Application of plyometric training: How does it affect throwing strength and speed in handball?

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Penerapan latihan plyometrik: Bagaimana pengaruhnya terhadap kekuatan dan kecepatan lemparan dalam bola tangan?

Original Article

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Abstract.

Background Handball demands balanced physical abilities in every aspect. Throwing power is one of the key factors in this sport because it plays a role in scoring goals, making passes, and increasing the speed of the game.

Objectives This study aims to analyze the effectiveness of plyometric training on the throwing power of handball athletes.

Methods This study uses an experimental method with a one-group pretest-posttest design. This research was conducted at Mariano Marcos State University, Philippines. The sampling technique used perposive sampling, so that all 15 athletes in the team aged 17-22 years were used as research samples. The treatment given was in the form of plyometric training for 4 weeks with a frequency of three times per week. Data collection was carried out using a strength test with the Medicine Ball Javelin Quadrathlon instrument. Data analysis was carried out with the help of the SPSS version 26 application.

Results Based on data analysis, there is a significant difference between the average pretest score (19.93) and posttest score (22.00), showing an increase of 2.07. The significance test results show a p-value of 0.000 (<0.05), which indicates that plyometric training is significantly effective in increasing strength and throwing speed in handball.

Conclusion The results of this study prove that plyometric training is effective in increasing the strength and speed of a ball throw in handball. Therefore, plyometric training can be applied as a training method to develop the performance of athletes in this sport.

Keywords: exercise, plyometrics , strength , throws , handball.

Abstrak.

Latar belakang Handball menuntut kemampuan fisik yang seimbang dalam setiap aspeknya. Kekuatan lemparan merupakan salah satu faktor kunci dalam olahraga ini, karena berperan dalam mencetak gol, melakukan operan, serta meningkatkan kecepatan permainan.

Tujuan Penelitian ini bertujuan untuk menganalisis efektivitas latihan pliometrik terhadap kekuatan lemparan atlet handball.

Metode Penelitian ini menggunakan metode eksperimen dengan desain one-group pretest-posttest. Penelitian ini dilakukan di Mariano Marcos State University, Filipina. Teknik pengambilan sampel menggunakan perposive sampling, sehingga seluruh 15 atlet dalam tim berusia 17-22 tahun yang dijadikan sampel penelitian. Perlakuan yang diberikan berupa latihan pliometrik selama 4 minggu dengan frekuensi tiga kali per minggu. Pengumpulan data dilakukan menggunakan tes kekuatan dengan instrumen Medicine Ball Javelin Quadrathlon. Analisis data dilakukan dengan bantuan aplikasi SPSS versi 26.

Hasil Berdasarkan analisis data, terdapat perbedaan signifikan antara nilai rata-rata pretest (19,93) dan posttest (22,00), menunjukkan peningkatan sebesar 2,07. Hasil uji signifikansi menunjukkan nilai p sebesar 0,000 (<0,05), yang mengindikasikan bahwa latihan pliometrik secara signifikan efektif dalam meningkatkan kekuatan serta kecepatan lemparan dalam permainan handball.

Kesimpulan Hasil penelitian ini membuktikan bahwa latihan pliometrik efektif dalam meningkatkan kekuatan dan kecepatan lemparan bola dalam handball. Oleh karena itu, latihan pliometrik dapat diterapkan sebagai metode latihan untuk mengembangkan performa atlet dalam cabang olahraga ini.

Kata kunci: latihan, plyometrics, kekuatan, lemparan, bola tangan.

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INTRODUCTION

Sports serve as a means to enhance the quality of life, promoting health and fitness. This activity can be performed by individuals from various backgrounds (Suryadi et al., 2022). Engaging in sports provides numerous benefits, including improved physical fitness (Suryadi, Suganda, et al., 2023; Rubiyatno et al., 2023), increased endurance (Suryadi, Yanti, et al., 2023), and enhanced motor skills in children (Samodra et al., 2023). Sports can be categorized into different types, such as physical education, recreational sports, rehabilitation sports, and competitive sports. One of these is handball.

Handball is a team sport where the primary objective is to score goals by throwing the ball into the opponent's net (Yogi et al., 2023). To earn points, shooting is one of the most crucial techniques in handball. Therefore, this sport requires power, speed, agility, endurance, balance, flexibility, accuracy, and coordination (Karcher & Buchheit, 2014). Additionally, executing various movements in handball demands a combination of physical abilities, including repeated sprints, jumps, strength, and aerobic endurance (Massuca et al., 2014; Wagner et al., 2014). Given its physically demanding nature, the game involves acceleration, deceleration, and intermittent movements (Luteberget & Spencer, 2017).

