

Application of plyometric training in handball games: How effective is it on throwing power and speed?

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Published online: May 31, 2024

Accepted for publication : May 15, 2024

DOI:10.7752/jpes.2024.05136

Abstract

Introduction and Objectives. Handball requires a range of physical skills, with throwing power being essential for scoring goals, passing, and enhancing overall speed. Plyometric training, a type of exercise that merges strength and speed to boost athletic performance, is well-regarded for its ability to improve explosive power and agility. This study explores the use of plyometric training in handball and assesses its effects on players' throwing power and speed. **Materials and Methods.** This experimental study employed a one-group pretest-posttest design. The participants were members of the Sambas district handball team, aged 17-22 years, chosen through total sampling, resulting in 15 athletes. The intervention involved plyometric exercises conducted over four weeks, with three sessions each week. Data were collected using the Medicine Ball Javelin Quadrathlon strength test, and the analysis was performed using SPSS version 26. **Results.** The data analysis showed a significant difference between the pretest average score of 19.93 and the posttest average score of 22.00, indicating an increase of 2.07. The significance level was 0.000, which is less than 0.05, confirming that plyometric exercises significantly improve throwing strength and speed in handball. **Conclusions.** The results indicate that plyometric exercises effectively enhance strength and speed in handball throwing. These findings suggest that including plyometric exercises in handball training programs can lead to significant improvements in athletic performance. Coaches and trainers are advised to incorporate plyometric training to enhance players' explosive power and speed, thereby improving their performance in competitive handball. Therefore, plyometric exercises are recommended for handball players to boost their throwing abilities.

Key words: Plyometric training, handball, throwing power, speed, athletic performance

Introduction

Sport is an activity that is used as a means to improve the quality of life to be healthy and fit (Donie et al., 2023). Where activity This can done various circles (Suryadi et al., 2022). Lots benefits with do activity sports including physical fitness (Suryadi, Suganda, et al., 2023; Rubiyatno et al., 2023), increased endurance (Suryadi, Yanti, et al., 2023), and good motor skills for children (Samodra et al., 2023; Stimulation of Motor Skills through Game Models in Early Childhood and Elementary School Students: Systematic Review in Indonesia, 2024). Sport alone consists from various type like sport education, sports recreation, sports rehabilitation, and sport achievement (Suryadi, Komaini, et al., 2024; Suryadi, Nasrulloh, et al., 2024; Suryadi, Susanto, et al., 2024). One of them is sport handball game.

Handball is a team sport wherein the primary objective is to score points by putting the ball into the opponent's goal (Ramadhan et al., 2024; Yogi et al., 2023). Scoring or shooting points is a fundamental technique in handball, necessitating a combination of various physical attributes such as power, speed, agility, endurance, balance, flexibility, accuracy, and coordination (Karcher & Buchheit, 2014). Next in handball, For Performing various movements requires a variety of physical abilities including repeated sprints, jumps, strength to aerobics (Massuca et al., 2014; Wagner et al., 2014). With once this game is physically demanding, acceleration, deceleration and intermittent (Luteberget & Spencer, 2017).

Studies conducted by Chelly et al., (2014); van den Tillaar et al., (2015) focus on enhancing specific physical attributes for handball; however, they do not specifically investigate the impacts of training. Intervention studies usually investigate different physical abilities in relation to injury prevention (Myklebust et al., 2003; Peterson et al., 2005). Several studies have also examined the effects of different strength training programs on physical abilities related to professional handball and found positive effects of strength training, explosive power, sprinting, change of direction and throwing performance (Gorostiaga et al., 2006; Granados et

al., 2008; Marques & Gonzlaez-Badillo, 2006). Positive results will only succeed through the manipulation of proper training methods with modifiable factors because these methods are reported to be effective in sports (Teichmann et al., 2016).

Next by Hodgson et al., (2005) suggested that to take advantage of the post-activation potentiation effect, athletes should alternate using strength and speed training methods in the same training session. The impact that occurs is seen in an increase in acute muscle power output as a result of a history of the ability to contract at high intensity such as intense strength training before running which can improve performance (DW, 2005). In addition, a combination of strength training and plyometrics or called complex training is usually used to improve performance (Ebben, 2002). This training method is recommended for various sports including sports involving throwing (Ebben & Watts, 1998). This is in accordance with the movements that are often carried out in handball, one of which is throwing to score goals (Rios et al., 2021).

