Jurnal SPORTIF: Jurnal Penelitian Pembelajaran
Vol. 11 No. 3, December 2025, pp. 399 - 419
https://doi.org/10.29407/js_unpgri.v11i3.26960

Enhancing Footwork Performance in U-21 Male Badminton Athletes: The Impact of Combined Plyometric and Shadow Training

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Received: 15 April 2025; Revised: 29 May 2025; Accepted: 9 October 2025; Available online: 31 December 2025.

Abstract

Badminton is a high-intensity sport that requires excellent footwork, agility, and explosive movements. Footwork techniques are essential for positioning the body to execute optimal strokes, and deficiencies in this area can negatively affect performance. Plyometric training improves lower-body power and quickness, while shadow training enhances movement patterns and court positioning. Combining these two methods may significantly improve footwork performance, particularly among under-21 male athletes, yet this approach remains underexplored. This study examined the effect of combined plyometric and shadow training on the footwork ability of badminton athletes. A quasi-experimental one-group pretest–posttest design was used, involving fifteen under-21 male badminton athletes from Universitas Negeri Padang selected through purposive sampling based on inclusion criteria of being active, under-21, and injury-free. Participants completed sixteen training sessions of combined plyometric and shadow exercises. Footwork ability was measured before and after the intervention using the validated six-way footwork test with a shuttlecock, recorded manually with a stopwatch. Data were analyzed using SPSS 26, applying normality and homogeneity tests followed by a paired-sample t-test. The results showed a significant improvement in footwork performance ($p < 0.05$), with most athletes shifting from “poor” in the pretest to “good” or “excellent” classifications in the posttest. These findings demonstrate that the combined training effectively enhanced agility, coordination, and movement efficiency. In conclusion, the integration of plyometric and shadow training provides an effective and engaging approach for improving badminton athletes’ footwork ability and can be recommended for coaches aiming to optimize player performance.

Keywords: Movement coordination, footwork, badminton, plyometrics, shadow.

How to Cite: Arnando, M., Ihsan, N., Syafruddin, Okilanda, A., & Ockta, Y. (2025). Enhancing Footwork Performance in U-21 Male Badminton Athletes: The Impact of Combined Plyometric and Shadow Training Muhammad Arnando. Jurnal SPORTIF : Jurnal Penelitian Pembelajaran, 11(3), 399–419. https://doi.org/10.29407/js_unpgri.v11i3.26960

Authors contribution: a – Preparing concepts; b – Formulating methods; c – Conducting research; d – Processing results; e – Interpretation and conclusions; f - Editing the final version.

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INTRODUCTION

Badminton is one of the most popular racket sports worldwide, particularly in Indonesia, where it continues to develop in both recreational and competitive contexts (Ardha et al., 2024; Supriyanto et al., 2022). As a high-intensity sport, badminton requires a combination of agility, muscular strength, and inter-limb coordination for athletes to perform effectively (Li et al., 2023; Marin et al., 2023). Lower-limb strength supports explosive actions such as lunges, jumps, and quick recoveries after each shot (Radulović et al., 2022). At the same time, coordination ensures the synchronization of upper and lower body movements to maintain balance and accuracy during rapid rallies (Saini et al., 2025).

Among these physical components, footwork plays a pivotal role in determining performance. It allows athletes to move efficiently across the court, reach the shuttlecock on time, and position their bodies for precise and powerful strokes (Pratama et al., 2024). Effective footwork depends on technical mastery and agility, speed, and explosive power—attributes that enable athletes to respond to the shuttlecock's unpredictable trajectory with balance and control (Hu et al., 2023; Luo et al., 2022). Badminton requires constant multidirectional movement—covering the court to intercept the shuttlecock, returning to the base position, and preparing for the next shot (Donie et al., 2023). This sequence demands high levels of physical readiness and coordination between the eyes, hands, and feet (Ghosh et al., 2024). Even minor footwork errors, such as mistimed steps or delayed movements, can disrupt body alignment and reduce shot accuracy (Li et al., 2023; Shimizu & Yamada, 2024). Therefore, mastering footwork is fundamental for every badminton player, as it forms the foundation of both offensive and defensive performance (Chiu et al., 2020; Wang et al., 2024; Supriyanto et al., 2022).

