.75 ± 13.81	0.003117
Test 3	21.12 ± 1.65	21.62 ± 1.71	0.115405
Test 4	98.5 ± 24.25	104.37 ± 25.62	0.00052
Test 5	155.0 ± 21.25	157.62 ± 21.03	0.02852

Table 4. Dynamics of strength fitness indicators in boys of the control group

Test	January 2024 (Mean ± SD)	May 2024 (Mean ± SD)	<i>p</i>
Test 1	20.1 ± 7.4	20.4 ± 7.5	0.284
Test 2	55.8 ± 15.1	56.2 ± 14.9	0.412
Test 3	21.0 ± 1.7	21.1 ± 1.7	0.365
Test 4	97.9 ± 24.1	98.3 ± 23.8	0.298
Test 5	154.2 ± 21.0	154.6 ± 21.2	0.340

Table 5. Dynamics of strength fitness indicators in girls of the experimental group

Test	January 2024 (Mean ± SD)	May 2024 (Mean ± SD)	<i>p</i>
Test 1	16.0 ± 1.2	17.2 ± 1.84	0.011153
Test 2	54.0 ± 11.6	56.8 ± 11.76	0.003689
Test 3	14.2 ± 11.12	14.6 ± 11.76	0.139829
Test 4	80.4 ± 12.48	82.4 ± 14.88	0.033567
Test 5	131.4 ± 2.32	132.6 ± 3.12	0.140738

An analysis of the data presented in Table 5 showed that girls in the experimental group demonstrated moderately expressed positive dynamics in most of the assessed strength tests. Statistically significant differences ($p < 0.05$) were recorded in Tests 1, 2, and 4, reflecting improvements in indicators associated with strength endurance of the upper shoulder girdle muscles and static strength. In Tests 3 and 5, the increases in mean values were minimal and did not reach statistical significance ($p > 0.05$). This may indicate a more stable nature of these indicators or lower sensitivity of the applied methodology to changes in this group of participants. Overall, the results demonstrate a tendency toward improved strength characteristics in girls of the experimental group following the implementation of the low-intensity external resistance exercise program.

In girls of the control group, the observed changes were also minimal, and differences in mean values did not reach statistical significance ($p > 0.05$). This reflects the absence of targeted training intervention and the stability of strength characteristics under conditions of usual physical activity (Table 6).

To provide a clear visualization of changes in strength indicators in boys from the experimental and control groups, a comparative diagram was constructed illustrating the dynamics of values across all five tests (Figure 1).

The diagram illustrates differences in the dynamics of strength indicators between the groups. Boys in the experimental group demonstrated a pronounced increase in mean values in most tests following the eight-week exercise program. In the control group, changes remained minimal and did not exceed the range of natural variability. The most notable differences in favor of the experimental group were observed in Tests 1, 2, 4, and 5, which is consistent with the data presented in the tables and the results of the statistical analysis.

A similar comparative diagram was constructed for girls, allowing assessment of differences in the dynamics of strength fitness between the experimental and control groups (Figure 2).

In girls of the experimental group, a moderate increase in strength indicators was observed in Tests 1, 2, and 4, whereas values in the control group remained virtually unchanged. The observed

Table 6. Dynamics of strength fitness indicators in girls of the control group

Test	January 2024 (Mean \pm SD)	May 2024 (Mean \pm SD)	<i>p</i>
Test 1	15.9 \pm 1.3	16.1 \pm 1.4	0.240
Test 2	53.8 \pm 11.4	54.2 \pm 11.5	0.334
Test 3	14.1 \pm 11.0	14.2 \pm 11.2	0.402
Test 4	80.0 \pm 12.3	80.3 \pm 12.5	0.276
Test 5	131.0 \pm 2.2	131.2 \pm 2.3	0.310