The development of throwing speed is based on a stable throwing technique through progressive development of strength and speed (Cherif et al., 2016), and must be in line with fine motor control (Wagner et al., 2011). Various training methods that can be applied in sports training include plyometric exercises (Escamilla et al., 2011; Szymanski, 2012). Previous studies have investigated the plyometric effect of short-term training on strength, power and sprint performance (Chelly et al., 2014; Saez-Saez de Villarreal et al., 2010; van den Tillaar et al., 2015). In addition, many reports have confirmed that plyometric exercises can be used in handball training aimed at developing strength and jumping ability (Hermassi et al., 2011; Marques, 2010). This is because plyometric training has a positive influence on the development of abilities related to speed when throwing the ball (Spieszny & Zubik, 2018).

Much literature also suggests that plyometric training is capable of developing speed, explosive jumping power, and strength for athletes (Petruzela et al., 2023). Research conducted by Markovic & Mikulic, (2010); Michailidis, (2015) regarding plyometric training on muscle strength and speed. The two studies agreed that plyometric training can improve sprint and jump performance in ball games at various levels. In addition, research conducted by Soundara & Pushparajan, (2010) confirmed that plyometric training can increase muscle strength and explosive power. Meta-analyst studies investigating the effect of plyometric training on back and leg muscle strength found that there was an increase in back and leg muscles and the force capacity of these muscles (Kayantas & Soyler, 2020).

Player performance can also be improved through a number of training methods including resistance training (Zech et al., 2010), neuromuscular training (Steib et al., 2016) and plyometric training (Akinbiola & Yekeen, 2022). A study provides information regarding the effective use of plyometric exercises in increasing muscle strength and sprint speed in amateur and professional volleyball players (Ramirez-Campillo et al., 2021). As well as being able to improve special volleyball skills such as jumping spikes and jumping in the opposite direction. furthermore other methods such as sprint intervals or circuit training can also increase throwing speed (Petruzela et al., 2023; Vila & Ferragut, 2019).

In the game of handball, the ability to throw with great power and speed is a crucial skill that can determine success in scoring goals, making effective passes, and improving game dynamics (Massuca et al., 2014; Ramadhan et al., 2023; Wagner et al., 2014). Understanding how best to improve these physical attributes through specific training methods such as plyometrics can give athletes a significant competitive advantage. While plyometric training has been recognized as effective for improving explosive strength and agility, its specific application in the context of handball has not been widely studied. This study aims to provide empirical data that can assist coaches and sports experts in designing more effective and efficient training programs for handball players, specifically in improving throwing power and speed.

There is a lack of explicit guidance regarding the most efficacious interventions for augmenting the power and speed of handball throwers. This arises from the fact that handball throwing involves rapid motions with high velocity and acceleration, necessitating strength and endurance training to be impactful in enhancing throwing speed (Behm et al., 2017). Strength and speed are among the determining factors for success in this sport. Therefore, to optimize the effectiveness of strength and speed training, it must be integrated into the overall training program developed for certain sports disciplines (Bompa & Buzzichelli, 2019). The purpose of this study is to see the influence and effectiveness of plyometric training on the strength and speed of throwing the ball in the sport of handball. In addition to developing strength, proper training is needed, this is because strength development should be prioritized over explosion in adolescent athletes (Behm et al., 2017). This study may also add to the scientific literature on the benefits of plyometric training in team sports, particularly handball. With strong empirical evidence, the scientific community and sports practitioners can better understand the mechanisms and benefits of this type of training, so as to develop more sophisticated and evidence-based training strategies.

Material and methods

Participant. The participants in this study were members of the men's handball team, Sambas Regency aged between 17 and 22 years. Sampling was carried out with a total sampling technique, where all athletes were included as research participants totaling 15 people, this is in accordance with the principle of training. The

handball team members who were sampled were amateur athletes who would take part in the provincial sports week championship. Where before being given treatment, the sample was given an overview related to plyometric training on the strength and speed of throwing the ball in handball sports.

Research Design. This study adopts an experimental approach, specifically employing a one-group pretest and posttest design. The initial phase involves gathering baseline data through a pre-test to assess the abilities of each player before undergoing treatment. The plyometrics exercises in this study emphasize overall stamina and speed by involving several consecutive efforts with high intensity, including: standing long, triple jump, jump: higher and longer steps, hops and jump, heavy medicine ball. The intervention applied in this study was plyometric exercise performed within a span of 4 weeks, with a frequency of 3 sessions per week, for a total of 12 sessions. After completing the treatment within a predetermined time span, a final test was conducted to reevaluate strength and speed abilities. More details can be seen in table 1.