Training methods such as plyometric and shadow training are commonly used to improve footwork in badminton. Plyometric training has been shown to significantly enhance lower limb explosive power, agility, and quick directional changes, which are essential for badminton footwork

(Panda et al., 2022; Alvarez et al., 2021; Ethiraj et al., 2024). Meanwhile, shadow training is an established method in racket sports, helping athletes to simulate actual game movements without a shuttle, thereby refining movement efficiency, anticipation, and rhythm (Pratama et al., 2024).

To perform these basic badminton techniques effectively, athletes must also possess good physical condition because, during badminton matches, they rely heavily on strength, speed, agility, endurance, and coordination (Kuo et al., 2022). Therefore, by having a high level of physical conditioning, athletes can increase confidence during matches and maximize the implementation of technical and tactical skills. These aspects of physical condition are very important because in badminton, players must perform complex movements such as jumping, fast movements to chase the shuttlecock, turning the body, and stepping wide to maintain body balance (Phytanza et al., 2021). Based on this, it is clear that there are four factors for achievement: physical condition, technique, tactics, and mentality. In other words, many factors influence sporting success.

Several footwork movements in badminton include the split-step, running steps, chase, cross-behind, hop/pivot, lunge, jump, and landing (Lam et al., 2017). Because many footwork patterns are performed depending on shuttlecock placement and stroke type, mastering these requires systematic and repetitive training programs designed specifically to improve the athlete’s ability. The main problem in badminton footwork is maintaining speed, precision, and balance during quick multidirectional movements. Badminton requires rapid changes that challenge stability and coordination (Ma et al., 2024). Fatigue can further slow reactions and increase positioning errors, negatively affecting anticipation and movement efficiency (Abdollahi et al., 2022).

In badminton, there are various methods and training models that can enhance an athlete's footwork skills, including shadow training, plyometrics, shuttle runs, skipping, and ladder drills (Arnando et al., 2024; Pratama et al., 2024). If training is repeated in the same format every session, athletes may experience fatigue or a decrease in motivation due to

https://doi.org/10.29407/js_unpgri.v11i3.26960
11 (3) 2025| 399-419

ISSN : 2477-3379 (Online)
ISSN : 2548-7833 (Print)

a lack of variety (Suchomel et al., 2021). Based on this, combining plyometric exercises with shadow training is expected to improve footwork while also adding variety to each training session. Plyometric training has been proven to enhance explosive power, speed, and agility, which are essential for quick directional movements in badminton (Permana et al., 2022). On the other hand, shadow training improves agility, coordination, and anticipation by simulating real-game footwork patterns without shuttle interaction. Combining both methods prevents monotony and fatigue in practice, while providing a sport-specific approach that prepares athletes more effectively for match conditions.

In badminton, shadow training often involves picking up and placing the shuttlecock at the edges of the court, then moving to mimic shadow movements to each corner of the court. The purpose of this training is to improve agility and speed in movement, helping athletes become accustomed to moving quickly to different corners of the court in response to the game's situation (Ihsan, Nasrulloh, Nugroho, & Yuniana, 2024; Pratama et al., 2024). Through this exercise, athletes move to every corner of the court, helping them develop quick reaction patterns during matches. This exercise is carried out similarly to an actual game situation, where the athlete moves to each corner to strike the shuttlecock according to the intended direction (Malwanage et al., 2022). This training must be done regularly during practice so that athletes can develop proper rhythm and reaction timing when responding to the shuttlecock during actual gameplay.

