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Effectiveness of plyometric training in handball: impact on throwing power and speed
Eficacia del entrenamiento pliométrico en balonmano: impacto en la potencia y velocidad de lanzamiento

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Abstract. Handball calls for a variety of athletic skills, but throwing force is crucial for passing, scoring, and gaining momentum. Plyometric training uses explosive exercises that increase muscular contraction speed and force to improve power and speed. The purpose of the study is to ascertain whether adding plyometric workouts to handball players' training regimens can enhance their throwing ability to a noticeable degree. The research utilized an experimental design with a pretest-posttest methodology for a single group. The Sambas district handball team, which consisted of 15 athletes, picked the participants, who were between the ages of 17 and 22. Plyometric training was the intervention, and it was done in three sessions a week for four weeks. The Medicine Ball Javelin Quadrathlo strength test was used to gather data, and SPSS version 26 was used for analysis. The research showed that the mean throwing power and speed had significantly increased, with improvements of 2.07 between the pretest and posttest values of 19.93 and 22.00, respectively. The significance value obtained was 0.000, indicating a statistically significant enhancement. The plyometric training was found to be highly effective in enhancing the explosive strength and neuromuscular coordination required for powerful and fast throws in handball. In conclusion, the findings suggest that incorporating plyometric training into the training programs of handball players can substantially improve their throwing performance. Coaches and trainers are recommended to integrate plyometric exercises to maximize the athletic potential of their players.
Keywords: plyometric training, handball, throwing power, throwing speed, explosive strength, athletic performance

Resumen. El balonmano requiere diversas habilidades atléticas, pero la fuerza de lanzamiento es crucial para pasar, marcar y ganar impulso. El entrenamiento pliométrico utiliza ejercicios explosivos que aumentan la velocidad y la fuerza de contracción muscular para mejorar la potencia y la velocidad. El objetivo del estudio es determinar si la adición de ejercicios pliométricos a los regímenes de entrenamiento de los jugadores de balonmano puede mejorar su capacidad de lanzamiento en un grado notable. La investigación utilizó un diseño experimental con una metodología pretest-postest para un solo grupo. El equipo de balonmano del distrito de Sambas, formado por 15 atletas, eligió a los participantes, que tenían entre 17 y 22 años. El entrenamiento pliométrico fue la intervención, y se realizó en tres sesiones semanales durante cuatro semanas. Se utilizó la prueba de fuerza con balón medicinal y jabalina Quadrathlo para recopilar los datos, y para el análisis se utilizó el SPSS versión 26. La investigación mostró que la potencia y la velocidad medias de lanzamiento habían aumentado significativamente, con mejoras de 2,07 entre los valores pretest y postest de 19,93 y 22,00, respectivamente. El valor de significación obtenido fue de 0,000, lo que indica una mejora estadísticamente significativa. El entrenamiento pliométrico resultó muy eficaz para mejorar la fuerza explosiva y la coordinación neuromuscular necesarias para realizar lanzamientos potentes y rápidos en balonmano. En conclusión, los resultados sugieren que la incorporación del entrenamiento pliométrico a los programas de entrenamiento de los jugadores de balonmano puede mejorar sustancialmente su rendimiento en los lanzamientos. Se recomienda a entrenadores y preparadores físicos que integren ejercicios pliométricos para maximizar el potencial atlético de sus jugadores.
Palabras clave: entrenamiento pliométrico, balonmano, potencia de lanzamiento, velocidad de lanzamiento, fuerza explosiva, rendimiento atlético.

