

## INFLUENCE OF A HANDBALL EXERCISE PROGRAM ON THE DEVELOPMENT OF UPPER LIMB STRENGTH IN HIGH SCHOOL STUDENTS

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**Abstract:** The strength of the upper limbs directly influences motor activities specific to handball, such as passing, throwing and blocking. In the context of physical education classes, the integration of exercises inspired by handball can be an effective means for the development of this motor quality in high school students.

The main purpose of this research is to demonstrate that a program of exercises taken from handball contributes to the development of upper limb strength among high school students.

If a program based on exercises for the development of the strength of the upper limbs is implemented in the physical education lesson of the 10th grade students, it will determine the improvement of the execution capacity specific to handball.

The experiment took place in the school year 2024–2025, and the application of the improvement program was carried out for 8 weeks. The subjects included in the experiment were 25 students from the 10th grade from the "Neagoe Basarab" Theoretical High School in Oltenita, evenly divided between boys and girls.

Statistically significant differences are observed between the indicators obtained by the students at the initial and final testing, in terms of progress, as a result of the application of the program. Applied tests revealed a clear improvement in upper limb strength, with a balanced mean progress and standard deviation, confirming the formulated hypothesis.

The implementation of a program based on handball exercises in physical education lessons contributes to the development of upper limb strength in high school students.

**Keywords:** *handball, upper limb strength, dynamic exercises, physical education, high school.*

### Introduction

Handball is a complex team sport that involves dynamic movements, sustained effort, and specific coordination, contributing significantly to the development of motor qualities. Due to its practical and attractive nature, handball can be effectively used as a means of developing muscular strength in the upper limbs.

The present paper aims to highlight the influence of handball-specific exercises on the development of upper limb strength among high school students. Strength represents one of the main motor abilities that contribute to the efficiency of actions in sports games, particularly in handball.

The development of this quality must be carried out gradually, through exercises adapted to the students' age level and individual characteristics (Cârstea, 2000).

To validate the formulated hypothesis, a pedagogical experiment was conducted on a group of 25 students, evenly divided between boys and girls. Over a period of eight weeks, the students participated in a training program based on dynamic exercises inspired by handball, designed

to stimulate muscular strength in a functional and engaging manner.

Within team sports, physical training plays a crucial role in optimizing performance and shaping complex motor skills (Dragnea & Mate-Teodorescu, 2002)

### Research Methods

The subjects included in the experiment were students from the 10th grade C at "Neagoe Basarab" Theoretical High School in Oltenița. The group consisted of 25 students — 13 boys and 12 girls — with an average age of  $16 \pm 0.5$  years.

All participants were included in a single experimental group, with no control group. The students participated voluntarily, with the consent of their parents and the school administration.

The research respected ethical principles and confidentiality standards, ensuring the protection of participants' identities and the exclusive scientific use of data.

Scientific research on physical activities aims to decipher the mechanisms of the body's adaptation to effort — an essential aspect for the rational design of physical education lessons (Epuran, 2005).

Tests applied for research validation

To assess upper limb strength and validate the impact of the proposed program, the following control tests were applied:

1. Push-ups – testing strength

This test is frequently used to evaluate the strength of the arms and back, especially the biceps brachii, latissimus dorsi, and shoulder girdle.

Subjects assumed the prone position, supported by palms (shoulder width apart) and toes, keeping the body aligned from shoulders to heels.

The exercise was performed for 30 seconds, counting only complete repetitions (lowering the torso until elbows reached 90°, then full extension). Pauses or incomplete flexions were not accepted.

The total number of correctly executed repetitions was recorded for each student and used for comparative analysis between the two test sessions.

2. Pull-ups on an inclined bar (45°) – testing upper body strength

This test assessed the strength of the triceps brachii, pectoral muscles, and shoulder girdle. Students performed as many correct repetitions as possible on a fixed low bar with a pronated grip, without leg impulse.

The bar height was adjusted to maintain a body angle of approximately 45° relative to the ground. A repetition was valid when the chin passed the bar level, followed by a controlled descent.

The total number of correct repetitions was recorded for comparative analysis.

3. Chest pass with a 2 kg medicine ball – testing explosive strength

This test evaluated the explosive power of the arms and trunk in a motion similar to a handball pass. Students stood with feet shoulder-width apart and knees slightly bent, holding a 2 kg medicine ball at chest level.

The throw was executed frontally with both hands, without a step forward or momentum. The distance traveled by the ball was measured in meters from the starting line to the first point of contact with the ground.