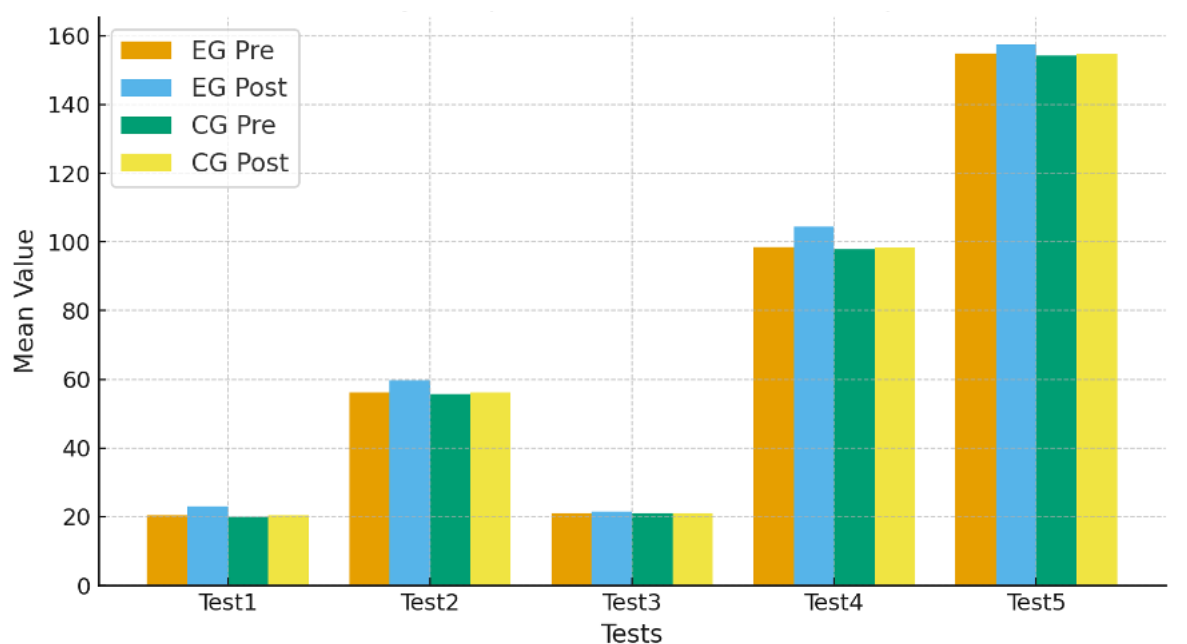


Figure 1. Comparison of strength indicators in boys from the experimental and control groups (Pre–Post).