Previous research has focused on developing physical attributes specific to handball (Chelly et al., 2014; van den Tillaar et al., 2015), but few studies have examined the effects of specific training interventions. Intervention studies typically investigate different physical abilities in relation to injury prevention (Myklebust et al., 2003; Peterson et al., 2005). Several studies have also analyzed the effects of different strength training programs on physical performance in professional handball, revealing positive outcomes in strength, explosive power, sprint speed, change of direction, and throwing performance (Gorostiaga et al., 2006; Granados et al., 2008; Marques & Gonzlaez-Badillo, 2006). Achieving these positive results requires manipulating appropriate training methods with adjustable variables, as these approaches have been proven effective in sports (Teichmann et al., 2016).

Hodgson et al. (2013) suggested that to maximize the benefits of post-activation potentiation, athletes should combine strength and speed training within the same session. This combination enhances acute muscle power output due to the history of high-intensity contractions, such as performing intense strength exercises before sprinting to improve performance (DW, 2005). Additionally, combining strength training with plyometrics—known as complex training—is commonly used to enhance athletic performance (Ebben, 2002). This training method is recommended for various sports, particularly those involving throwing movements (Ebben & Watts, 1998). This aligns with handball, where throwing is a fundamental skill for scoring goals (Rios et al., 2021).

Throwing speed development relies on stable throwing techniques and the progressive enhancement of strength and speed (Cherif et al., 2016), which must also be complemented by fine motor control (Wagner et al., 2011). Various training methods can be applied in sports conditioning, including plyometric training (Escamilla et al., 2011; Szymanski, 2012). Previous studies have examined the short-term effects of plyometric training on strength, power, and sprint performance (Chelly et al., 2014; Saez-Saez de Villarreal et al., 2010; van den Tillaar et al., 2015). Moreover, several studies have confirmed that plyometric training is particularly beneficial for handball players, as it enhances strength and jumping ability (Hermassi et al., 2011; Marques, 2010). This is because plyometric exercises positively impact the development of speed-related skills, including throwing velocity (Spieszny & Zubik, 2018).

Extensive literature highlights the effectiveness of plyometric training in improving speed, explosive jumping power, and overall strength in athletes (Petruzela et al., 2023). Research by Markovic & Mikulic (2010) and Michailidis (2015) on plyometric training's impact on muscle strength and speed concluded that this method enhances sprint and jumping performance in ball sports across different skill levels. Additionally, a study by Soundara & Pushparajan (2010) confirmed that plyometric training improves muscle strength and explosive power. Meta-analyses investigating the effects of plyometric exercises on back and leg muscle strength found significant increases in muscle force capacity (Kayantas & Soyler, 2020).

Athlete performance can also be enhanced through various training methods, including resistance training (Zech et al., 2010), neuromuscular training (Steib et al., 2016), and plyometric training (Akinbiola & Yekeen, 2022). One study provided evidence on the effective use of plyometric

training to improve muscle strength and sprint speed in both amateur and professional volleyball players (Ramirez-Campillo et al., 2021). This training method also enhances volleyball-specific skills, such as spiking and jumping in the opposite direction. Furthermore, other training techniques, such as sprint intervals or circuit training, have also been shown to increase throwing speed (Petruzela et al., 2023; Vila & Ferragut, 2019).

Currently, there are no definitive recommendations regarding the most effective interventions for improving throwing power and speed in handball. This is because handball throwing involves high-speed and high-acceleration movements, requiring strength and endurance training to be carefully structured for optimal throwing performance (Behm et al., 2017). Strength and speed are key determinants of success in this sport. Therefore, to maximize the effectiveness of strength and speed training, these elements must be systematically integrated into comprehensive training programs tailored to specific sports disciplines (Bompa & Buzzichelli, 2019).

This study aims to analyze the effects and effectiveness of plyometric training on handball throwing strength and speed. Beyond strength development, appropriate training methodologies are essential, as strength enhancement must be prioritized over explosive movements, particularly in adolescent athletes (Behm et al., 2017).

METHOD

Participant.

The subject of this study was the Mariano Marcos State University team in the Philippines, aged 17-22 years. Sampling was carried out using purposive sampling technique so that all athletes were used as research samples, totaling 15 people in accordance with the training principles.

Research Design.

This research is an experimental type with a one group pretest and posttest design. The first step taken was to collect the initial data, namely the pre-test in order to have data about the ability of each player before being given treatment. In this study the treatment given was in the form of plyometric exercises within 4 weeks with a frequency of 3 times a week. After completing the treatment within the specified time, then the final test is carried out again regarding the ability of strength and speed.

Pretest and posttest data collection instruments use strength and speed tests. In this study to determine the strength and speed abilities of handball players using a strength test, the Medicine Ball Javelin Quadrathlon (Mackenzie, 2005). This can be seen in Figure 1.

