INDONESIAN JOURNAL OF RESEARCH IN PHYSICAL EDUCATION, SPORT, AND HEALTH
e-ISSN: 2986-8831
Vol. 3 No 1, April 2025
Research Article

The effects of competitive plyometric training on speed, strength, and defensive skills of handball players

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ABSTRACT
Background: The importance of this research lies in preparing handball players with enhanced physical and skill capabilities through modern methods such as competitive plyometric training. The study was motivated by observed performance inconsistencies among Iraqi handball teams, particularly a decline in players' physical and technical execution toward the end of matches. This issue is attributed to the use of traditional training programs, which fail to develop the players' physical fitness and technical performance adequately. Objective: This study examines the effects of competitive plyometric training on handball players' speed, strength, and defensive skills. Methods: The research was driven by the observation that many teams in the Iraqi Handball League exhibit performance decline toward the end of matches, which is attributed to inadequate physical and skill preparation under traditional training programs. An experimental design was used, involving 18 young male players from the Karbala Handball Club, divided randomly into experimental and control groups. The experimental group followed an 8-week competitive plyometric training program, while the control group continued with standard training. Result: Results showed significant improvements in the experimental group's speed-strength and defensive skills compared to the control group. Conclusion: In conclusion, competitive plyometric training effectively enhances physical and skill performance in handball players and is recommended as part of structured training programs. It is recommended that future research explore the long-term effects of competitive plyometric training across different age groups and levels of play, to determine its applicability and sustainability in improving athletic performance.

ARTICLE HISTORY
Received February 04, 2025
Accepted April 26, 2025
Published April 30, 2025
KEYWORDS
Competitive plyometric training, defensive skills, speed, strength.

Introduction

Handball is one of the sports that has rapidly developed internationally due to its diverse technical skills and strategies, making it engaging for players and spectators. It is widely recognized as a team sport that fosters cooperation and unity to achieve high athletic performance. Success in handball is not only based on functional variables but also relies heavily on physical qualities and fundamental skills. These elements are crucial for achieving mastery and consistency in performance, regardless of the match conditions. They are essential both with and without the ball, depending on the specific demands of each position and situation (Gómez, A. 2024).

Given the physical and skill-based nature of the game, reaching optimal performance levels requires scientifically grounded and sustainable training curricula. These programs help players keep pace with the continuous advancement of performance levels observed in regional and international competitions. Handball players compete through tactics and strategies and demonstrate superior physical conditioning and technical execution (Hussein, Hrebid, & Mohamed, 2022). As such, contemporary and structured training approaches are essential to maintain competitiveness in this dynamic and physically demanding sport.

One training method that has shown significant promise in developing strength, speed, and related physical attributes is plyometric training. This method intensifies exercises through a cycle of muscle lengthening (eccentric phase) followed by rapid contraction (concentric phase), known as the stretch-shortening cycle. When implemented in a competitive context, plyometric training not only enhances the effectiveness of muscle contraction but also improves the speed and precision of movement execution (Obando, Cetina, Ojeda, & Velandia, 2024). The principle behind this method lies in utilizing the energy stored during the eccentric phase to generate greater force during the concentric phase. This process is further enhanced by introducing competitive elements and resistance tools such as rubber bands or weighted equipment, enabling athletes to simulate high-intensity scenarios in training (Hernández-Mosqueira et al., 2024).

Although plyometric training has been widely studied in various sports, including volleyball, basketball, and football, most studies focus on general physical fitness components such as vertical jump, sprint time, or explosive power (Ramirez-Campillo et al., 2020). In contrast, few studies have specifically investigated competitive plyometric training—which incorporates elements of athlete-to-athlete challenge and game-like intensity—particularly in the context of defensive skill development in handball. This represents a notable research gap, considering that defense is a critical aspect of handball performance that requires quick reaction, strength-speed coordination, and tactical awareness (Granados et al., 2011).

The novelty of this research lies in implementing competitive plyometric exercises as a central method to enhance strength characterized by speed and defensive skills, such as lateral movement and two-way blocking, which are rarely the primary focus in previous plyometric studies. Unlike traditional plyometric approaches, the competitive nature of the exercises in this study may increase neuromuscular engagement, decision-making under pressure, and motivational intensity (Markovic & Mikulic, 2010).

From a practical standpoint, the study contributes to sports science and coaching practice by providing evidence-based support for integrating competitive plyometric training into structured handball programs, particularly for youth players. This aligns with recent recommendations to design training that simulates competitive match conditions to improve the transfer of training outcomes to actual performance (Kraemer & Nitka, 2021).

Despite the benefits of plyometric training, limited research has explored its application in a competitive format aimed explicitly at improving defensive skills in handball. Recognizing this gap, the present study adopted a modern method by applying competitive plyometric exercises to develop handball players' physical and skill-based capacities, particularly in the defensive domain.