Plyometric training is a key exercise method for improving badminton footwork, as it focuses on developing explosive strength and agility through rapid eccentric and concentric muscle contractions known as the stretch-shortening cycle (Kurt et al., 2023). This mechanism enhances the storage and release of elastic energy, resulting in faster and more powerful movements (Loturco et al., 2023). Effective footwork in badminton requires quick acceleration, deceleration, and multidirectional changes—all of which are supported by the biomechanical benefits of plyometric training. Previous studies have shown that plyometric exercises significantly improve lower-

https://doi.org/10.29407/js_unpgri.v11i3.26960
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limb power, speed, agility, and vertical jump ability, which are essential for executing lunges, side-steps, and quick recoveries during rallies (Akbar et al., 2024; Daneshjoo & Raeisi, 2020; Longakit et al., 2025). By enhancing neuromuscular efficiency and increasing force output, athletes can perform more efficient push-offs and maintain balance during high-intensity movements (Kang, 2018). When combined with shadow training, plyometrics build explosive power and simulate realistic footwork patterns, helping athletes refine rhythm, coordination, and anticipation on the court (Ihsan, Nasrulloh, Nugroho, & Yuniana, 2024). Therefore, integrating plyometric and shadow exercises provides a comprehensive approach to developing physical strength and movement precision essential for efficient badminton footwork.

This synergy of exercises directly supports better footwork, allowing players to position themselves and respond faster to in-game situations efficiently. Footwork in badminton is crucial for quick, precise movements, as athletes must react explosively to the shuttlecock's trajectory, which can be effectively trained through targeted conditioning. While plyometric exercises are known to enhance agility, vertical jump, and explosiveness, shadow training improves body positioning and movement efficiency. Therefore, the integration of these training methods provides a comprehensive approach that significantly improves footwork by boosting speed, agility, and responsiveness during play.

In addition to shadow training, plyometric exercises have been empirically shown to improve badminton footwork by enhancing lower-limb explosive power, jump performance, and agility. For instance, Reinoso et al. (2024) demonstrated that plyometric training significantly increased athletes' change-of-direction speed, while Lu et al. (2022) reported improvements in vertical jump and rapid lateral movement—both critical for covering the court efficiently. These results highlight that plyometric training develops general physical qualities and directly supports the agility and quick directional changes required in badminton footwork. Shadow and plyometric exercises differ in form but aim to enhance agility and jumping

https://doi.org/10.29407/js_unpgri.v11i3.26960
11 (3) 2025| 399-419

ISSN : 2477-3379 (Online)
ISSN : 2548-7833 (Print)

ability, which are crucial in badminton. The game demands quick directional changes, vertical jumps, lunges, and dynamic body positions performed repeatedly at high intensity. Thus, this study aims to examine the combined effect of plyometric and shadow training on improving badminton players' footwork ability.

METHOD

This study employed an experimental approach aimed at examining the impact of combining plyometric and shadow training on improving badminton footwork. The research sought to identify new phenomena while controlling external influences that could affect performance outcomes. The study used a true experimental pretest–posttest control group design, while also applying a one-group pretest–posttest format to observe changes in athletes' footwork performance after the intervention. Participants were divided into an experimental group, which received 8 weeks of plyometric and shadow training (three sessions per week), and a control group, which continued with regular training. This design enabled direct comparison between pretest and posttest results, allowing the researchers to determine the effectiveness of the combined plyometric and shadow training program in enhancing agility, movement efficiency, and footwork ability among badminton athletes.

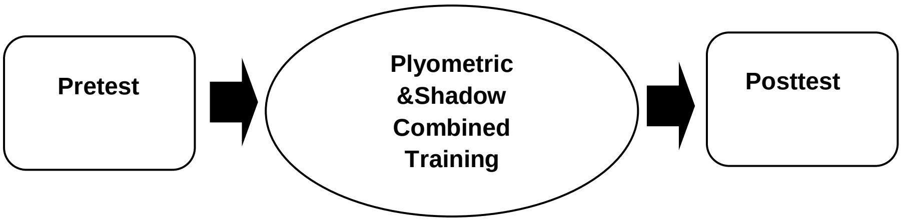

Figure 1. Study Design

The population in this study consisted of 15 male badminton athletes aged under 21 from Universitas Negeri Padang. These athletes were actively engaged in competitive badminton training at the university level. The sample in this study included the entire population using a total sampling technique, meaning that all population members were selected as participants. The sampling process followed a purposive approach to

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ensure that participants met specific inclusion criteria—male, under 21 years of age, actively training, and injury-free during the research period. The 15 participants represented the entire population of eligible athletes within the badminton club of Universitas Negeri Padang.

