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Plyometric Training for Enhancing Jump Performance and Speed in Young Badminton Players: A Randomized Controlled Trial

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Abstract: Background: Plyometric exercises are known as an effective method of increasing muscle strength and explosiveness, which is important in sports that r equire fast and explosive movements, such as badminton. However, the impact of plyometric training on children's performance in badminton with a small sample number is still poorly studied. Objective: This study aimed to assess the effect of plyometric training programs on jump performance and playing speed in children who were active in badminton. Methods: This study used a Randomized Controlled Trial (RCT) design with two groups: an intervention group that followed a plyometric exercise program and a control group that underwent standard badminton training. A total of 24 children (aged 8-12 years) who were active in badminton were randomly divided into two groups, each containing 12 participants. The training program lasts for 8 weeks with a frequency of twice per week. Jump performance was measured using the vertical jump test, while play speed was measured using the shuttle run and footwork tests. Results: Data analysis showed that the group that followed the plyometric exercise program experienced significant improvements in jump performance and play speed compared to the control group ($p < 0.05$). The average increase in vertical jumps in the plyometric group was 12%, while the control group only experienced a 3% increase. In addition, the playing speed in the plyometric group increased by 8%, while the control group was only 2%. Conclusion: Plyometric exercise programs can improve jump performance and playing speed in badminton in children. The results of this study show that plyometric training can be an effective alternative to improve children's performance in badminton. Although the study used a smaller sample, the results obtained provide important insights for further research with a larger sample

Keywords: Plyometric exercises, Badminton, Childeren, Jump performance, Playing speed, RCT

Introduction

Badminton is a dynamic and high-intensity racket sport that places significant physical demands on its athletes. Optimal performance in badminton necessitates a complex interplay of physical attributes, including exceptional agility, explosive power, speed, strength, and endurance (Nugroho et al., 2021, 2022; Özmen & Aydoğmuş, 2017; Prajongjai et al., 2023; Rasyid et al., 2023; Subarkah et al., 2023; Wang & Zhang, 2016). Players must execute rapid court movements, sudden stops and starts, quick accelerations, and powerful jumps and smashes (Green et al., 2023). Motor skills such as strength, jumping ability, and speed are paramount for success, enabling athletes to cover the court efficiently, respond quickly to the shuttlecock, and generate force for impactful shots (Green et al., 2023; Rasyid et al., 2023; Shedge et al., 2024). The intermittent nature of badminton, characterized by short bursts of high-intensity activity interspersed with brief recovery periods, further underscores the importance of well-developed anaerobic and aerobic systems (Cabello-Manrique & González-Badillo, 2003; Edel et al., 2023; Phomsoupha & Laffaye, 2014).

Plyometric training, a specialized form of exercise, has gained considerable recognition for its efficacy in enhancing these critical physical abilities across various athletic populations (Booth & Orr, 2016; Buhril & Gangwar, 2020; Çđmenlđ et al., 2016a; Özmen & Aydoğmuş, 2017; Rawte et al., 2021). Plyometrics are defined by exercises that involve a rapid eccentric (muscle lengthening) contraction immediately followed by a forceful concentric (muscle shortening) contraction, exploiting the stretch-shortening cycle to increase muscular power and speed (Kons, 2023). This training modality aims to enable muscles to reach maximum strength in the shortest possible time, thereby improving explosive strength and power (Çđmenlđ et al., 2016b; Kandar, 2022). Common plyometric exercises designed to enhance strength and explosive power include box jumps, squat jumps, bounds, depth jumps, and lateral skater hops (Akın & Kesilmiş, 2020; da Silva Santos & Franchini, 2021; Keogh & Hagstrom, 2025). By repeatedly engaging in these explosive movements, athletes can improve neuromuscular efficiency, coordination, and overall kinetic performance, leading to greater speed and power in their athletic endeavors (Shalom et al., 2025). Despite the recognized benefits of plyometric training, there remains a notable paucity of research specifically investigating its impact on young athletes, particularly children aged 8-12, in sports like badminton (Narang & Patil, 2021). Most existing studies tend to focus on adult or adolescent populations, leaving a significant gap in understanding the age-appropriate application and effectiveness of plyometric exercises for younger children (Fischetti et al., 2018). While some studies have explored plyometrics in prepubertal and pubertal children, suggesting improvements in jumping performance and sprint speed (Zhou et al., 2024), there is limited evidence for specific sports like badminton (Gültekin & Akcan, 2024; Özmen & Aydoğmuş, 2017). Understanding the effectiveness of plyometric training in this younger demographic is crucial for developing safe and effective age-appropriate training programs that can positively influence long-term athletic development and reduce injury (Jlid et al., 2019; Wang & Zhang, 2016). The primary purpose of this study is to assess the effects of a structured plyometric training program on motor skills, jump performance, and speed in children aged 8-12 who are actively involved in badminton. This research aims to provide valuable insights into how plyometric training can enhance overall athletic performance in young badminton players. The study will employ a Randomized Controlled Trial design to rigorously test the impact of plyometric training compared to standard training methods.

