The combination of plyometric and ladder drills can improve acceleration and footwork skills in badminton players

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Received: 2025-12-12
Accepted: 2026-03-02
Published: 2026-03-09

A – Research concept and design
B – Collection and/or assembly of data
C – Data analysis and interpretation
D – Writing the article
E – Critical revision of the article
F – Final approval of article

ABSTRACT

Background: Recognized globally as the fastest racket sport in the world, badminton demands exceptional acceleration and footwork skills for competitive success. However, many intermediate players often struggle to produce the explosive power needed for fast-paced rallies. To enhance these physical attributes, targeted training interventions, such as a hybrid regimen of plyometric and ladder drills, are often required.

Objectives: This study aims to analyze the efficacy of integrating plyometric exercises with ladder drills in enhancing acceleration and footwork proficiency among badminton players.

Methods: This research employed a quasi-experimental design with a non-equivalent control group. Through purposive sampling, 24 male participants (aged 14-16 years) with at least 2 years of training experience, good health, and no history of recent injuries were selected. They were assigned to either the PLD Group (age: 15.00 ± 0.74 years; height: 162.00 ± 0.07 cm; weight: 50.58 ± 5.68 kg; BMI: 19.20 ± 0.88 kg/m²) or the CV Group (age: 15.00 ± 0.85 years; height: 162.08 ± 0.08 cm; weight: 51.75 ± 8.05 kg; BMI: 19.59 ± 1.56 kg/m²). The intervention spanned six weeks, with three sessions per week. Performance in acceleration was assessed using a 10-meter sprint, and footwork skills were assessed using the footwork skills test (Tohar version) pre- and post-intervention. Data analysis employed the Wilcoxon signed-rank and the Mann-Whitney tests.

Results: The Wilcoxon analysis indicated that both the PLD and CV Groups achieved improvements in acceleration and footwork skills ($p<0.05$). However, the Mann-Whitney test revealed a statistically significant difference between the two groups, with the PLD Group demonstrating superior gains in both acceleration ($p<0.05$) and footwork skills ($p<0.05$) compared to the CV Group.

Conclusions: Integrating plyometric training and ladder drills is an effective strategy for significantly improving acceleration and footwork skills in badminton players.

Keywords: acceleration, badminton, footwork skills, ladder drill, plyometric.

How to cite this article: Ar Rasyid, M. L. S, Wiriawan, O., Rusdiawan, A., Andriana, L. M., & Damayanti, E. D. R. (2026). The combination of plyometric and ladder drills can improve acceleration and footwork skills in badminton players. *Physical Education and Sports: Studies and Research*, *5*(1), 28-39. https://doi.org/10.56003/pessr.v5i1.669

INTRODUCTION

Frequently cited as the world's fastest racket sport (Sivamani et al., 2022), badminton is characterized by high-intensity dynamics, featuring rapid movements and extended rallies (Gomez et al., 2020). In this situation, badminton athletes must be in ideal physical condition to maximize their performance on the court (Ihsan et al., 2024; Rahadhi et al., 2025). Badminton players who lack a strong physical foundation struggle to maintain peak performance during intense matches (Li et al., 2024).

Victory in high-level competition requires technical skills, such as precise strokes and efficient, effective footwork. Biomotor components such as explosive power, reaction speed, and body coordination are also important (Trofin et al., 2022). To become a champion, a badminton player must possess important abilities such as acceleration speed and footwork skills (Pryer et al., 2025). All these components work together to ensure that the badminton player is in the correct body position before executing a shot (Milon, 2014).

One crucial physical component in badminton that differs from general running speed is acceleration (Chiu et al., 2020). While general speed focuses on linear velocity, acceleration in badminton cannot be considered in isolation. It is inextricably linked to the ability to change direction quickly. Due to the limited area of the badminton court, players rarely reach maximum speed (Madsen et al., 2015). Instead, badminton players are required to perform explosive and repetitive stop-and-go movements, which demand rapid deceleration, sudden directional changes, and immediate re-acceleration (Dos'Santos et al., 2022). Therefore, initial acceleration (pick-up acceleration) is crucial in chasing fast-moving shuttlecocks hit by opponents and unexpectedly sent to various corners of the court (Nagano et al., 2020). Badminton players will lose precious fractions of a second if they have slow acceleration. Meanwhile, efficient footwork skills complement this acceleration by enabling optimal court control and energy conservation during the match (Phomsoupha et al., 2019; Valldecabres et al., 2020).

