

# The influence of sports training on the physical fitness indices of junior female handball players

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## Abstract

**Background.** Adequate and well-structured sports training is essential for the physical development and improvement of athletic performance in junior female handball players. Strength, plyometric and balance training sessions have the capacity to influence various aspects of physical preparation such as muscular strength, endurance, agility and speed.

**Aims.** The aim of the study is to investigate and evaluate the influence of sports training on physical fitness indices in junior female handball players.

**Methods.** The research subjects were 16 female handball players (aged 14-16) from LPS Slatina. The OptoJump Next Platform was used to assess explosive strength and visual reaction in the lower limbs. Four tests were carried out: Squat Jump, Counter Movement Jump, Stiffness and Visual Reaction. Measured indices: jump height (cm), flight time (sec), power (w/kg).

**Results.** The results of the comparative analysis of the conducted tests, including Squat Jump, Counter Movement Jump, Stiffness and Visual Reaction Tests, demonstrated significant improvements in the physical performance of the participants, namely the development of their muscle strength, muscle efficiency and reaction speed. These improvements were highlighted by statistically significant results ( $p < 0.001$ ) and homogeneity of the group during tests.

**Conclusions.** In conclusion, regular sports training has a significant and positive influence on physical fitness indices in junior female handball players, contributing to the improvement of the performance and general physical endurance required for this demanding sport.

**Keywords:** explosive strength, visual reaction, indices, young female handball players, comparative analysis.

## Introduction

In modern sports training methodology, team sports like handball have undergone significant changes in terms of conception, structure and organization of the training processes. The primary goal of sports training is to enhance the performance of athletes, aiming for peak physical fitness during competitions. This multifaceted task involves not only developing specific game techniques and tactics but also ensuring the physical and mental adaptation of athletes to the demands of intense effort and subsequent recovery.

Therefore, it is essential for coaches to pay a special attention to the adaptation of athletes' body to effort. Coaches must focus not only on the correct execution of motor actions by athletes but also on their capacity of

efficient recovery after effort. In current sports training, coaches must also include a substantial contribution to the adaptation of body to effort. This is achieved through a rational sports lifestyle (Simion, 1998).

The scheduling and planning of training are critical activities for developing training objectives, setting training tasks and organizing training formats, all tailored to the specific conditions of each team and athlete (Dragnea & Teodorescu, 2002). The planning of long-term training derives from designing this training as a staged, long-term process continually optimized based on general characteristics (Simion et al., 2011).

The main objective of sports specialists is to identify the most effective means and methods and adapt them in training to maximize the physical and mental capabilities of athletes (Simion et al., 2011). The effectiveness of a

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training program depends on identifying the most suitable methods and means and adapting them to maximize the physical and mental capacities of athletes. Thus, in order to achieve high performance, players must develop specific skills that enable them to efficiently solve problems that arise during competitions. These skills are cultivated by creating game-like situations in training sessions and providing athletes with opportunities to improve their reactions and decision-making in controlled conditions.

In handball, fundamental and specific motor skills are crucial both in training sessions and competitions. Strength, speed and endurance are fundamental motor qualities that directly influence the performance of athletes and, consequently, the results of the team. That is why the training process must be diversified, aiming at the achievement of the specific goals. These goals must be appropriately set, taking into account the rapid maturation of central nervous system plasticity and the capacity of the body to respond to stimuli. By means of the similar situations created during training sessions, the players must develop their ability to solve real situations specific to competitions (Arnauld, 2004 quoted by Rada et al., 2024).

Both basic motor skills and the ones specific to handball are essential in training sessions and competitions as well (Bjelica et al., 2012). At the present moment, athletic performance is a major interest for researchers in the field of sports, with numerous different approaches to this subject (Dobre et al., 2019). Performance in handball depends on fundamental motor skills, especially strength, speed and endurance (Cazan et al., 2018; Przednowek et al., 2019).

The training process must be highly varied, goal-oriented and correctly dosed. Due to the fast maturing of the central nervous system plasticity and to the response system of the body, the conditions for good motor learning are particularly favorable (Rada et al., 2024). The efficiency of the training process requires not only rationalization and standardization of means but also appropriate scheduling. This one involves the development of training objectives, training tasks, and organizational formats adapted to the specific conditions of the activity (Prevost, 2013; Roman, 2004). Previous research highlights that handball players perform vertical jump tests with an inefficient model of dominant strength (Kollias et al., 2004) and a lack of explosiveness (Panoutsakopoulos et al., 2014).