Table 1. Plyometric Training Program

Length of Exercise	1 Week (Monday, Wednesday, Friday)	
Intensity	High impact Exercise	
Time (duration)	30 - 60 menit	
Exercise Program	Plyometrik	
Exercise Type	Exercise Measure	Description
Main Exercises: Plyometrics are: (standing long, triple jump, jump: higher and longer steps, hops and jumps, heavy medicine ball)	Frequency: 3 times/week Duration: 30 - 60 minutes Repetitions: Max Reps Sets: 3 - 5 sets Rhythm: Smooth Recovery: 10 - 15 seconds between sessions & 120 seconds/set.	Gradually increase reps and sets each week.

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).

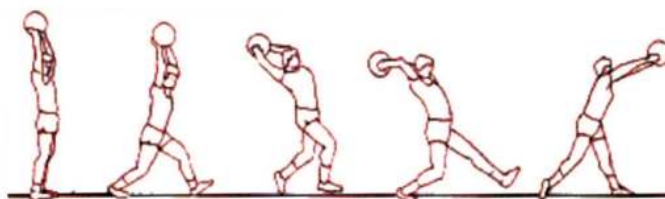


Figure 1. Medicine Ball Javelin Quadrathlon

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

This research began by collecting initial pre-test data related to the strength and speed of Sambas district handball team players to determine initial abilities and will also be comparative data at the end. The results of data analysis through the normality test using the one sample Kolmogorov Smirnov formula. Results shows that the residual values are normally distributed with a significance value of $0.125 > 0.05$, then the effect test is continued (t test). Complete results can be seen in table 2. Results on Table 3 shows mark significance $0.000 < 0.05$ then can said significant. Based on results the can concluded that proven plyometric exercises give effectiveness to strength and speed ball throw in game handball.

Table 2. 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

Table 3. Results of statistical data analysis paired sample T-test

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

Table 4. Descriptive Data Results of the pretest and posttest 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

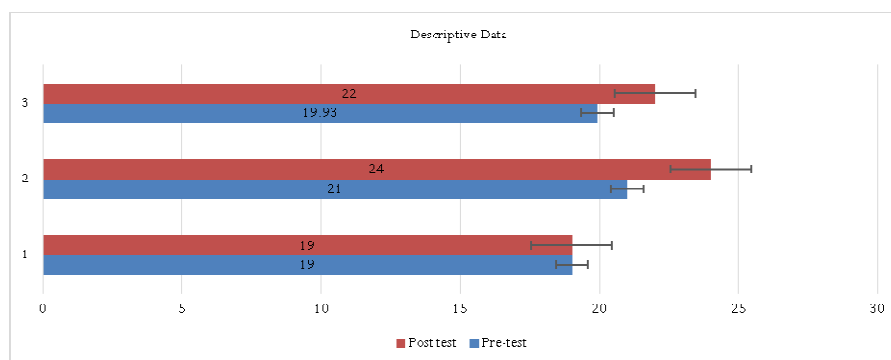


Figure 2. Differences in Pretest and Posttest Value Results

The results of the descriptive statistical analysis of the data in table 4 and figure 2 show the mean at pretest 19.93 while the mean at posttest is 22, where results This prove exists difference pretest and posttest values using plyometric exercises.

Discussion

The objective of this study is to assess the impact of plyometric training on the strength and speed of ball throwing in handball matches. The results of this investigation suggest that plyometric training has a significant effect on enhancing both the strength and speed of handball throwing. This confirms relevant previous research regarding plyometric exercises conducted by Ramirez-Campillo et al., (2020) showing the results of his research regarding plyometric jumping exercises being able to significantly increase muscle explosive power, sprint speed, balance and muscle strength of basketball players. Subsequent research on plyometric training in short seasons can improve physical performance (strength and speed in youth soccer players (van den Tillaar et al., 2015). As well as effectively increasing the height of the jump because of the force profile or speed and the same motion pattern (Teo et al., 2016).