Although general physical training is often carried out, challenges in the field indicate that more specific methods are still needed to improve performance (Erdogan, 2020). Previous studies have reported the positive impacts of plyometric exercises and ladder drills on physical performance across various contexts. For instance, recent research combined agility ladders with plyometrics but applied it to completely different sports demographics, such as young female volleyball players (Bassa et al., 2024). In the context of badminton, a study by Rasyid et al. (2023) explored a similar combination; however, their research was limited to school extracurricular students rather than competitive club athletes, and it used only a single type of plyometric and ladder drill. Often, conventional methods are not focused enough to improve physical biomotor aspects simultaneously (Matias et al., 2022).

Therefore, there remains a notable gap in the literature regarding a comprehensive, multi-exercise combined application of these methods for competitive development. The novelty of this study lies in its integrated training design and specific subject demographic. Unlike previous studies, this research evaluates a structured dual-training regimen—incorporating varied plyometrics and multidirectional ladder drills—tailored explicitly for intermediate adolescent club-

level athletes (aged 14-16 years). Plyometric exercises are focused on increasing muscular power, which serves as the physiological foundation for speed. By improving the muscles' ability to generate force rapidly, athletes can produce a more vigorous explosive thrust against the ground, directly translating into maximum acceleration during court movement (Duchateau & Amiridis, 2023; Krakan et al., 2020).

Meanwhile, to complement the agility aspect, ladder drills were implemented by targeting speed and foot coordination relevant to badminton movement patterns (Rasyid et al., 2023). While previous studies have independently established the benefits of plyometrics and ladder drills, there remains a notable gap in the literature regarding their combined application. The novelty of this study lies in addressing the gap by integrating both modalities into a single, cohesive training regimen tailored explicitly for intermediate badminton athletes. The combination of these two methods is expected to have a greater synergistic effect than conventional training alone.

In light of these considerations, the primary objective of this study is to analyze the impact of a dual-training approach (incorporating plyometrics and ladder drills) on improving acceleration and footwork skills in intermediate badminton players. Furthermore, these findings will provide badminton coaches and sports practitioners with a scientifically validated, time-efficient training protocol. This integrated approach can be directly implemented into daily club routines to accelerate the physical and technical development of youth athletes transitioning to higher competitive levels.

METHODS

Study Design and Participants

The research adopted a quasi-experimental framework utilizing a non-equivalent control group design. A schematic representation of the experimental design is illustrated in Figure 1.

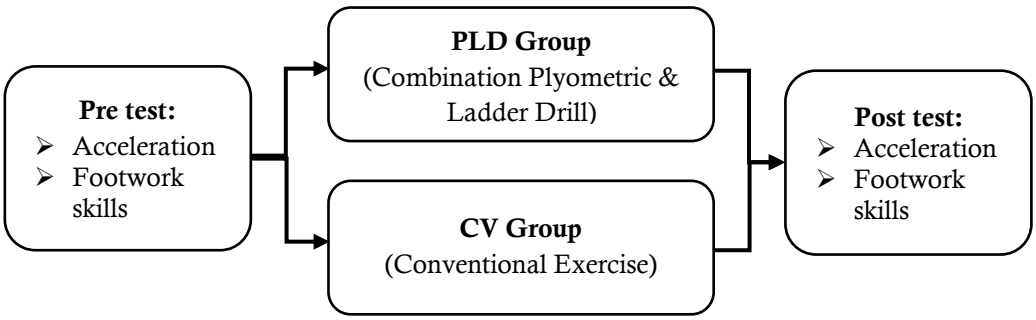

Figure 1. Research Design

The participants in this study were badminton players from PB Remaja Jombang. Participants were selected via purposive sampling based on specific eligibility requirements: male athletes aged 14-16 years with at least 2 years of badminton training experience, who were not sick/injured/undergoing post-injury rehabilitation, and who expressed a willingness to participate voluntarily. The participants in this study were intermediate athletes, meaning they already had strong basic skills but had not yet reached the elite level. Twenty-four participants were

assigned to two groups: the PLD Group (receiving the hybrid plyometric-ladder drill intervention) and the CV Group (not receiving any specific physical training). A summary of the participants' characteristics is presented in Table 2.