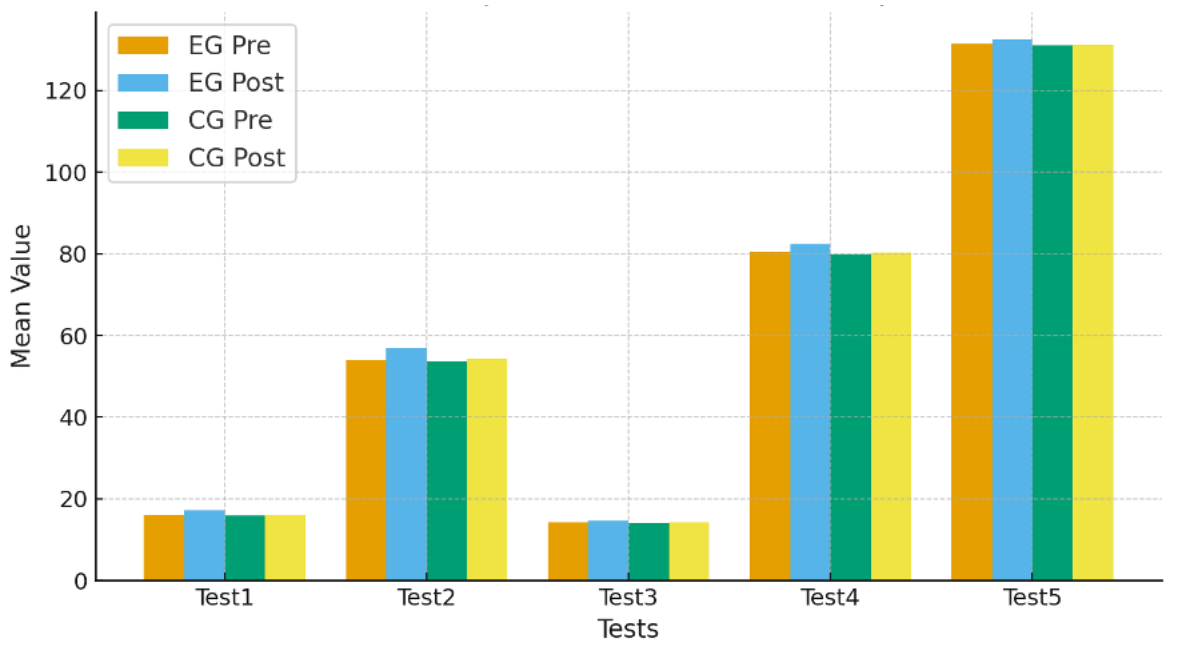


Figure 2. Comparison of strength indicators in girls from the experimental and control groups (Pre–Post).

positive dynamics in the experimental group are consistent with the results presented in Table 2 and confirm differences in the trajectory of changes compared with the control group, in which no significant shifts were detected.

Discussion

The aim of the study was to analyze changes in strength indicators in students aged 12–13 resulting from low-intensity external resistance exercises under conditions of wartime stress. The obtained data made it possible to characterize the dynamics of strength fitness in boys and girls of the experimental group and to compare these changes with those observed in the control group, which did not participate in a targeted training program.

The results of the comparative analysis showed that participants in the experimental group exhibited a moderate improvement in strength characteristics across several tests, whereas changes in the control group remained minimal and did not reach statistical significance. The most pronounced differences were observed in tests associated with strength endurance and static strength, which is consistent with the orientation of the applied low-intensity exercise program. At the same time, some indicators demonstrated limited changes, highlighting the heterogeneous nature of participants' responses to training stimuli under conditions of altered The obtained results indicate that low-intensity external resistance exercises are capable of producing moderate positive changes in the strength fitness of early adolescent students even under conditions of restricted motor activity. This pattern of changes is consistent with findings

from systematic reviews reporting that dosed resistance loads lead to improvements in strength endurance and static strength in children and adolescents when principles of gradual progression and technical control are observed [10, 13, 18]. Other studies confirm that even low levels of external resistance can elicit adaptive muscular responses and contribute to functional improvements during adolescence [11, 19, 20]. Synthesized analytical evidence emphasizes that low-intensity resistance activity can support the development of basic muscular qualities in adolescents when overall motor activity is limited [21, 22]. At the same time, the observed heterogeneity of changes across individual tests is consistent with conclusions indicating that the response of different muscle groups to training stimuli depends on exercise specificity, baseline fitness level, and the context in which physical activity is performed [14].

Comparison of the obtained data with findings from studies conducted under conditions of restricted motor activity or exposure to stress factors reveals similar trends. Research examining the impact of the wartime situation on the lifestyle and physical condition of children in Ukraine highlights a reduction in overall mobility, irregular physical activity patterns, and a decrease in time allocated to strength- and endurance-oriented exercises [1, 4]. These conclusions are consistent with broader investigations addressing the consequences of armed conflicts [23, 24]. The results demonstrate that a stressful environment and disruption of habitual daily routines exert a substantial influence on the functional state of children, including levels of motor activity and capacity for physical adaptation. Under

such conditions, even small doses of structured physical activity may assume a compensatory role, which corresponds to the observed improvements in selected strength indicators among students in the experimental group.

Additional evidence reported by Sennersten et al. regarding the effects of stressful environments on children's physical development supports the notion that adaptive responses of the organism may be delayed and may vary across different components of physical fitness [2]. This is partially reflected in the present study, where increases in strength indicators were heterogeneous and differed across tests and participant subgroups. The observed tendency is consistent with conclusions from studies emphasizing the importance of minimal organized physical activity for maintaining functional stability in children exposed to external stressors [5, 25].