This test highlights the ability to generate power through the upper kinetic chain. In this context, Hermassi et al. (2019) demonstrated that an 8-week in-season weightlifting program significantly improves upper-limb maximal strength, muscle volume, and throwing performance in male handball players.

Upper limb strength directly influences performance in handball, as demonstrated by Saccol et al. (2022) through the analysis of medicine ball throw tests in athletes.

4. Explosive vertical medicine ball slam (2 kg) – testing dynamic vertical strength

This test measured dynamic strength, coordination, and explosive capacity of the trunk and upper limbs in a downward motion. Students held the 2 kg medicine ball above the head with both hands and slammed it forcefully to the ground in a controlled motion.

The exercise was repeated for 30 seconds, counting only complete repetitions (the ball had to be lifted fully and slammed with power).

This exercise involves strong engagement of trunk, abdominal, and upper limb muscles and is frequently used in team sports.

Popescu (2018) emphasized that medicine ball exercises develop functional strength with a practical character, explaining the progress observed in the experimental group.

Similarly, Rădulescu and Cojocaru (2019) showed that modern circuit-based methods contribute to improved coordination and strength in team sports.

**Training Program and Implementation**


The experiment took place during the 2024–2025 school year, and the improvement program was applied over a period of eight weeks. After the initial testing, the entire group participated in a program based on handball-specific exercises conducted during physical education classes. The lessons objectives are presented in table 1. The program included two sessions per week and aimed to develop upper limb strength through passing, dynamic throwing, pair exercises, and the use of the medicine ball.

**Table 1. The chronology and lessons objectives**


Week 1 – Adaptation to effort and coordination	Lesson 1 – Consolidation of fundamental passing techniques Lesson 2 – Introduction of resistance and general activation
Weeks 2 and 5	Lesson 3 – Coordination in motion and endurance Lesson 4 – Passing and action completion
Weeks 3, 6, and 8	Lesson 5 – Strength and skill consolidation through dynamic passes Lesson 6 – Passing rotation and coordination
Weeks 4 and 7	Lesson 7 – Reaction, execution speed, and spatial orientation in handball Lesson 8 – Consolidation of motor skills through dynamic play

The description of the applied exercise program for each lesson can be found in the following tables. In the first Week, the objective was "adaptation to effort and coordination", the applied lesson 1 for the consolidation of fundamental passing techniques is described in table 2 and lesson 2 regarding the introduction of resistance and general activation is described in table 3.

**Table 2. Lesson 1 – Consolidation of fundamental passing techniques**

Exercise	Materials	Organization	Dosage
Two-handed passes from above the head (3 m) 	Balls	Pairs facing each other	2 sets × 10 reps
Two-handed chest passes (3 m)	Balls	Pairs facing each other	2 sets × 10 reps
One-handed passes with dominant hand (3 m)	Balls	Pairs facing each other	2 sets × 8 reps
One-handed passes with non-dominant hand (3 m)	Balls	Pairs facing each other	2 sets × 8 reps
One-handed overhead passes at 6 m	Balls	Pairs facing each other	2 sets × 8 reps
One-handed overhead passes at 10 m	Balls	Pairs facing each other	2 sets × 6 reps
Inclined pull-ups at 45°	Balls	Individual	2 sets × 4 reps

**Table 3. Lesson 2 – Introduction of resistance and general activation**

Two-handed passes from above the head (3 m)	balls	Pairs of 2	2 sets × 10 reps
Two-handed chest passes (3 m)	balls	Pairs of 2	2 sets × 10 reps
Two-handed overhead passes	2 kg medicine ball	Pairs of 2	2 sets × 10 reps
Two-handed chest passes	2 kg medicine ball	Pairs of 2	2 sets × 10 reps
Dribbling relay over 10 m around a cone and back	balls, cones	Teams of 4–5 	3 repetitions

Lesson 3 regarding the coordination in motion and endurance (table 4) and Lesson 4 regarding passing and action completion (table 5) were applied in week 2 and 5 of the training program.