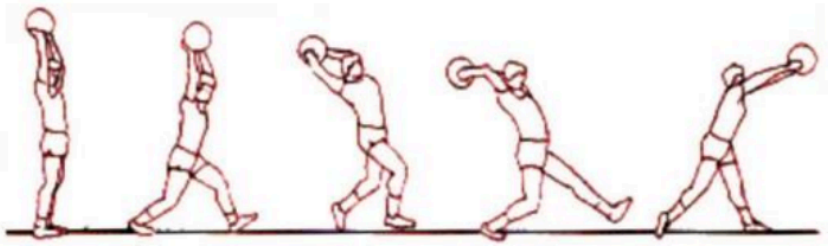

Figure 1. Medicine Ball Javelin Quadrathlon

Statistical Analysis.

Analysis of the research data used the normality test as a prerequisite after that the effect test (t test) and if the data is not normal then use the non-parametric test with the help of the SPSS Version 26 application.

RESULTS AND DISCUSSION

Results

This study began by collecting pre-test data on the strength and speed of handball players from the Sambas district team. The purpose of this was to assess their initial abilities, which would later serve as comparative data for the post-test results.

Table 1. Kolmogorov-Smirnov Normality Test Results

One-Sample Kolmogorov-Smirnov Test		
Results		Unstandardized Residuals
N		15
Normal Parameters [a,b]	Means	0E-7
	std. Deviation	2.00976326
Most Extreme Differences	absolute	,376
	Positive	,208
	Negative	-,376
Kolmogorov-Smirnov Z		1.455
asymp. Sig. (2-tailed)		0 .129

The normality test was conducted using the One-Sample Kolmogorov-Smirnov Test. The results indicate that the residual values are normally distributed, with a significance value of 0.129, which is greater than 0.05. This confirms that the data meet the assumption of normality, allowing further analysis through hypothesis testing. The complete results are presented in Table 1.

Table 2. Paired Sample T-Test Results

Pair 1	Results	Means	std. Deviation	t	df	Sig. (2-tailed)
	Pretest - Posttest	-3.26667	1.27988	-9,885	14	0.000

A paired sample t-test was performed to determine the effect of plyometric training on handball throwing performance. The results in Table 2 show a significance value of 0.000, which is less than 0.05. This indicates a statistically significant difference between pre-test and post-test results. Therefore, it can be concluded that plyometric exercises are effective in improving throwing strength and speed in handball.

Table 3. Descriptive Statistics for Pre-Test and Post-Test Results of Throwing Strength

Results	N	Minimum	Maximum	Range	Means	SD	Variances
Pre-test	15	19	21	2	19.93	0.70	0.495
Post test	15	19	24	5	22.00	1.77	3,143

The descriptive statistical analysis in Table 3 shows that the mean pre-test score was 19.93, while the mean post-test score increased to 22.00. This demonstrates a clear improvement in throwing strength following the plyometric training program. Additionally, the range of scores expanded from 2 (pre-test: 19-21) to 5 (post-test: 19-24), further highlighting the impact of the intervention.

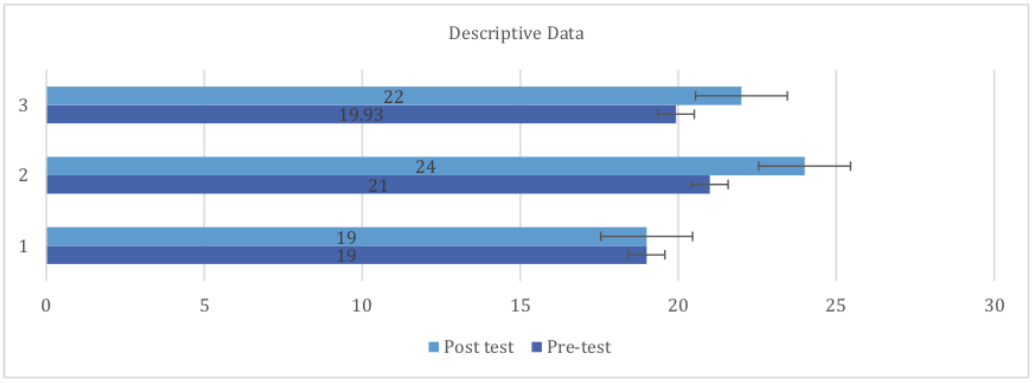

Figure 2. Differences Between Pre-Test and Post-Test Values

Figure 2 illustrates the differences between pre-test and post-test values, reinforcing the findings that plyometric training contributes significantly to the enhancement of handball players' throwing strength and speed.