Method

Research Design

This study employed an experimental research design with two parallel groups: an experimental group that received competitive plyometric training and a control group that followed standard training routines. The design aimed to identify the causal effects of the intervention on specific physical and defensive performance variables in handball players.

Participants

The population consisted of 18 male players from the Karbala Handball Club during the 2023–2024 season. Using simple random sampling, 14 players were selected and divided evenly into 7 participants (experimental and control) groups. The remaining four players were used for pilot testing to ensure the reliability of instruments and procedures.

Research Instruments

The instruments used included three tests: (1) the Partridge test to assess leg speed-strength; (2) a defensive movement agility test simulating real-game defensive actions; and (3) a two-way blocking test to measure specific blocking skills. All tests demonstrated strong validity and reliability during preliminary trials.

Research Procedure

The experimental group participated in a structured competitive plyometric training program conducted thrice weekly over eight weeks (24 sessions total). Each session lasted 30–45 minutes and included high-intensity and repetitive interval exercises using tools such as resistance bands. Both pre-tests and post-tests were administered under identical conditions.

Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS). Independent and paired sample t-tests were used to compare pre-and post-test results within and between groups. Levene's test was used to ensure sample homogeneity and equality at baseline. A significance level of 0.05 was adopted throughout the analysis.

Results and Discussion

Results

Presentation of the results of tests of physical variables and basic skills for the experimental group

The researcher came to several conclusions after gathering the data and statistically analysing it, which he then chose to display as Table 1.

Table 1. Statistical comparison of pre- and post-test scores in the experimental group

Variables	Tests	Mean	Std. Deviation	Mean Differences	Std. Differences	T Value	Sig Level	Sig Type
Defensive Moves	Pre	9.3000	0.35051	1.97500	0.65411	8.540	0.000	Sig
	Post	7.3250	0.36154					
Blocking	Pre	7.8750	0.83452	-2.75000-	1.28174	-6.068-	0.001	Sig
	Post	10.6250	0.51755					
Strength-distinguished Speed	Pre	38.3750	1.06066	-9.87500-	1.24642	22.409-	0.000	Sig
	Post	48.2500	0.88641					

Referring to Table 1, the 8-week competitive plyometric training program significantly improved handball players' physical performance and defensive skills in the experimental group. In the Defensive Moves variable, there was a decrease in the mean score from 9.30 (pre-test) to 7.33 (post-test) ($p < 0.001$), indicating an increase in defensive movement efficiency (i.e., faster reaction time). For Blocking, the score increased drastically from 7.88 to 10.63 ($p = 0.001$), reflecting a more precise and responsive blocking ability. The most significant improvement was in strength-distinguished SpeedSpeed, where scores jumped from 38.38 to 48.25 ($p < 0.001$), indicating increased leg muscle explosiveness, which is crucial in the handball game. These results prove that competitive plyometric training improves strength and speed of motion execution.

Presentation of the results of the physical variables and basic skills tests for the control group

Based on Table 2, the control group that only underwent the standard training program also improved on all variables, but to a lesser extent. On Defensive Moves, the score dropped from 9.29 to 8.11 ($p < 0.001$), while Blocking increased from 8.00 to 9.21 ($p = 0.005$). For Strength-distinguished Speed, the score increased from 38.25 to 44.00 ($p < 0.001$). Although statistically significant, the magnitude of change in the control group (e.g., strength-speed improvement of 5.75) was much smaller than that of the experimental group (9.88). This confirms that conventional training is less than optimal in holistically developing players' physical and technical aspects.

Table 2. Statistical comparison of pre- and post-test scores in the control group

Variables	Tests	Mean	Std. Deviation	Mean Differences	Std. Differences	T Value	Sig Level	Sig Type
Defensive Moves	Pre	9.2875	0.26424	1.17500	0.39188	8.481	0.000	Sig
	Post	8.1125	0.17269					
Blocking	Pre	8.0000	0.92582	-1.21250-	0.84926	-4.038-	0.005	Sig
	Post	9.2125	0.30443					
Strength-distinguished Speed	Pre	38.2500	0.88641	-5.75000-	1.03510	-15.712-	0.000	Sig
	Post	44.0000	1.30931					

Presentation of the results of the post-tests of the research variables for members of the experimental and control groups

Table 3. Statistical comparison of post-test scores between the two groups

Variables	Groups	Mean	Std. Deviation	T Value	Sig Level	Sig Type
Defensive Moves	Control	8.1125	0.17269	5.559	0.000	Sig
	Experimental	7.3250	0.36154			
Blocking	Control	9.2125	0.30443	-6.654-	0.000	Sig
	Experimental	10.6250	0.51755			
Strength-distinguished Speed	Control	44.0000	1.30931	-7.603-	0.000	Sig
	Experimental	48.2500	0.88641			