**Table 4. Lesson 3 – Coordination in motion and endurance**

Exercise	Materials	Organization	Dosage
Lateral moving passes with added step, two hands overhead (3 m)	balls	Pairs in lines facing each other	2 laps × 6 passes
Lateral moving passes with added step, two hands chest level (3 m)	balls	Pairs in lines facing each other	2 laps × 6 passes
Shuttle passing drill (3 m distance)	balls	4 rows facing each other (2x2)	2 sets × 8 passes
Shuttle passing drill	2 kg medicine ball	4 rows facing each other (2x2)	2 sets × 8 passes
Modified push-ups (on knees)	Mat	Individual	2 sets × 10 reps

**Table 5. Lesson 4 – Passing and action completion**

Exercise	Materials	Organization	Dosage
Two-person passing while moving, overhead with one hand (6 m)	balls	2	x2
Two-person passing while moving, finishing with a shot on goal (dominant hand)	Handball, goal	2	x2
Two-person passing with simple crossover dribble and finish	ball	Pairs, starting in line	X4
Inclined pull-ups (45°)	Fixed bar	Individual	2 sets × 6 reps

In the next weeks 3, 6, and 8, the training program applied were presented in table 6, lesson 5 to improve strength and skill consolidation through dynamic passes, also lesson 6 (table 7) for the training of passing rotation and coordination.

**Table 6. Lesson 5 – Strength and skill consolidation through dynamic passes**

Exercise	Materials	Organization	Dosage
Alternating quick passes: two-handed chest / overhead	balls	Pairs facing each other (3 m)	2 sets × 10 passes
Passing in threes, moving laterally, chest pass	2 kg medicine ball	Groups of 3 in line	2 × 10 m laps
Passing in threes, moving laterally, overhead pass	2 kg medicine ball	Groups of 3 in line	2 × 10 m laps
Passing in threes, moving, one-handed (dominant hand)	2 kg medicine ball	Groups of 3 in line	2 sets × 6 passes/person
Passing in threes, moving, one-handed (non-dominant hand)	2 kg medicine ball	Groups of 3 in line	2 sets × 6 passes/person
Classic push-ups	Mat	Individual	2 sets × 6 reps

**Table 7. Lesson 6 – Passing rotation and coordination**

Exercise	Materials	Organization	Dosage
Passing and zone change – square with 8 m sides, four students in corners; simultaneous diagonal passes with 2 balls; after passing, each player moves to the next corner counterclockwise	4 cones, 3 balls	4 groups of 4 players	3 x 1 min
Same drill using a 2 kg medicine ball	4 cones, 2 medicine balls	4 groups of 4 players	2 x 1 min
Triangular groups of 3 – pass, sprint to the cone, and return; at signal, change direction of passing	4 cones, 3 balls	Groups of 3	3x1 min
Same drill with medicine ball	3 cones, medicine balls	Groups of 3	2x1 min

In the weeks 4 and 7, the main objectives of the lessons were reaction, execution speed, and spatial orientation in handball (Lesson 7 – table 8) and also consolidation of motor skills through dynamic play (Lesson 8 – table 9).

**Table 8. Lesson 7 – Reaction, execution speed, and spatial orientation in handball**

Exercise	Materials	Organization	Dosage
Pair exercise – ball touch: one student holds the handball, partner tries to touch it while holder changes position rapidly.	Balls	Pairs facing each other (1 m)	3 × 30 sec (roles switched)
Same drill with 2 kg medicine ball	2 kg medicine ball	Pairs facing each other (1 m)	3 × 30 sec (roles switched)
Passing in threes with interception – two students pass at 6 m, third intercepts and switches places	Bakks	Groups of 3 (2 lines + 1 center)	3 x 2 min
“Give-and-go” game – two teams of 11 students, played with 1 kg medicine ball; no dribbling allowed; points scored when ball is placed in opponent’s semicircle	1 kg medicine ball	2 teams × 11	2 halves × 10 min

**Table 9. Lesson 8 – Consolidation of motor skills through dynamic play**

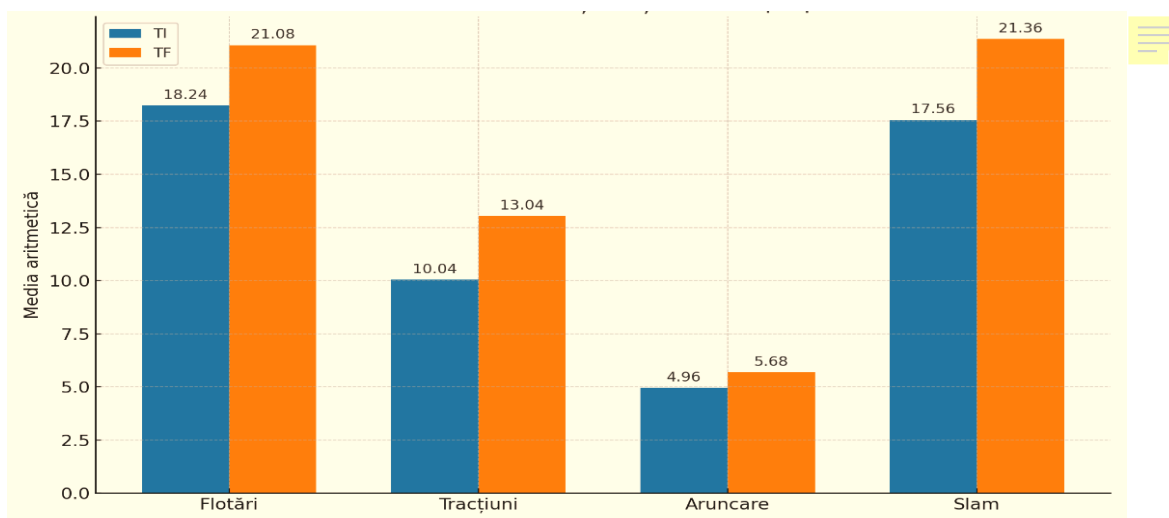
Exercise	Materials	Organization	Dosage
Passing in line while moving, chest passes (4 students, 3 m apart, 10 m track)	balls	Groups of 4	4 laps back and forth
Passing in line while moving, overhead passes	2 kg medicine ball	Groups of 4	4 laps back and forth
“Give-and-go” game – same rules, played with 1 kg medicine ball	1 kg medicine ball	2 teams × 11	2 halves × 15 min