Discussion

This study aims to determine the effectiveness of plyometric exercises in enhancing handball players' throwing strength and speed. The findings indicate that the plyometric training method significantly impacts these aspects, confirming previous research on plyometric exercises. For instance, a study by Ramirez-Campillo et al. (2020) demonstrated that plyometric jump training effectively improves muscle explosive power, sprint speed, balance, and muscle strength in basketball players. Similarly, research by van den Tillaar et al. (2015) found that short-term plyometric training enhances physical performance, particularly strength and speed, in youth soccer players. Additionally, Teo et al. (2016) highlighted the effectiveness of plyometric training in increasing jump height due to its influence on force profile, speed, and movement patterns.

Plyometric training is a highly recommended method for improving handball players' strength as it follows natural human movement patterns, utilizing the stretch-shortening cycle (SSC). This cycle converts stored elastic potential energy during the eccentric phase into kinetic energy during the concentric phase (Ramirez-Campillo et al., 2020). Strength improvements are often observed at the beginning of a training cycle, particularly in mesocycles focused on plyometrics (Dietz & Peterson, 2012). Furthermore, consistent plyometric training enhances muscle tolerance to high eccentric loads, allowing for better utilization of the SSC (Spieszny & Zubik, 2018).

In adolescent handball players, plyometric training promotes better interaction between movement-controlling muscles, leading to improved skills and coordination (Yasumitsu et al., 2011; Zech et al., 2010). The training consists of rapid muscle elongation followed by contraction, maximizing strength output in minimal time (Kayantas & Soyler, 2020; Michailidis, 2015; Razaimanesh et al., 2011). Plyometric exercises, which involve controlled muscle stretching and shortening, enhance an athlete's ability to change direction, stop, and initiate movement efficiently. These exercises are particularly beneficial in increasing muscle speed and strength, both of which are crucial for explosive sports movements (Akinbiola & Yekeen, 2022). Several studies also suggest that combining plyometric training with strength training improves vertical jump performance, leg power, and overall muscle strength (Slimani et al., 2016; Suresh et al., 2020).

One common challenge in strength training programs is determining the appropriate resistance level—whether to use heavier or lighter weights (Abuajwa et al., 2022). The effectiveness of different training intensities and methods must be tailored to specific movement patterns, such as handball throwing (Petruzela et al., 2023). Additionally, technical aspects, such as refining motor programs through neuromuscular conditioning and adaptations of muscle spindles, Golgi tendon organs, and proprioceptors, contribute to performance improvements (Aman et al., 2015). Core training may also be beneficial, particularly in the early stages of training for youth athletes, as it enhances muscle stability (Jebavy et al., 2020). However, its impact on throwing speed is generally moderate, as seen in a study where female adolescent athletes showed only a slight improvement in throwing velocity (less than 1 m/s over six weeks (Saeterbakken et al., 2011). Other research suggests that endurance training can improve throwing speed without compromising accuracy (Bragazzi et al., 2020). Similarly, Petruzela et al. (2023) found that random repeated sprint training had a significant positive effect on jumping shots (d = 1.92) and a moderate effect on standing throws (d = 0.52). Sprinting, as an expression of maximal power, contributes to improved jump performance and influences ball-throwing power (Saavedra et al., 2019).

Another factor affecting throwing speed is athlete fatigue. Research has investigated the impact of fatigue on throwing speed between the first and second halves of a match, revealing that there is no standard recovery time to ensure fatigue does not impair performance (Zapardiel Cortés et al., 2017). Therefore, incorporating fatigue assessment into throw-speed testing could provide more accurate performance insights (Iacono et al., 2016). Additionally, the development of high anaerobic power in the upper limbs and trunk is closely linked to the ability to generate high ball velocity during throws. Many researchers consider this a key offensive factor influencing player performance during a match (Debanne & Laffaye, 2011, 2013).

CONCLUSION

The results of this study provide strong evidence regarding the relationship between strength and speed in handball throws, as discussed in the previous sections. The findings confirm that plyometric exercises are significantly effective in enhancing both the strength and speed of handball throws. Implementing a four-week plyometric training program has proven to be effective in strengthening arm muscles, particularly for handball players. To achieve optimal results, coaches and

field practitioners should design structured training programs that ensure athletes maintain discipline throughout their training. However, one limitation of this study is that the findings are specific to young players participating in short-season handball, meaning that outcomes may differ depending on factors such as training intensity, duration, repetitions, and season length.

As a recommendation for future research, integrating plyometric training with strength training is suggested to provide a more comprehensive conditioning approach, enhancing not only speed but also muscular endurance in athletes.

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AUTHOR CONTRIBUTION STATEMENT

JMC was responsible for conceptualizing and designing the study, collecting data, and drafting the manuscript. PJR contributed to the analysis, interpretation of results, and critical revision of the manuscript. PJR also acted as the correspondence author, handling all correspondence and revisions related to the publication.

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