Ethical approval statement

The research follows Declaration of Helsinki ethical guidelines and received approval from the Universitas 'Aisyiyah Surakarta Ethics Committee (Protocol No. KEP/UNI-AISKA/007/2025/0107).

Exercise Program Intervention Procedure

All research participants took a pre-test first. After the pre-test, random grouping was carried out, with 12 subjects allocated to each of the PLD and CV Groups. Prior to commencing the intervention, baseline data were collected on participants' maximum repetitions as a basis for 100% of their abilities. The exercise intervention consisted of 18 sessions, conducted over 6 weeks, with 3 sessions per week (Table 1). The post-test was conducted after the last session.

The training program given to the PLD group was conducted after the warm-up phase and before technical training. Meanwhile, the CV group was not given special physical training after the warm-up phase, as they were serving as the comparative benchmark against the experimental group receiving the specific training. Below is a table of the training program for participants in the PLD Group.

Table 1. Exercise Program for PLD Group

Week	Exercise	Intensity	Set	Recovery (min)	Interval (min)
1 – 2	Plyometric: Tuck Jump and Squat Jump Ladder Drill: Bunny Hop and Quick Feet	50% Max Rep	3	2	2
3 – 4	Plyometric: Tuck Jump and Squat Jump Ladder Drill: Bunny Hop and Quick Feet	60% Max Rep	3	2	2
5 – 6	Plyometric: Tuck Jump and Squat Jump Ladder Drill: Bunny Hop and Quick Feet	70% Max Rep	3	2	2

Note. Max Rep = Maximum Repetition

Research Instruments

Data collection relied on two primary assessment tools: the 10-meter sprint and a footwork skills test. Participant acceleration was quantified using the 10-meter maximum sprint (Lockie et al., 2013; Zhang et al., 2022), whereas the footwork skill test was administered to gauge the players' court movement capabilities. The Tohar version was selected for the footwork evaluation (Putra Pratama et al., 2024). This instrument is noted for its high psychometric standards, demonstrating a validity coefficient of 0.98 and a reliability score of 0.93 (Kusuma & Aminullah, 2019).

Data Analysis

Statistical evaluation encompassed descriptive analysis, the Shapiro-Wilk normality test, and nonparametric inferential testing using the Wilcoxon and Mann-Whitney methods. As indicated in Table 4, the data were non-normal. Consequently,

nonparametric tests (Wilcoxon and Mann-Whitney) were deemed appropriate for hypothesis testing. All computational processes and statistical analyses were performed using Microsoft Excel 2019 and SPSS (version 23 for Windows).

RESULTS

Table 2 provides a descriptive analysis related to age, weight, height, and Body Mass Index (BMI) for the cohort of 24 badminton players.

Table 2. Participant Characteristics

Variables	Mean ± SD	
	PLD Group	CV Group
Age (years)	15.00 ± 0.74	15.00 ± 0.85
BMI (kg/m^2)	19.20 ± 0.88	19.59 ± 1.56
Weight (kg)	50.58 ± 5.68	51.75 ± 8.05
Height (cm)	162.00 ± 0.07	162.08 ± 0.08

Note: SD = Standard Deviation; PLD = Plyometric – Ladder Drill (intervention group); CV = Conventional (no-intervention group).

Descriptive statistics capturing the pre-test, post-test, and the rate of change or delta (Δ) values for both acceleration and footwork skills are outlined in Table 3.

Table 3. Descriptive Statistics on Acceleration Ability and Footwork Skill Variables

Variables	Group	Mean ± SD	Min	Max
Pre test acceleration (seconds)	PLD Group	2.797 ± 0.199	2.335	2.980
	CV Group	2.803 ± 0.137	2.580	2.960
Post test acceleration (seconds)	PLD Group	2.599 ± 0.144	2.305	2.740
	CV Group	2.758 ± 0.134	2.500	2.910
Δ (post-pre) acceleration (seconds)	PLD Group	-0.198 ± 0.070	-0.030	-0.310
	CV Group	-0.045 ± 0.030	-0.010	-0.100
Pre test footwork skills (rep)	PLD Group	15.917 ± 2.234	13	19
	CV Group	16.083 ± 1.975	13	19
Post test footwork skills (rep)	PLD Group	18.667 ± 2.535	15	23
	CV Group	17.417 ± 2.021	14	21
Δ (post-pre) footwork skills (rep)	PLD Group	2.750 ± 0.965	1	4
	CV Group	1.333 ± 0.985	0	3

Following the descriptive evaluation, the data distribution was examined to determine normality. The outcomes of the Shapiro-Wilk normality assessment are exhibited in Table 4.