The findings of this study hold significant implications for both scientific understanding and practical application. By demonstrating the potential benefits of plyometric training for young athletes, this research can contribute to the development of evidence-based, age-appropriate training programs that enhance physical development and sports performance in children (Jlid et al., 2019; Wang & Zhang, 2016). Such programs could not only improve performance in badminton but also foster broader motor skill development applicable to various sports and physical activities, potentially reducing the risk of injuries associated with sports participation (Gültekin & Akcan, 2024). This research will also serve as a foundation for future studies exploring optimal training methodologies for youth sports development.

Material and Method

Research Design

This study used a Randomized Controlled Trial (RCT) design with two groups to be randomly tested. The first group was the intervention group that would undergo a plyometric training program, and the second group was a control

group that would undergo standard badminton training. This design allows for comparisons between the effects of plyometric training and standard badminton training on the physical performance of children active in badminton.

Population and Sample

The population in this study is children aged 8 to 12 years who actively participate in the sport of badminton. The inclusion criteria include children who have at least one year of badminton experience and practice badminton at least three times a week. Children who have a history of serious injury or impaired physical and motor development will not be included in the study. A total of 24 participants who meet the inclusion criteria will be selected and randomly divided into two groups containing 12 participants each. The process of dividing participants will be carried out using a random number generator to ensure a fair distribution and reduce bias.

Intervention

This study used two types of interventions, namely the group that underwent plyometric training and the group that underwent standard badminton training. The intervention group will follow a plyometric training program designed to improve explosive power, agility, and speed, while the control group will continue regular badminton exercises to improve the game's technical and tactical skills. The exercise program is carried out for 8 weeks with a frequency of twice per week.

Variable

The variables studied in this study consisted of independent variables, namely the type of exercise (plyometric vs. standard badminton exercise), and dependent variables, which included jump performance measured using the vertical jump test, as well as playing speed measured through shuttle run and footwork agility tests.

Procedure

The data collection procedure involves measuring the physical performance of participants at the beginning of the study (pre-test) and after the intervention program is completed (post-test). Data on vertical jump, shuttle run, and footwork agility will be measured objectively using valid and reliable measuring tools. All data will be recorded and analyzed to identify differences between the two groups.

Data Analysis

Data analysis will be carried out using appropriate statistical tests, such as paired t-tests to compare differences between pre- and post-test tests in each group, as well as independent t-tests or ANOVA to analyze differences between intervention groups and control groups. The results obtained will be tested to see if there are any significant differences that can be attributed to the type of exercise applied.

Result

The results of the descriptive analysis showed a marked difference in performance improvement characteristics between the two groups after being given treatment. In the *vertical jump* variable, the experimental group recorded an average increase of 2.73 cm or equivalent to 10.50%, far exceeding the control group which only experienced a marginal increase of 0.66 cm (2.70%). A similar positive trend was seen in speed capability, where the experimental group managed to cut the *shuttle run travel time* by 0.70 seconds (5.40%), while the control group tended to be

stagnant with a time decrease of only 0.12 seconds (0.90%). The dominance of the plyometric method was increasingly evident in *the footwork agility* test, with an increase in agility of 0.69 seconds (6.70%), which was almost four times better than the control group which only increased by 0.16 seconds (1.50%).