Plyometric training is one method or method that is highly recommended to be used to increase the strength of handball players. This is because plyometric exercises follow the form of human movement using the stretch-shortening cycle principle (SSC) to convert elastic potential energy in the outer contraction stage into kinetic energy in the concentric contraction stage (Ramirez Campillo et al., 2020). The data is proven by the results obtained in table 4 and figure 2 showing the mean at pretest 19.93 while the mean at posttest is 22, where these results prove an increase by using plyometric exercises. The observation of strength gains is one of the variables that reacts favorably when starting a training cycle with a mesocycle that focuses on plyometrics (Dietz & Peterson, 2012). In addition, regular plyometric training also increases muscle tolerance to significant eccentric loads and allows better use of stretching cycles (Spieszny & Zubik, 2018).

Adolescent handball players generally experience an increase in the interaction between the muscles that control movement resulting in better skills and increased coordination between muscles (Yasumitsu et al., 2011; Zech et al., 2010). Plyometric training itself consists of rapid muscle extension followed by shortening of the same muscles and connective tissue with the aim of maximizing strength in the shortest time (Kayantas & Soyler, 2020; Michailidis, 2015; Razaimanesh et al., 2011). Plyometric drills, which entail muscle elongation followed by rapid muscle contraction, are executed to facilitate changes in direction, as well as the ability to halt and initiate movement. Engaging in plyometric exercises enhances muscle speed and strength, enabling quick bursts of movement essential for various sports activities (Akinbiola & Yekeen, 2022). Several researchers have found that combining plyometric training with strength training improves vertical jump performance, leg strength and muscle strength (Slimani et al., 2016; Suresh et al., 2020).

The problem that often arises in increasing strength in training programs is related to using heavier or lighter weights (Abuajwa et al., 2022). Therefore the effect of different training methods and their intensity must be adjusted for certain movement patterns such as throwing a handball (Petruzela et al., 2023). Besides that, technically strengthening the motor program by conditioning neuromuscular and nerve adaptation of the muscle

spindles, golgi-tendon organs and proprioceptors which causes an increase to occur (Aman et al., 2015). In the early training phase in the youth category, players may benefit from core training but its efficiency is primarily for muscle stability (Jebavy et al., 2020), and lasts for several weeks (Jebavý et al., 2013). In support of this, one study using core training in the female adolescent category showed a small positive effect (an average increase of less than 1 m/s over 6 weeks) on throwing speed (Saeterbakken et al., 2011). Furthermore, the results of other studies show that endurance training increases throwing speed without losing accuracy (Bragazzi et al., 2020). Reconfirmed by research Petruzela et al., (2023) regarding random repeated sprint training had a large positive effect on jumping shots ($d = 1.92$), and a moderate effect on standing throws ($d = 0.52$). Sprint is a real form of the fastest power, which generates greater force to make the performance of the jump better and affect the ball throw (Saavedra et al., 2019).

Another problem that can affect throwing speed is the athlete's fitness which can lead to fatigue. One study investigated the effect of fatigue on throwing speed between the first and second rounds in general and there was no standard recovery time to guarantee that fatigue did not affect throwing speed (Zapardiel Cortés et al., 2017). Therefore, including a test that takes fatigue into account during the throw speed test can be useful (Iacono et al., 2016). The ability to develop high anaerobic power in the upper limbs and trunk is also associated with the ability to apply high speed to the ball during throw. So that many researchers considered it to be the main offensive factor affecting player performance during a match (Debanne & Laffaye, 2011, 2013).

Conclusions

The study's findings, as discussed thoroughly, underscore the strong correlation between the strength and speed of handball throws. The results affirm that plyometric exercises are highly effective in significantly improving both the strength and speed of handball throws. Specifically, implementing plyometric training over a 4-week period has been shown to notably enhance the strength of arm muscles, particularly among handball players. To achieve optimal results, coaches or field practitioners may structure training programs to instill discipline among athletes. It's important to note the study's limitations, namely that its findings are applicable only to young players engaged in short-season handball. Variations in results may occur based on factors such as training intensity, duration, repetitions, and the overall length of the training season. Overall, this research provides a valuable contribution to the development of theory and practice in the field of sports, especially in improving the performance of handball athletes through plyometric training. In light of these limitations, research recommendations suggest combining plyometric training with a strength training approach to comprehensively condition athletes' muscles, thereby addressing both speed and endurance aspects.

Acknowledgement

The author would like to thank all parties for the cooperation so that the research can run well and smoothly.

Conflict of interest

There is no conflict of interest.

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