Table 4. Shapiro-Wilk Normality Test Results

Variables	Group	p-value (Sig.)
Pre test acceleration	PLD Group	0.035*
	CV Group	0.072
Post test acceleration	PLD Group	0.066
	CV Group	0.184
Δ (post-pre) acceleration	PLD Group	0.079
	CV Group	0.265
Pre test footwork skills	PLD Group	0.213
	CV Group	0.650
Post test footwork skills	PLD Group	0.449
	CV Group	0.988
Δ (post-pre) footwork skills	PLD Group	0.134
	CV Group	0.053

**: denotes non-normal data distribution (where p>0.05 indicates normality).*

Due to the non-normal distribution observed in specific variables, the study utilized non-parametric testing. Specifically, the Wilcoxon test was applied to evaluate significant differences between pre- and post-test scores for acceleration and footwork skills within each group.

Table 5. Wilcoxon Test Results

Variables	Group	p-value
Pre test – post test acceleration	PLD Group	0.002*
	CV Group	0.002*
Pre test – post test footwork skills	PLD Group	0.002*
	CV Group	0.004*

**: p-value<0.05 signifies a statistically significant difference between the pre- and post-test measurements.*

As a demonstrated by the Wilcoxon test results (Table 5), both the experimental and control arms exhibited enhanced performance in acceleration and footwork skills ($p<0.05$). Further analysis was performed to ascertain inter-group disparities, these findings from the Mann-Whitney test are detailed in Table 6.

Table 6. Results of Mann-Whitney test

Variables	p-value
Δ acceleration	0.000*
Δ footwork skills	0.004*

**: p-value below 0.05 denotes a statistically significant difference between the PLD and CV Group.*

Analysis via the Mann-Whitney test revealed statistically significant disparities between the PLD and the CV cohorts regarding both acceleration capabilites and footwork skills. For a visual representation of these comparative performance shifts, refere to Figure 2.

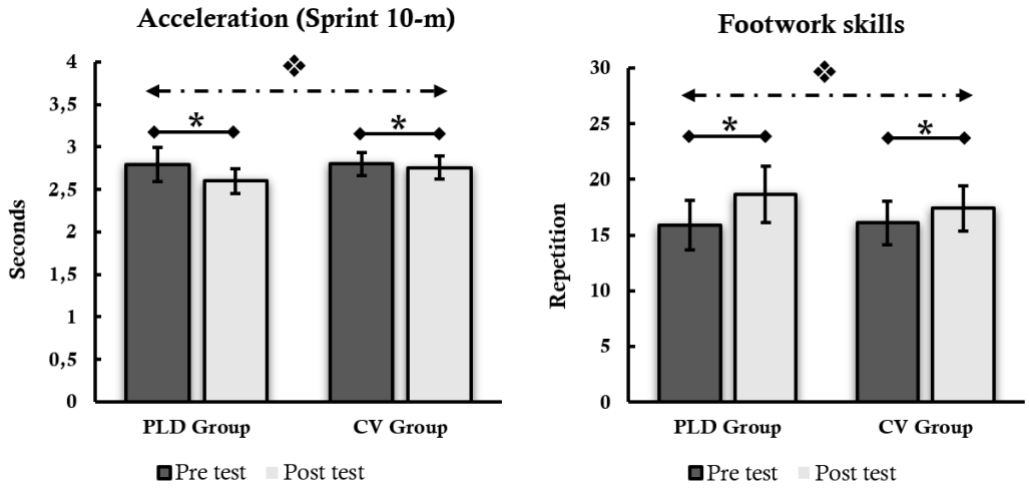

Figure 2. Pre-test vs Post-test Performance Metrics for Acceleration and Footwork Skills within the PLD and CV Groups. Symbols indicate Statistical Significance: (*) Denotes Intra-group Improvements (pre vs. post), while (❖) Indicates Significant Disparities Between Two Groups.