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Introduction

In the team sport of handball, the object of the game is to score by launching the ball into the opponent's goal (Yogi et al., 2023). To score, one must possess a combination of strength, speed, agility, endurance, balance, flexibility, accuracy, and coordination (Karcher & Buchheit, 2014). A variety of athletic skills are required for the activity, including strength, aerobic capacity, and repeated sprints and jumps (Massuca et al., 2014; Wagner et al., 2014). It involves frequent acceleration, deceleration, and intermittent motions due to its physically demanding nature (Luteberget & Spencer, 2017). Research by Chelly et al., (2014); van den Tillaar et al., (2015) se ha centrado en la mejora de atributos físicos específicos para el balonmano, aunque estos estudios no suelen abordar los efectos de los regímenes de entrenamiento. Los estudios de intervención suelen examinar diversas capacidades físicas en relación con la prevención de lesiones (Liza et al., 2023, 2024; Myklebust et al., 2003; Peterson et al., 2005; Sumantri et al., 2023). Otras investigaciones han estudiado los efectos de los programas de entrenamiento de fuerza en jugadores profesionales de balonmano, encontrando resultados positivos en la potencia explosiva, el sprint, los cambios de dirección y el rendimiento en los lanzamientos (Gorostiaga et al., 2006; Granados et al., 2008; Marques & Gonzlaez-Badillo, 2006).

Los métodos de entrenamiento eficaces, que implican una manipulación adecuada de los factores modificables, son cruciales para lograr resultados positivos en el deporte (Rozi et al., 2023; Rubiyatno et al., 2023; Sudirman et al., 2024; Teichmann et al., 2016).

Hodgson et al., (2005) suggest that athletes should alternate strength and speed training methods in the same session to benefit from the post-activation potentiation effect, enhancing acute muscle power output. This method involves intense strength training followed by running, improving performance (DW, 2005; Hardinata et al., 2023; Supriatna et al., 2023; Suryadi et al., 2023). Furthermore, complex training a technique that combines strength and plyometrics—is frequently employed to improve performance (Ebben, 2002). It is advised to use this technique for a variety of activities, including throwing sports (Ebben & Watts, 1998), aligning with the frequent throwing movements in handball (Rios et al., 2021).

Throwing speed development relies on a stable throwing technique and the progressive development of strength and speed (Cherif et al., 2016), along with fine motor control (Wagner et al., 2011). Studies have examined the impact of several training techniques, such as plyometric exercises, on strength, power, and sprint performance (Chelly et al., 2014; Escamilla et al., 2011; Saez-Saez de Villarreal et al., 2010; Szymanski, 2012; van den Tillaar et al., 2015). Plyometric exercises are confirmed to aid in developing strength and jumping ability in handball (Hermassi et al., 2011; Marques, 2010), and have a positive impact on throwing speed (Spieszny & Zubik, 2018).

According to research, plyometric exercise helps athletes gain strength, speed, and explosive jumping ability (Petruzela et al., 2023; Sudirman et al., 2024). Studies by Markovic & Mikulic, (2010) and Michailidis, (2015), indicate that plyometric training enhances sprint and jump performance in various ball games. Soundara & Pushparajan, (2010) also found that it increases muscle strength and explosive power. Meta-analyses show that plyometric training improves back and leg muscle strength (Kayantas & Soyler, 2020).

There are several ways to improve an athlete's performance, one of which is resistance training (Zech et al., 2010), neuromuscular training (Steib et al., 2016), and plyometric training (Akinbiola & Yekeen, 2022). For both amateur and professional volleyball players, plyometric workouts are very beneficial for enhancing muscular strength and sprint speed, as well as abilities like jumping spikes (Ramirez-Campillo et al., 2021). Throwing speed can also be increased by other techniques like circuit training or sprint intervals (Petruzela et al., 2023; Vila & Ferragut, 2019).

Explicit guidelines are required about the best interventions to improve the power and speed of handball throwing. Throwing handballs requires quick, high-velocity motions, therefore developing strength and endurance is necessary to increase throwing speed (Behm et al., 2017). In handball, having both strength and speed is essential for success. For this reason, it is crucial to incorporate these training components into the entire training program in order to maximize performance (Bompa & Buzzichelli, 2019). Examining the impact and efficacy of plyometric training on the force and velocity of handball throws, this study highlights the significance of appropriate training, particularly when it comes to increasing strength over explosive power in teenage athletes (Behm et al., 2017).

Materials and Methods

Participant

The Sambas Regency men's handball team members who took part in this study ranged in age from 17 to 22. In compliance with training guidelines, a total of 15 athletes were included as research subjects, and the sampling was carried out using a complete sampling technique. The amateur athletes chosen for the handball squad were getting ready to play in the provincial sports week championship. The impact of plyometric exercise on the strength and speed of handball throwing was explained to the participants prior to the intervention.