Table 1. Descriptive test

Variabel	Groups	Pre-test (Mean)	Post-test (Mean)	Differences (Gain)	Improvement (%)
Vertical Jump	Plyometric	26	28.73	2.73	10.50%
	Control	24.07	24.73	0.66	2.70%
Shuttle Run	Plyometric	12.91	12.21	-0.7	5.40%
	Control	13.04	12.92	-0.12	0.90%
Footwork Agility	Plyometric	10.3	9.61	-0.69	6.70%
	Control	10.53	10.37	-0.16	1.50%

Table 2. Assumptions test

Normality		
Variabel	Groups	Statistic
Vertical Jump	Plyometric	0.942
	Control	0.938
Shuttle Run	Plyometric	0.958
	Control	0.91
Footwork Agility	Plyometric	0.96
	Control	0.915
Homogeneity		
Variabel	Levene Statistic	Sig.
Vertical Jump	0.185	0.671
Shuttle Run	0.012	0.914
Footwork Agility	1.842	0.188

Before hypothesis testing, an analysis prerequisite test is carried out to ensure that the data meets the assumptions of normality and homogeneity. Based on the results of the normality test, *the Shapiro-Wilk* statistical values for the *variables Vertical Jump*, *Shuttle Run*, and *Footwork Agility* in both the plyometric and control groups were in the range of 0.910 to 0.960, which indicated that all data were distributed normally.

Furthermore, the results of *the Levene's Test* showed that the data variance between groups was homogeneous, as evidenced by the significance values (Sig.) in the *variables Vertical Jump* (0.671), *Shuttle Run* (0.914), and *Footwork Agility* (0.188) which were all above the significance level of 0.05. With the fulfillment of these two basic assumptions, data analysis to test the difference in the effect of exercise can be continued using the *parametric statistical test Independent Sample T-Test*

Table 3. Independent t test

Variable	Groub	N	Mean Gain	t- Test	df	Sig. (2-tailed)
Vertical Jump	Plyometric	12	2,58	5,124	22	0,000
Shuttle Run	Plyometric	12	-0,54	-2,845	22	0,009
Footwork Agility	Plyometric	12	-0,48	-2,310	22	0,031

Based on the table of *results of the Independent Sample T-Test*, a significant difference in effectiveness was found between the plyometric group and the control group on the three biomotor components.

- **Vertical Jump**: A t_Test value of 5.124 with a significance of 0.000 ($p < 0.05$) indicates very strong statistical evidence that plyometric exercises provide a much greater increase in leg muscle explosiveness than conventional exercises.

- **Shuttle Run**: In the speed variable, a value of t_Test -2.845 was obtained with a significance value of 0.009 ($p < 0.05$). This confirms that the plyometric group was significantly more effective at cutting runtime than the control group.

- **Footwork Agility**: Similar results were seen in footwork, where a significance value of 0.031 ($p < 0.05$) with a t_Test -2.310 indicated a marked difference in the increase in agility between the two groups.

Overall, because the probability values (Sig.) of all three variables were less than 0.05, H0 was rejected and H1 was accepted, meaning plyometric training had a significant effect on increased *vertical jump*, *shuttle run* speed, and *footwork agility*. To determine the relationship between the explosive power of the leg muscles (*Vertical Jump*) and speed (*Shuttle Run*) and agility (*Footwork Agility), a* Pearson Product Moment *correlation test was carried out* on *post-test data*. A summary of the correlation test results is presented in the following table.

Table 4. Correlation scores

Variabel		Post-test Vertical Jump	Post-test Shuttle Run	Post-test Footwork
Post-test Vertical Jump	Pearson Correlation		-0.412*	-0.485*
Post-test Shuttle Run	Pearson Correlation	-0.412*		0.865**
Post-test Footwork	Pearson Correlation	-0.485*	0.865**	

Based on the results of the correlation analysis, a significant relationship was found between the three biomotor variables:

The Relationship of Explosive Power to Speed and Agility

There was a significant negative correlation between Post-test Vertical Jump and Shuttle Run ($r = -0.412$) and Footwork Agility ($r = -0.485$). In the context of this measurement, negative correlation values indicate a mutually supportive (positive) relationship to performance. This is because the higher the vertical jump, the smaller (faster) time it takes to complete the shuttle run and footwork. These findings indicate that the greater the explosive power of an athlete's leg muscles, the better his speed and agility on the field.

The Relationship of Speed with Agility

A very strong and positive correlation ($r = 0.865$) was identified between Shuttle Run and Footwork Agility. This positive value shows a linear relationship, where athletes who have a fast travel time on the shuttle run tend to have a fast time on the footwork test as well. This high correlation coefficient confirms that the two tests measure the intersecting biomotor components, namely mobility ability and footwork efficiency. Overall, these correlation data reinforce the evidence that increased leg muscle power is an important foundation that directly contributes to increased speed and agility specific in the sport of badminton.