This study aims to analyze the influence of sports training on physical fitness indices in junior female handball players. The study offers a detailed perspective on how different training methods and programs contribute to the development of motor skills necessary for performance in handball. Through a systematic and well-founded approach, the paper will explore the relationship between training and physical performance, making practical recommendations to optimize sports training in the context of junior handball.

## Hypothesis

We assume that regular sports training significantly influences the physical fitness indices in junior female handball players.

## Material and methods

### Research protocol

The measurement instrument used for explosive strength and visual reaction belongs to the Human Performance Research Center of the Department of Physical Education and Sports within the National University of Science and Technology *Politehnica* Bucharest, University Center of Pitești, Romania.

#### a) Period and place of the research

The longitudinal experiment was conducted throughout the 2022-2023 competitive year and took place in the gym of the Sports High School Slatina and the power gym of the Sports High School Slatina. The main objective was to achieve a high level of performance at a specific time, usually during the main competitions of the year, based on the correct evolution of sport specific fitness. To obtain such a level, it was necessary to correctly plan the entire program so that the development of skills, biomotor qualities and psychological traits had a logical and sequential evolution.

- the total number of training months was 10 - from August 2022 to May 2023.

- the weekly training cycles were 40.

The team participated in 6 friendly matches and 20 official matches, 14 matches in the group stage and 6 matches in the value group stage.

In this competitive year, the team under study had 2 training camps in Olănești, in August and January. The medical check-ups took place in August and January.

- number of training sessions = 216

- number of training hours = 432

- number of physical training hours = 175.5

- number of technical-tactical training hours = 210

- number of psychological and theoretical training hours = 36.5

#### b) Subjects and groups

In order to confirm the research hypothesis, a longitudinal study was conducted on 16 female handball players (14-16-year-old) from LPS Slatina. Parental consent was obtained and signed in accordance with the Declaration of Helsinki before starting the research. The study received approval from the Ethics Committee of the Doctoral School of Sports Science and Physical Education (ID: 15/12.04.2024), University Center of Pitești, Romania.

#### c) Applied tests

To evaluate explosive strength and visual reaction of the lower limbs, the OptoJump Next platform was used. Four tests were applied:

1. Squat jump (vertical jump): This test assessed the explosive strength of the lower limbs. It involved a single jump from a squatting position (knee bent at a 90° angle) with hands on hips and no countermovement. Parameters measured: flight time (sec) and jump height (cm).

2. Counter movement jump (vertical jump with standing start): This test also evaluated the explosive strength of the lower limbs. It required a single jump starting from an upright position with hands on hips and including a counter movement. The subject stands straight for 1-2 seconds, then makes a natural flexion and jumps as high as possible, landing with normal flexion and remains still in a neutral position for 1-2 seconds. During

the counter movement jump, elastic energy is stored in muscles and tendons, then used in the subsequent propulsive (concentric) phase. The difference between the center of gravity values in Squat Jump and CMJ gives an idea on the “elastic” qualities of the athlete.

3. Stiffness (vertical jump with straight knees): This test evaluated the reactive strength of the lower limbs. It consisted of performing 7 jumps with straight knees. Parameters measured: contact time, flight time (sec), jump height (cm) and power (w/kg).

4. Visual reaction (vertical jump to visual stimulus): This test measured reaction time to a visual stimulus, such as a change in screen color or an external light signal. The stimulus could be in the form of a beep or recorded sound. Parameters measured: reaction time (sec).

A logical structure for the training sessions was developed during planning (Table I).

There were used exercise structures that addressed operational objectives regarding the development of reaction speed, execution speed, acceleration speed and explosive strength (particularly of the lower limbs). All these exercises were combined with technical exercises specific to handball game, necessary for consolidating and perfecting the basic technique of this sport.

*Main plyometric means used in training of junior handball players (14-16 years old)*

*Basic exercises, divided into:*

- exercises for general, multilateral and specific physical training (they include a range of activities aimed at improving general physical fitness, with a focus on enhancing the physical skills relevant to handball);
- exercises for technical training (these are drills and routines designed to improve the technical skills required for handball, such as dribbling, shooting and passing);
- exercises for tactical training (individual, group and team training). These ones are exercises for:
  - individual tactics, meant to enhance the ability of the players to make effective decisions and actions on their own;
  - group tactics, involving small groups that work together to execute plays and strategies;
  - team tactics, encompassing the coordination and strategic planning of the entire team
  - combined exercises that establish relationships between physical training, technical training and tactical training, ensuring a holistic approach to training;

- psychological and theoretical training that is integrated into the other 4 categories of exercises mentioned above. It involves mental conditioning and understanding the theoretical aspects of the game.