**Results**

The differences in the values obtained when testing the subjects, at the beginning (T<sub>I</sub>) and at the end (T<sub>F</sub>) of the proposed training program, demonstrated differences (presented in table 10 and Graph no. 1).

**Table 10. Dynamics of motor parameter values processed statistically, comparative between initial testing and final testing**

Parameters	Final Test (T <sub>F</sub> )			Initial Test (T <sub>I</sub> )			Difference T <sub>F</sub> -T <sub>I</sub>	
	$\bar{x}$	±S	Cv	$\bar{x}$	±S	Cv	$\bar{x}$	p
Push-ups	21,08	4,71	22,34	18,24	4,74	25,98	2,84	<0.0005
Pull-ups on fixed bar	13,04	2,98	22,86	10,04	2,91	28,99	3,00	<0.0005
Medicine ball throw	5,68	0,86	15,14	4,96	0,81	16,33	0,74	<0.0005
Medicine ball slam	21,36	12,75	12,88	17,56	2,89	16,45	3,80	<0.0005



Graph no. 1 – Results of Initial and Final Testing

### Discussion

Recent research has highlighted the critical role of upper limb strength in handball, as it directly affects both throwing speed and accuracy. Bauer, Gruber, and Muehlbauer (2022) reported a significant relationship between trunk muscle endurance and throwing velocity. Similarly, Zhang et al. (2024) demonstrated that the maximum speed achieved in ballistics tests serves as a key indicator of throwing performance.

As you can see in the Table nr.1, statistical analysis of the motor parameters indicates a significant improvement in the overall mean across all four tests administered. In arm extensions from prone support (push-ups), the mean increased from 18.24 to 21.08 repetitions, yielding an average improvement of +2.84 repetitions, which reflects a marked enhancement in muscular endurance. Concurrently, the coefficient of variation (Cv) decreased slightly, suggesting a modest homogenization within the group.

Regarding pull-ups on the fixed ladder, performance improved by +3 repetitions (from 10.04 to 13.04), with the standard deviation remaining stable and relative dispersion decreasing. This outcome indicates the development of muscular strength in the back and arms, which is essential for grip and support actions that are specific to handball performance.

In the case of the medicine ball chest throw, the mean increased from 4.96 m to 5.68 m, reflecting an improvement of +0.72 m. This test assessed explosive strength, and the significant enhancement was accompanied by the maintenance of low variability in the results.

The explosive medicine ball slam test recorded an average improvement of +3.80 repetitions, with

more homogeneous values observed in the final testing. This test highlighted the development of dynamic strength and the capacity for vertical-plane actions.

In a comparative analysis, the results obtained in the present study align with the findings of Gaamouri et al. (2023), who demonstrated that the implementation of a structured elastic-band exercise program leads to significant improvements in upper-limb strength and power in adolescent handball players.

### Conclusions

Following the implementation of a handball-inspired exercise program over a period of eight weeks, a significant increase in upper limb strength was observed among high school students included in the experimental group. The improvements recorded across all four applied tests (push-ups, bench pull-ups, medicine ball throw, and medicine ball slam) confirm the effectiveness of the motor content utilized.

The differences between the initial and final testing were statistically supported, and the improvements were accompanied by a slight reduction in result variability, suggesting a homogeneous progression within the group. These findings validate the research hypothesis and support the use of handball-specific exercises in physical education classes to enhance strength development.

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