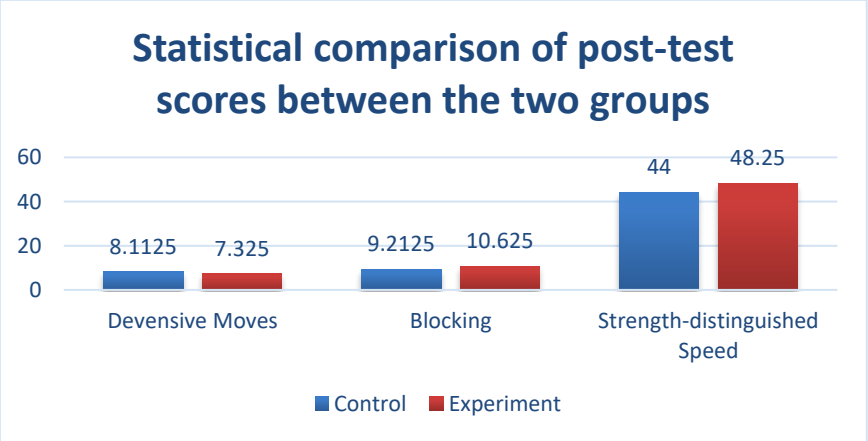

Figure 1. Statistical comparison of post-test scores between the two groups

Table 3 dan Figure 1 emphasizes that the experimental group consistently outperformed the control group after the intervention. On Defensive Moves, the experimental group's score (7.33) was significantly better than the control (8.11) ($T = 5.56$, $p < 0.001$). For Blocking, the experimental group achieved a score of 10.63, significantly higher than the control (9.21) ($T = -6.65$, $p < 0.001$). On Strength-distinguished Speed, the difference was also very striking: 48.25 (experimental) vs. 44.00 (control) ($T = -7.60$, $p < 0.001$). These findings demonstrate the superiority of competitive plyometric programs and confirm that competition-based and high-intensity training approaches are more effective in transferring training results to actual performance on the field.

Discussion

After completing the data collection and statistical analysis of the post-test results, it was evident that there were significant differences between the experimental and control groups. The most notable improvement was observed in the experimental group, which followed a program based on competitive plyometric exercises. These exercises, requiring high levels of precision, focus, and motor coordination, positively and effectively impacted player performance (Hatem & Hussein, 2024).

According to Hussein & Shaalan (2021), mental and physical skill awareness can significantly enhance performance when implemented within a scientifically grounded training program. In handball, players are often faced with varying resistances, and the ability to focus attention while repeatedly visualizing and executing technical movements is crucial for goal-setting, accuracy, and error reduction.

The improvements noted in the experimental group can be attributed to the nature of the training, which emphasized adapting to various forms of resistance in a competitive setting (Pinto & Monteiro, 2025). These exercises incorporated progressive loading to develop key performance variables, particularly the strength and speed of the legs. Plyometric exercises synchronize strength and speed through rapid muscle contractions and relaxations, enabling athletes to overcome obstacles with skill and velocity (Al-Jubouri & Hussein, 2022).

This training method is further supported by Hussein (2025), who highlighted that developing strength with speed involves fast muscle contractions against resistances approximating game-like conditions. Such development benefits defensive movements, especially when blocking walls are constructed, and quick directional shifts are made.

Additionally, the researcher suggests that the training improved neuromuscular efficiency in the experimental group. This included enhancements in the contraction force of specific muscle groups, resulting from improved neural activity. The intense training stimulated greater motor unit recruitment and synchronization, boosting muscle force output and contraction speed (Mulyono, Siregar, & Sulaiman, 2024). This is consistent with Ayubi et al. (2024), who emphasized that increased motor neuron excitation activates additional motor units and elevates the frequency of neural signals to those units.

Despite these promising results, the study had several limitations. It was restricted to male players from a single club and did not evaluate the long-term retention of training outcomes or potential injury risks associated with competitive plyometric training. Future research should address these limitations by including female participants, employing larger and more diverse samples, and assessing the training protocol's long-term efficacy and safety.

Conslusions

Competitive plyometric exercises are very effective for developing the elements of physical fitness, especially the strength and speed of the legs, as well as some defensive skills in handball, as they have a positive and prominent impact on their development and the experimental group's competitive plyometric exercises were better than the control group in developing some physical variables and defensive handball skills for the players. Based on the above, the researcher recommends: The necessity of using modern methods and means in developing the physical and skill variables of handball and the need for coaches to adopt competitive plyometric training in developing physical and skill variables, also great interest in developing defensive and blocking skills because of their great importance in deciding many matches. These findings support the inclusion of competitive plyometric exercises in structured handball training to enhance defensive performance metrics.

Authors' contributions

ABK was responsible for data collection, analysis, article design, writing, and revision and approved the final manuscript.

Acknowledgment

The author would like to express his deepest gratitude to Kerbala Club players involved in this study.

Competing interests

The authors declare no competing interests.

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