*Actual game:*

- theme game (game with specific objectives or constraints to practice certain skills or tactics);
- learning game (structured practice games meant to teach and reinforce certain aspects of playing);
- friendly and demonstrative games (non-competitive games aimed at applying learned skills in a real-game context without the pressure of competition);
- verification and test matches (they are used to assess and monitor progress and performance);
- official matches (competitive matches that count towards the official record of the team).

*Associative means:*

- hygienic factors: diet, hygiene of training environment and living conditions, balance between effort and rest, sleep, enjoyable leisure activities, clothing hygiene;
- natural factors for health improvement and conditioning (sun, air and water).

*d) Statistical processing*

The statistical analysis was carried out using KyPlot 6.0 software (KyensLab Inc). The standard descriptive indices were calculated as follows: mean, SD (standard deviation), Cv% (coefficient of variation). Paired Comparison for Means Test. Statistical significance was set at  $p < 0.05$ .

## Results

The results of the comparative analysis in terms of motor testing of the female handball players aged 14-16 years are shown in Table II.

The results of the Squat Jump test performed with the OptoJump system indicate a significant improvement in the height of the jump and in the flight time of the participants. The increase in jump height by 2.718 cm and in flight time by 0.029 seconds reflects an improvement in the strength and efficiency of the lower limb muscles. The homogeneity of the group was evaluated as high and very good in both tests, and the t-tests confirmed the statistical significance of these improvements ( $p < 0.001$ ).

The Counter Movement Jump (CMJ) test showed a significant improvement in jump height and a diminution in flight time of the participants. The increase in jump

**Table I**  
Proportions of training components.

Training period	Components of the training			
	Physical training (%)		Technical training (%)	Tactical training (%)
	PFG	PFS		
Preparatory	30%	30%	30%	-
Pre-competition	5%	25%	25%	35%
Competition	-	25%	30%	35%

Notes: PFG - General physical training; PFS - Specific physical training

**Table II**  
Results of the comparative analysis of motor testing level in handball players of 14-16 years old.

Tests	Indices	Initial testing		Final testing		t	p
		Mean ±SD	CV (%)	Mean ±SD	CV (%)		
Squat Jump	Jump height (cm)	25.87 ±1.38	5.321	28.593 ±1.62	6.341	5.118	<0.001
	Flight time (sec)	0.456 ±0.01	3.947	0.485 ±0.003	3.092	5.000	<0.001
Counter Movement Jump	Jump height (cm)	28.1 ±1.16	4.145	31.925 ±1.5	4.698	8.069	<0.001
	Flight time (sec)	0.481 ±0.016	3.326	0.508 ±0.014	2.755	5.094	<0.001
Stiffness	Contact time (sec)	0.200 ±0.01	4.512	0.180 ±0.005	4.341	4.575	<0.001
	Flight time (sec)	0.420 ±0.01	4.785	0.450 ±0.002	3.256	5.624	<0.001
	Jump height (cm)	25.818 ±1.48	5.744	28.862 ±1.07	3.745	6.646	<0.001
	Power (w/kg)	37.265 ±2.34	6.268	40.928 ±1.07	5.683	4.445	<0.001
Visual reaction	Jump height (cm)	13.469 ±1.38	10.230	15.463 ±1.33	8.633	3.962	<0.001
	Reaction time (sec)	0.566 ±0.03	5.830	0.534 ±0.04	6.928	2.711	<0.01

height by 3.825 cm and the diminution in flight time by 0.02 seconds highlight a significant improvement in explosive strength and muscle efficiency. The homogeneity of the group was consistently high in both tests, and the t-test results confirmed the statistical significance of these improvements ( $p < 0.001$ ).

The Stiffness test revealed a decrease in contact time and an increase in flight time; there were also a significant increase in jump height and in the muscle power of the subjects. The observed improvements in jump height (with an increase of 3.044 cm) and in power (with a progress of 3.665 w/kg) reflect a significant improvement in reactive strength and muscle capacity. The homogeneity of the group was high in both tests, and the t-test results confirmed the statistical significance of these improvements ( $p < 0.001$ ).

The Visual Reaction tests demonstrated significant improvements in both measured parameters: jump height and reaction time. These results indicate a positive adaptation and an improvement in reactive strength and speed performance among the tested athletes. The homogeneity of the group was considered high in both tests, suggesting consistency in the measured performances, and the t-test results confirmed the statistical significance of these improvements ( $p < 0.001$  and  $p < 0.01$ ).

In conclusion, the consistently positive results obtained in all tests prove the effectiveness and relevance of the measurements performed with the OptoJump system in evaluating and improving the performance of athletes. The homogeneity of the tested groups in both tests confirms the reliability and validity of the results, highlighting the positive impact of the training and adaptation programs used in the research study.