Footwork ability was measured using standardized badminton-specific tests: the shuttle run, four-corner footwork test, and lunge recovery test. These tests assessed agility, coordination, speed, and precision in reaching different court positions. The tests were performed before and after the intervention to evaluate improvement in footwork ability. Participants' performances were timed manually and evaluated based on speed, movement control, and directional accuracy. The collected data reflected each athlete's ability to perform badminton-specific footwork movements such as acceleration, deceleration, and rapid directional changes on the court.

This research was conducted over three months at the Badminton Field of Universitas Negeri Padang. The study began with a pretest to assess baseline footwork ability among all participants. Following the pretest, athletes in the experimental group participated in a combined plyometric and shadow training program for eight weeks, consisting of three sessions per week and sixteen training sessions. Each session integrated plyometric drills such as jump training, bounding, and hopping exercises to develop lower-limb explosive power and quick directional changes, along with shadow movements simulating actual badminton gameplay to improve coordination and anticipation. The control group continued their regular training routines during the same period.

The sixteen-session duration was determined based on prior research suggesting that interventions lasting between six and ten weeks, with two to three sessions per week, provide sufficient time for athletes to experience measurable improvements in agility, speed, and explosive power (Malwanage et al., 2022). This schedule was designed to ensure consistent practice and adequate adaptation to the combined training load, thereby enhancing the athletes' performance. The implementation process was

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monitored during the training sessions to ensure proper technique and consistency. After completing the intervention period, all participants underwent a posttest using the same footwork ability tests as in the pretest to measure improvement.

The pretest and posttest data were analyzed using SPSS version 26. Descriptive statistics were used to summarize participants' footwork scores at both stages, including mean and standard deviation values. Before inferential testing, normality and homogeneity tests were conducted to ensure that the data met the assumptions required for parametric analysis. To examine changes within groups, a paired-sample t-test was employed to determine whether there was a statistically significant difference in footwork ability before and after the training intervention. Additionally, an independent-sample t-test was applied to compare differences between the experimental and control groups. The significance level was set at $\alpha = 0.05$.

This analytical procedure was used to evaluate whether the combined plyometric and shadow training could significantly improve agility, speed, and explosive movement, while enhancing movement efficiency and positional accuracy during badminton play. The three-month duration with three sessions per week was chosen to provide sufficient training adaptation, consistent monitoring, and measurable outcomes that reflect the effectiveness of integrating both training techniques for enhancing athletic performance in badminton.

RESULT

The following tables present the footwork ability data for badminton athletes at Universitas Negeri Padang. The data consists of results from pretest and posttest measurements, comparing footwork skills before and after the training intervention. The analysis includes normality tests to ensure data validity, a homogeneity test to confirm equal variances, and a hypothesis test (t-test) to determine if the training significantly affected the athletes' performance.

Data Description

Descriptive statistics provide an overview of the minimum, maximum, mean, and standard deviation of the athletes' scores. This step allows us to understand the central tendency and variability of the data, giving context to how the values are distributed within the sample. By providing descriptive statistics, the subsequent classification using interval tables can be better interpreted in relation to the overall data pattern. For more details, you can see Table 1 below:

Table 1. Descriptive Statistics of Footwork Ability Data

Variable	N	Min	Max	Mean	Std. Deviation
Pretest Footwork	15	13.77	15.98	14.92	0.55
Posttest Footwork	15	12.95	15.12	14.20	0.61

The footwork ability data is presented using interval classes to categorize athletes' performance levels. This method helps group continuous data into manageable categories, making interpreting and comparing pretest and posttest results easier. Using interval classes allows us to identify trends in the athletes' abilities and assess the impact of the training intervention more effectively. Therefore, the results were grouped using interval classes to make the distribution of scores clearer and easier to interpret. The interval classes allow for the categorization of performance levels (Excellent, Good, Medium, Poor, Very Poor) based on the observed score ranges. The data from the pretest are presented in terms of absolute frequency (Fa) and relative frequency (Fr%) across different interval classes. These interval classes represent ranges of footwork ability scores, categorizing participants into classifications such as "Excellent," "Good," "Medium," "Poor," and "Very Poor." The classification is based on the scores derived from the pretest, which helps assess the initial footwork abilities of the participants before the intervention. The interval class ranges were determined based on the distribution of the footwork scores to give a clear picture of the participants' abilities before the training began. For more details, see Table 1 and Figure 2.