Research Design

An experimental design, specifically a one-group pretest-posttest design, is used in this investigation. In the first stage, baseline data is gathered via pretests to assess each player's skills before to the intervention. The plyometric activities in this study include standing long leaps, triple jumps, higher and longer step jumps, hops, and jumps, as well as workouts with a heavy medicine ball, with the goal of improving overall stamina and speed through multiple consecutive high-intensity efforts. The intervention took the form of 12 sessions of plyometric exercise spread over 4 weeks, with 3 sessions each week. A follow-up exam was administered to evaluate the participants' strength and speed once the intervention was finished. Additional information is given in Table 1.

Table 1.
Program for Plyometric Training

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
Principal Exercises: Standing long, triple jumping, jumping, higher and longer steps, hopping and jumping, and heavy medicine ball are examples of plyometric exercises.	Period: thrice weekly Time frame: 30 to 60 minutes Reps: Maximum Reps Three to five sets Smooth Recovery: 10 to 15 seconds in between sets and 120 seconds in total for rhythm.	Gradually increase reps and sets each week.

Strength and speed tests were among the data gathering tools used for the pretest and posttest. This study used the Medicine Ball Javelin Quadrathlon strength test to evaluate the handball players' speed and strength (Mackenzie, 2005).

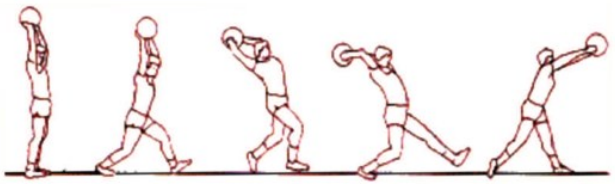

Figure 1. Medicine Ball Javelin Quadrathlon

Statistical Analysis

The normality test was the first step in the analysis of the study data, followed by the effect test (t test), and if the data were not normal, a non-parametric test using the SPSS Version 26 program was utilized.

Results

In order to determine the baseline abilities of the Sambas district handball team players and to provide comparison data for the final assessment, this research began with the collection of initial pretest data on the strength and speed of the players. Table 1 and Figure 2 give the results of the descriptive statistical analysis, which indicate a mean pretest score of 19.93 and a mean posttest score of 22. These findings show a change between pretest and posttest values, supporting the notion that plyometric activities are beneficial.

Table 2.
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

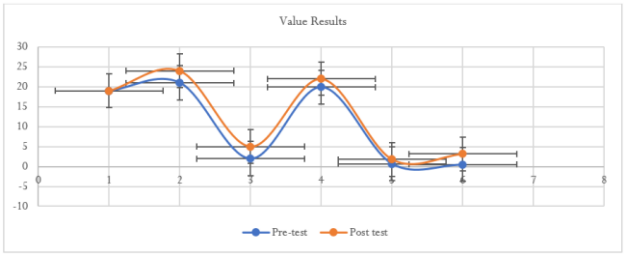

Figure 2. Differences in Pretest and Posttest Value Results

Table 3.
Kolmogorov Smirnov normality test results

Result	Shapiro-Wilk		
	Statistic	df	Sig.
Pretest Throwing Strength	0.897	15	0.085
Posttest Throwing Strength	0.847	15	0.116

Table 4.
Findings from the statistical analysis of the paired sample T-test

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

The one-sample Shapiro-Wilk formula was used to perform a normality test and acquire the data analysis results. The findings show that the residual values have a normal distribution and a significance value of p>0.05, which permits the effect test (t-test) to be conducted. Table 3 provides the full set of results. Table 4 presents results that support statistical significance with a significance value of 0.000, less than 0.05. These results indicate that plyometric activities are an excellent way to increase the strength and speed of handball throws.

Discussion

This study aims to assess how plyometric training affects the force and speed of ball throws in handball matches. The findings showed that plyometric training significantly increased the throwing length of handball games. Plyometric exercises capitalize on the force and speed generated by rapidly accelerating body weight against gravity, effectively enhancing various sports movements such as jumping, running, and throwing, making them more dynamic and explosive compared to traditional weight training.