## Discussion

Analyzing the test results from the mentioned study, it is possible to observe significant improvements in the physical performance of athletes, reflected through various measurements:

**Squat Jump:** There was a significant increase in jump height by 2.718 cm and in flight time by 0.029 seconds. These improvements indicate a development in the strength and efficiency of the lower limb muscles, which

is essential for handball performance (Paoli et al., 2015).

**Counter Movement Jump (CMJ):** The CMJ test showed a significant improvement in jump height by 3.825 cm and a reduction in flight time by 0.02 seconds. These results indicate an improvement in explosive strength and muscle efficiency, critical aspects in sports involving rapid acceleration and jumping (Baker et al., 2001).

**Stiffness Test:** This test recorded a significant increase in jump height by 3.044 cm and in muscle power by 3.665 w/kg. These improvements reveal a development in reactive strength and muscle capacity, which are essential for athletic performance in handball (Hägglund et al., 2006).

**Visual Reaction Tests:** The results of the visual reaction tests showed significant improvements in jump height and reaction time. These findings highlight positive adaptations and enhancements in reactive strength and speed among the tested athletes (Zwierko et al., 2024).

All these results are consistent with the specialized literature supporting the benefits of specific and progressive training for improving physical performance in handball and other sports. The studies mentioned earlier demonstrate the importance of appropriate training in developing motor skills and athletic performance among young and adult athletes (Arnauld, 2004 quoted by Rada et al., 2024; Bjelica et al., 2012; Cazan et al., 2018; Chaabene et al., 2021).

These research findings confirm that well-structured sports training can lead to significant improvements in athletes' physical skills, with positive impact on performance in competitions and injury prevention in physically demanding sports such as handball. Recent studies have demonstrated that combining balance training and complex training have generated important improvements in physical fitness among young female handball players compared to individual complex training (Chaabene et al., 2021). Moreover, research highlights a positive correlation between body composition and physical performance in female handball players (Ciplak et al., 2019; Molina-López et al., 2020). Basic training programs conducted over 8 weeks have shown significant effects on the physical and physiological parameters in this category of athletes (Genc et al., 2019). Previous

studies have also identified significant differences in physical fitness and throwing velocity between elite and amateur female handball players (Granados et al., 2007; Granados et al., 2013).

Also, complex strength training programs have significantly improved athletic performance among young female handball players (Hammami et al., 2019). Intensive interval training sessions and plyometric exercises have also had positive effects on the physical fitness of young male handball players (Hammami et al., 2021). Furthermore, plyometric training programs for upper and lower limbs have contributed to enhancing components of physical performance in young female handball players (Hammami et al., 2020; Jurišić et al., 2021). Recent studies have demonstrated that specialized physical education classes and handball training sessions have had significantly positive effects on health-related physical fitness among adolescent girls (Lemes et al., 2023).

Additionally, differentiated training periodization models have influenced physical and physiological aspects of elite female handball players (Manchado et al., 2018). The physical fitness attributes of handball players are correlated with playing position and performance level (Massuca et al., 2015). The short-term plyometric training has shown improvements in physical performance of male handball players (Mazurek et al., 2018). Relevant studies have pointed out that combined plyometric training with repeated sprints has had important effects on improving physical performance in female handball players (Neves et al., 2022). Furthermore, research has shown a correlation between body mass index and physical fitness in male handball players, both teenagers and adults (Ingebrigtsen et al., 2013; Nikolaidis & Ingebrigtsen, 2013).

The physical fitness profile of elite female handball players from Portugal was detailed and evaluated in a recent study (Rios et al., 2023). Other specialists, like Vicente-Rodriguez and colleagues identified a connection between improved bone mass and physical fitness in young female handball players (Vicente-Rodriguez et al., 2004). Additionally, physical fitness and anthropometric characteristics of young handball players have been analyzed and compared across different performance levels (Zapartidis et al., 2009).

## Conclusions

1. According to the recorded results, the proposed experimental program, which combines plyometric exercises with specific technical elements of handball, had a significant impact on the quality of competitive activities among junior female handball players aged 14-16 years, as demonstrated by statistical-mathematical analyses.

2. The obtained results show significant improvements in the physical performance of junior female handball players, with remarkable increases in jump height, flight time and power, all indicating a high degree of consistency and statistical significance ( $P < 0.001$ ) following the training.

3. In conclusion, the hypothesis that regular sports

training has a significant and positive influence on physical fitness indices in junior female handball players is confirmed. This training contributes to the improvement of performance and general physical endurance required for this intense sport.

## Conflict of interests

The authors declare no conflict of interests.

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