The obtained data indicate that the dynamics of strength indicators in boys and girls were uneven, which is consistent with well-established age- and sex-related characteristics of muscular system development in early adolescence. Boys demonstrated more pronounced changes in tests associated with upper limb strength endurance and static strength. This finding is consistent with studies reporting higher sensitivity of the shoulder girdle muscles to resistance loads in boys aged 12–14 years [12, 13, 26]. In contrast, girls were characterized by moderate positive changes, which may be related to lower levels of relative strength, differences in habitual motor activity, and specific features of muscle effort mobilization described in research on adolescent development [15].

The observed difference in responses to the training intervention is also consistent with the findings reported by Moran et al. [27]. The authors emphasize that gains in muscular strength in boys at this age stage may be more pronounced due to accelerated neuromuscular adaptation and the increasing influence of hormonal factors. Girls, in contrast, are traditionally reported to demonstrate a more favorable response to stabilization-oriented exercises and tasks requiring trunk control, which is explained by earlier development of motor coordination and postural skills [10, 28]. These patterns are partially reflected in the present findings, where changes in strength indicators in girls were more uniform but less pronounced than those observed in boys.

The practical significance of the obtained results lies in the fact that low-intensity external resistance exercises can be considered an accessible and relatively safe tool for maintaining strength fitness in students under conditions of restricted motor activity and exposure to chronic stressors. It should be noted that wartime conditions are characterized by irregularity of the educational process, reduced

levels of daily physical activity, and periodic stays of children in shelters. In this context, such exercises make it possible to organize a minimally necessary level of motor load without exacerbating external constraints. The mechanisms underlying the positive effects may be related to the fact that small doses of resistance activity provide sufficient stimulation of muscle groups without inducing excessive fatigue, which is particularly important under conditions of increased psychophysiological strain.

Comparison of the results with data from studies conducted among children living in unstable environments indicates that even moderate and structured physical loads can play a compensatory role. Such forms of motor activity allow maintenance of a basic level of physical work capacity and help prevent further declines in strength indicators. This approach is particularly relevant in situations where opportunities for full-scale physical activity are limited and the functional state of children is characterized by high sensitivity to external factors. Thus, the systematic inclusion of low-intensity exercises may be considered a means of maintaining the physical condition of students in a stressful environment, providing minimal but regular training stimulation.

Limitations of the Study

The study has several limitations. First, the sample size was relatively small and included students from a single educational institution, which limits the generalizability of the findings. Second, conducting the study under conditions of wartime stress involved factors that could not be fully controlled (air raid alerts, changes in class schedules, and time spent in shelters), which may have affected training regularity and participants' physical and psychological states. Third, the use of low-intensity exercises and standard bodyweight-based tests limited the depth of analysis of specific strength characteristics. In addition, the relatively short observation period does not allow assessment of the long-term effects of the proposed program.

Future research may focus on examining the long-term effects of low-intensity external resistance exercises and evaluating the sustainability of the observed changes over extended time periods. Expanding the sample to include different age groups and educational institutions would be of interest, as well as analyzing the effects of training programs with varying orientations and levels of variability on students's strength indicators. An important direction for further research may involve assessing the combined influence of training interventions and external environmental factors, including patterns of motor activity under stressful conditions. Additional studies employing instrumental measurement methods would allow for a more precise characterization of adaptive mechanisms in children and adolescents.

Conclusions

The obtained data demonstrated that low-intensity external resistance exercises contribute to a moderate improvement in strength indicators in students aged 12–13 under conditions of restricted motor activity and exposure to a wartime stress environment. Participants in the experimental group exhibited positive changes across several tests, whereas indicators in the control group remained stable. These findings confirm that regular, dosed physical loads can serve as an

effective means of maintaining physical fitness in children in situations where opportunities for full-scale physical activity are limited. The results highlight the appropriateness of implementing such programs in educational practice and underscore the need for further investigation of their potential under altered external conditions.

Conflict of interests

The authors declare that there is no conflict of interests.

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