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11 (3) 2025| 399-419

ISSN : 2477-3379 (Online)
ISSN : 2548-7833 (Print)

Table 2. Pretest Data of Footwork Ability

Interval Class	Fa	Fr (%)	Classification
< 13,77	0	0	Excellent
13,77 - 14,51	5	33	Good
14,51 -15,24	3	20	Medium
15,24 - 15,98	7	47	Poor
> 15,98	0	0	Very Poor
Total	**15**	**100**	

Note:
Fa: Absolute Frequency
Fr (%): Relative Frequency

The footwork ability test results were processed and presented using class intervals to categorize athletes' performance levels. This approach was chosen because the raw test scores are continuous, making them difficult to interpret directly. By grouping the scores into interval classes, the data become easier to analyze, compare, and interpret. The interval classes were constructed based on the observed score range of the sample, and were then classified into five categories: Excellent, Good, Medium, Poor, and Very Poor.

This method of data grouping is widely used in sports science research, especially when normative reference values are unavailable. The categorization provides a systematic way to identify trends, determine the majority level of athlete performance, and assess improvements after the intervention. Furthermore, presenting the data in interval form enables a clearer understanding of the frequency distribution and allows comparison between pretest and posttest results. Table 1 shows the frequency distribution of pretest scores of footwork ability, categorized according to the predetermined interval classes.

The table above shows the frequency distribution and percentage for the class intervals used in the assessment. Out of a total of 15 subjects, 33% fall within the interval 13.77 - 14.51, which is classified as "Good." 20% of the subjects have scores in the 14.51 - 15.24 range, categorized as "Medium." Meanwhile, 47% of the subjects are in the 15.24 - 15.98 interval, which is classified as "Poor." No subjects fall into the "Excellent" (<13.77) or "Very Poor" (>15.98) categories. Therefore, the majority of the subjects show results in the "Poor" and "Good" categories. For more details, see the diagram below:

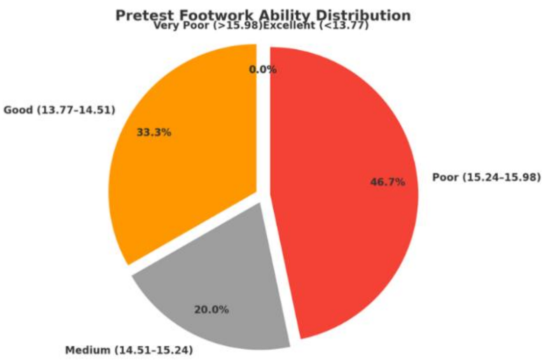

Figure 2. Pretest data of badminton athletes footwork

The data from the posttest are presented in terms of absolute frequency (Fa) and relative frequency (Fr%) across different interval classes. These classes represent the distribution of footwork ability scores of the 15 participants. The classification of scores is based on predetermined ranges that categorize the athletes' footwork ability as "Excellent," "Good," "Medium," "Poor," and "Very Poor." These classifications help to assess the improvement in footwork ability after the intervention, providing a clear comparison of the distribution before and after the training. For more details, see Table 2 and Figure 3.

Table 3. Posttest data on footwork ability

Interval Class	Fa	Fr (%)	Classification
< 13,02	2	13	Excellent
13,02 - 13,62	3	20	Good
13,62 -14,22	6	40	Medium
14,22 - 14,82	4	27	Poor
> 14,82	0	0	Very Poor
Total	**15**	**100**	

Note:

Fa: Absolute Frequency

Fr (%): Relative Frequency

Like the pretest results, the posttest data on footwork ability were also presented using class intervals. This method was applied to transform continuous posttest scores into categorical performance levels, thereby

https://doi.org/10.29407/js_unpgri.v11i3.26960
11 (3) 2025| 399-419

ISSN : 2477-3379 (Online)
ISSN : 2548-7833 (Print)

allowing for easier interpretation and comparison with the pretest results. The class intervals were determined based on the range of posttest scores observed in the sample. These were then classified into five categories: Excellent, Good, Medium, Poor, and Very Poor.