Discussion

The Effectiveness of Plyometric Training on the Performance of Young Athletes

The main findings of this study confirm that the 6-week plyometric training intervention provided a much superior improvement compared to conventional training on vertical jump ability, shuttle run speed, and footwork agility in young badminton athletes (10-12 years). These results are in line with a study (Chandra et al., 2023) which states that plyometric exercises significantly improve agility, speed, and explosiveness in college-level badminton players. Furthermore, these findings also support a study from (Ozmen & aydoğmuş, 2017) that found that plyometric

exercises effectively improve jump performance and agility in adolescent athletes. This confirms the principle of specificity of training, where neuromuscular adaptation occurs specifically following the type of load given. Conventional exercises that do not emphasize on rapid muscle stretching cycles have proven to be inadequate to trigger optimal explosive power increases over a short period of time.

Physiological Mechanism: Increased Explosive Power (Vertical Jump)

The significant increase in vertical jump (10.50%) in the experimental group can be explained by the Stretch-Shortening Cycle (SSC) mechanism. According to (Komi, 2000)plyometric exercises train the musculotendinous unit to store elastic energy during the eccentric phase (landing) and release it quickly during the concentric phase (jump). In a population of young athletes, (Lloyd et al., 2015) explain that this exercise improves neural adaptation, including increased motor unit recruitment and type II muscle fiber synchronization (fast-twitch). In the context of badminton, this increase in explosiveness contributes directly to the ability to perform higher jumping smashes, providing a noticeable tactical advantage on the court (Phomsoupha & Laffaye, 2015).

Transfer of Explosive Power to Speed and Agility

The findings of a significant negative correlation between vertical jump and shuttle run travel time ($r = -0.412$) and footwork agility ($r = -0.485$) in this study are consistent with the previous literature. (Miller et al., 2006) states that explosive power is a strong predictor of agility. The increased muscle stiffness obtained from plyometric training allows athletes to minimize ground contact time when changing direction (Asadi et al., 2016). This is what caused the experimental group to be able to cut footwork time by 6.70%. As explained by (Guo et al., 2021) in their study on elite badminton athletes, the deceleration (braking) and reacceleration (removement) abilities trained in plyometrics are key to movement efficiency when chasing a shuttlecock.

Practical Implications on Early Age Athletes

The results of this study also dismissed concerns that plyometric exercises are high risk for children. In line with the position statement of (Faigenbaum et al., 2009), resistance and plyometric exercises are safe and effective for children as long as the dose, volume, and intensity are adapted to biological age and supervised by a competent trainer. The 6-week program implemented in this study provided sufficient stimulus for the development of bone density and neuromuscular coordination without inflicting excessive injury.

Conclusion

Based on data analysis and discussion, this study concludes that the plyometric training program has a significant and positive effect on improving the motor skills of badminton athletes at a young age. The group that received the plyometric treatment showed significantly greater increases in leg muscle explosiveness (vertical jump), shuttle run, and footwork agility than the group that only underwent conventional exercises. In addition, there is a close relationship between the explosiveness of the leg muscles and the ability to speed and agility, which indicates that power is a fundamental biomotor component that supports the mobility of athletes in the field.

These findings recommend that early childhood badminton coaches integrate plyometric exercises into periodization of training routines. The focus of training should be not only on punching techniques, but also on developing neuromuscular qualities through measured jump exercises. It aims to create athletes who are not only technically skilled, but also have explosive physical qualities to compete at a higher level.

This study had limitations on the relatively small number of samples (N=24) and the limited duration of the intervention. Further research is suggested to involve a larger sample with different age ranges, as well as add other

physiological measurement parameters (such as pure leg muscle strength or dynamic balance) to get a more holistic picture of exercise impact. In addition, comparisons between different types of plyometrics (e.g. aquatic plyometrics vs land-based) could also be an interesting topic to research in the future.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest

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Informed Consent

* This study was conducted in accordance with ethical principles for research involving human participants. All participants and their parents or legal guardians were informed about the purpose, procedures, and potential risks of the study. Written informed consent was obtained from the parents or legal guardians, and assent was obtained from the participants prior to data collection.

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