These results are consistent with previous research by Bal et al., (2011),which also underscores the positive impact of plyometric training on athletes' physical performance. Similarly, Ramirez-Campillo et al., (2020) confirm that plyometric workouts can considerably increase basketball players' muscle strength, balance, and explosive power. Research by van den Tillaar et al., (2015) demonstrates that short-term plyometric training can enhance physical performance, including strength and speed, in youth soccer players. Additionally, Teo et al., (2016) highlight the efficacy of plyometric training in increasing jump height due to its force profile, speed, and consistent motion pattern.

Because plyometric training makes use of the stretch-shortening cycle (SSC) principle, it is highly advised for handball players looking to increase their strength. According to this theory, kinetic energy is produced during the concentric contraction phase from elastic potential energy during the eccentric contraction phase (Ramirez Campillo et al., 2020). Strength gains are often seen early in a training cycle that begins with a plyometric-focused mesocycle (Dietz & Peterson, 2012). Regular plyometric training also improves muscle tolerance to significant eccentric loads and enhances the effectiveness of stretching cycles (Spieszny & Zubik, 2018).

Plyometric training usually results in increased muscular coordination and movement skills for adolescent handball players (Yasumitsu et al., 2011; Zech et al., 2010). Plyometric exercises involve rapid muscle extension followed by contraction, aiming to maximize strength in the shortest time (Kayantas & Soyler, 2020; Michailidis, 2015; Razaimanesh et al., 2011). These exercises improve muscle strength and speed, which are crucial for a variety of athletic activities. They also make it easier to stop and start movements and change directions quickly (Akinbiola & Yekeen, 2022). Studies indicate that the integration of strength training and plyometric exercise improves muscular strength, leg strength, and vertical jump performance (Slimani et al., 2016; Suresh et al., 2020).

A common challenge in strength training programs is determining the appropriate weight intensity (Abuajwa et al., 2022; Suryadi, Komaini, et al., 2024; Suryadi, Nasrulloh, et al., 2024; Suryadi, Susanto, et al., 2024). Therefore, the intensity and type of training methods must be adapted to specific movement patterns like throwing a handball (Petruzela et al., 2023). Strengthening the motor program by conditioning neuromuscular and nerve adaptations of muscle spindles, golgi-tendon organs, and proprioceptors is essential ((Aman et al., 2015). Core training, especially in the early stages for youth players, can improve muscle stability and coordination (Jebavy et al., 2020; Jebavý et al., 2013). Studies show that core training in female adolescents can slightly enhance throwing speed (Saeterbakken et al., 2011). Other research indicates that endurance training can increase throwing speed without compromising accuracy (Bragazzi et al., 2020). Random repeated sprint training has been found to have a significant positive impact on jump shots and a moderate effect on standing throws (Petruzela et al., 2023). Sprinting, a form of high-intensity power, enhances jumping performance and influences ball throwing (Saavedra et al., 2019).

Athlete fitness is another aspect that affects throwing speed and might cause tiredness. There is no set recovery period to guarantee that weariness has no influence on throwing speed, according to a study looking at how it affects throwing speed in between game rounds (Zapardiel Cortés et al., 2017). It can be advantageous to take exhaustion into account while doing speed tests (Iacono et al., 2016). The capacity to apply high speed to the ball during throws is linked to the development of strong anaerobic power in the upper limbs and trunk, making it a critical offensive aspect influencing player performance (Debanne & Laffaye, 2011, 2013). In addition, some influencing factors include the use of supplements (Stefanska et al., 2024; Stefańska et al., 2024).

Conclusions

The findings of this study, as discussed throughout, are reinforced by the results and discussion section. The results showed that pliometric training significantly improved handball throwing power and speed. Specifically, the study confirmed that plyometric training is highly effective in improving the length of Medicine Ball throws. Continuous application of plyometric training will result in consistent improvements in these areas. Coaches and field instructors should create training plans that foster discipline in athletes for the best possible outcomes. The results of this study, however, are limited to young handball players who play in the short season, which has certain constraints. The length of the training season as a whole, as well as variables like exercise intensity, duration, and repetition, can all affect the results. In light of these drawbacks, the study suggests combining strength training methods with plyometric training to fully prepare the muscles of athletes and increase their speed and endurance.

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Conflict of interest

A conflict of interest does not exist.

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