Presenting the posttest data in interval classes provides a clear visualization of how the distribution of athletes' performance changed after the training intervention. This approach makes it possible to identify not only the improvement or decline of individual categories but also the overall trend in the group's performance level. The frequency and percentage for each class interval are presented in Table 2.

The table above shows the frequency distribution and percentage for the class intervals used in the assessment. Out of a total of 15 subjects, 13% fall within the interval <13.02, which is classified as "Excellent." 20% of the subjects scored in the 13.02 - 13.62 range, categorized as "Good." Meanwhile, 40% of the subjects are in the 13.62 - 14.22 interval, which is classified as "Medium." 27% of the subjects fall within the 14.22 - 14.82 interval, classified as "Poor." No subjects fall into the "Very Poor" (>14.82) category. Therefore, the majority of the subjects show results in the "Medium" and "Poor" categories. For more details, it can be seen in the diagram below**:**

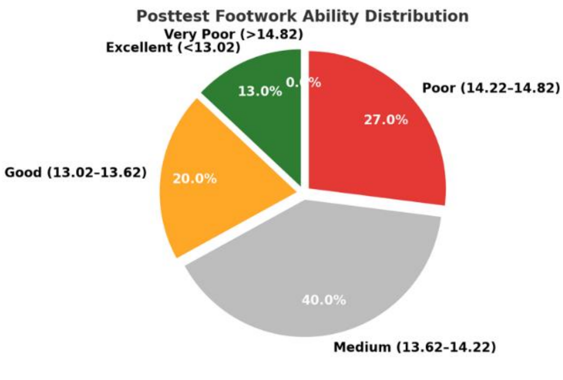

Figure 3. Posttest data of badminton athletes footwork

Normality Test

The results of the normality test L0 < Ltabel 0.20, then the data analysis is declared Normal with the provisions of the results of 15 samples of research subjects. For more details, please see Table 3.

Table 4. Pretest and posttest normality test

Group		N	Lo	Ltabel	Description
Plyometric & Shadow Combined Training	Pretest	15	0,195	0,220	Normal
	Posttest	15	0,135		

Homogenity Test

The data is declared homogeneous with the results of Fcount 1.52 < Ftable 2.48, with the conclusion that the data from the prerequisite analysis is declared Homogeneous. For more details, please see Table 4.

Table 5. Pretest and posttest normality test

Group	Varians	F_h	F_t	Description
Pretest & Posttest	0,55	1,52	2,48	Homogen
	0,36			

After these two requirements are answered, a hypothesis test is continued using a descriptive and inferential statistical formula with a dependent sample t-test formula. The purpose of presenting the T-test results in Table 5 is to statistically test whether the combination of plyometrics and shadow training significantly affects badminton athletes' footwork ability. The pretest and posttest data are compared using the dependent sample t-test to determine if there is a significant improvement in footwork ability after the training intervention. The calculated t-value (th = 14.56) is compared with the critical t-value (tt = 1.76) at a significance level of α = 0.05 to assess whether the null hypothesis (no effect) can be rejected.

Table 6. T-test of initial data (pretest) and final data (posttest)

Grup		N	t_h	t_t	Description
Plyometric &Shadow Combined Training	Pre Test	15	14,56	1,76	Sig.
	Post Test				

This hypothesis is tested with the t-test formula at a significant level α = 0.05%. These results are obtained from the results of the calculation of pretest and posttest data with the t-test of the combined plyometric and

https://doi.org/10.29407/js_unpgri.v11i3.26960
11 (3) 2025| 399-419

ISSN : 2477-3379 (Online)
ISSN : 2548-7833 (Print)

shadow training group obtained tcount = 14.56 and ttable (α = 0.05) = 1.76 which means tcount> ttable, then answered Ho is rejected and Ha is accepted with the meaning of combined plyometric and shadow training has a significant effect on improving the footwork ability of badminton athletes at Universitas Negeri Padang. The results of the data analysis showed that the combination of plyometric and shadow training significantly improved athletes' footwork ability. Descriptive statistics indicated an increase in the mean posttest score compared to the pretest, with a clear shift in the interval distribution: more athletes moved from the *Poor* and *Medium* categories in the pretest to *Good* and *Excellent* in the posttest. The normality and homogeneity tests confirmed that the data met the assumptions for parametric testing. The dependent sample t-test showed a significant difference between pretest and posttest scores (tcount = 14.56 > ttable = 1.76, $p < 0.05$). This demonstrates that the intervention had a measurable effect on improving footwork performance. These findings suggest that by targeting both agility and explosive footwork skills, the training method provided athletes with a balanced and effective way to enhance their movement performance in line with badminton demands, which requires fast directional changes, explosive movements, and precise footwork.

DISCUSSION

This study aimed to examine the effect of combining plyometric and shadow training on the footwork ability of badminton athletes. The analysis showed that the intervention significantly improved footwork performance, as evidenced by higher posttest mean scores compared to pretest values and confirmed by the dependent sample t-test results. This improvement indicates that the training program successfully enhanced athletes' agility, speed, and positioning, key elements of effective badminton performance. The arrangement of footwork techniques is vital in regulating the body's movement to reach the shuttlecock and strike it accurately. Footwork is the foundation that allows athletes to maintain proper positioning in offensive and defensive situations. This finding aligns with Valldecabres et al. (2020), who emphasized that good footwork allows the body to reach all corners of

https://doi.org/10.29407/js_unpgri.v11i3.26960
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the court and perform precise shots, highlighting agility and explosive power as critical supporting abilities.

Shadow training is an agility exercise that improves movement efficiency by simulating real-game footwork patterns without a shuttlecock. According to Pratama et al. (2024), shadow drills involve placing and retrieving shuttlecocks from different court parts while mimicking movements to all six corners, helping athletes anticipate shuttle trajectories and refine their response speed. This study found that after 16 sessions of combined training, participants showed measurable improvements in footwork ability, confirming that the integration of plyometric and shadow training was effective in developing coordination, reaction speed, and spatial awareness. These results demonstrate that targeted and structured training programs can significantly enhance specific movement skills essential for badminton performance.

Plyometric training, characterized by rapid eccentric and concentric muscle contractions, enhances explosive strength—an attribute crucial for performing quick, powerful, and multidirectional movements in badminton. The fast-paced nature of plyometric exercises such as jumps, hops, and sprints develops both agility and lower-body power, allowing athletes to change direction quickly on the court. Chen et al. (2023) and Chandra et al. (2023) found that plyometric training substantially improves muscle strength and reaction speed, key factors in effective footwork. When combined with shadow training, which refines coordination and rhythm, the resulting training model provides a balanced approach that builds both physical explosiveness and technical precision. Najwa Aulia et al. (2023) also supported the effectiveness of shadow exercises in enhancing agility and movement accuracy in racket sports, further reinforcing the synergy between these two methods.

The inclusion of various plyometric forms, such as lateral jumps, forward-backwards two-leg hops, and obstacle passing using cones or shuttlecock tubes, introduced diversity into each session when combined with shadow routines. This variation maintained athlete motivation and

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reduced monotony while allowing consistent progression in agility and footwork refinement. As Alvarez et al. (2021) and Agostini et al. (2017) noted, training variety helps sustain engagement and supports long-term skill development. The present study's findings confirmed that such an integrated training program effectively increased athletes' agility, speed, and positional control, essential components of successful badminton play.

CONCLUSION

The findings of this study show that combining plyometric and shadow training effectively improved the footwork ability of badminton athletes. Athletes demonstrated faster movement, better recovery between directions, and improved overall coordination. The intervention enhanced agility, speed, and movement efficiency during play. Plyometric exercises strengthened lower-limb power and explosive ability, allowing athletes to execute rapid directional changes with greater control. Shadow training refined agility, balance, and movement precision through simulated court patterns. These methods improved anticipation, coordination, and body control during defensive and offensive situations. The combination also maintained athlete motivation through diverse and engaging training routines. Overall, this integrated training model proved effective in enhancing agility, balance, and responsiveness. Future research should explore its application for athletes with different skill levels and training durations. Coaches are encouraged to incorporate these methods to optimize performance and sustain engagement in regular practice.

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