DISCUSSION

The primary objective of this study was to assess how merging plyometric exercises with ladder drills impacts badminton players' acceleration and footwork skills. Based on the Wilcoxon test results, the intervention successfully yielded significant gains in both acceleration ($p<0.05$) and footwork skills ($p<0.05$). Moreover, a comparative analysis using the Mann-Whitney test confirmed the

superior effectiveness of this combined approach compared with standard exercises for improving acceleration ($p<0.05$) and footwork skills ($p<0.05$).

Current observations are consistent with prior research highlighting the benefits of plyometrics. By utilizing the stretch-shortening cycle, this training modality has been shown to boost neuromuscular performance, amplify motor unit recruitment, and refine both elastic energy storage and intermuscular coordination (Booth & Orr, 2016; Davies et al., 2015; Kurniawan et al., 2025). This provides athletes with the opportunity to generate more power quickly and to produce faster movements and stronger shots when playing badminton (Chandra et al., 2023). Plyometric movements that require horizontal power are associated with faster acceleration ability (Lockie et al., 2012). With the ability to produce maximum power in a short period, it can improve acceleration and footwork speed during movements such as lunges and split steps, which are very useful for practicing footwork skills. Improving explosive ability is vital for badminton players, as it enables high-intensity actions, such as dynamic lunges, smashes, and rapid changes in direction and body position (Phomsoupha & Laffaye, 2020). Gepfert et al. (2025) found that plyometric training significantly improved leg muscle power, short sprints (10 meters), and multi-directional movement abilities in young badminton players. Thus, plyometrics play a significant role in improving acceleration and footwork skills in young badminton players.

Ladder drills are a training method that uses equipment such as plastic ladders and ropes (Putu et al., 2021; Rachman et al., 2024). Through systematic engagement in this training, athletes can enhance their responsiveness to external stimuli. This improvement is attributed to a significant reduction in the conduction time of the reflex arc, thereby optimizing the function of the central nervous system (Zhou & Xu, 2023). Widely adopted across diverse sports, these drills are designed to facilitate rapid and precise foot placement, ultimately fostering improvements in coordination, balance, speed, and agility (Chandrakumar & Ramesh, 2015). Badminton players with speed and agility can move quickly on the court (Shedge et al., 2024). If badminton players have good acceleration and footwork, they are more likely to perform at their best. Our results align with the existing literature, which consistently demonstrates the efficacy of ladder drills in significantly improving speed, acceleration, and agility (Alviana et al., 2020; Marwan et al., 2024; Padrón-Cabo et al., 2020).

The results of this study help identify the effects of combining plyometric and ladder-drill training methods in badminton players. The combination of plyometric and ladder drill training can improve physical attributes, such as acceleration, and technical attributes, such as footwork skills. In addition, the results of this study provide guidelines for badminton coaches in developing and planning appropriate training programs for players, especially to improve acceleration and footwork skills. Considering that badminton players greatly need acceleration (Kuo et al., 2022) and footwork skills (Malwanage et al., 2022; Yu & Mohamad, 2022) to achieve their goals of competing at the highest level.

Limitations of the study

There are several limitations in this study, including the small number of participants, the athletes' skill level, which is still at the district/city level, and the measurement of variables limited to acceleration and footwork skills.

Recommendations for future research include increasing the number of participants, raising the skill level of badminton athletes beyond the district/city level, and adding additional dependent variables, such as strength, speed, agility, and explosive power.

CONCLUSION

In summary, integrating plyometrics with ladder drills serves as an effective strategy to enhance acceleration and footwork skills among badminton players. Notably, the cohort subjected to this hybrid training model (specifically using tuck jumps and squat jumps to build explosive power, combined with bunny hops and quick feet for agility and footwork) exhibited superior performance outcomes compared to those in the conventional training group. Theoretically, this study implies that combining plyometric training with specific coordination exercises (ladder drills) has a significant effect compared to traditional physical training. In practice, the results of this study are recommended for application by badminton practitioners or coaches to improve the acceleration ability and footwork skills of their athletes, ensuring they are physically equipped to handle the fast-paced, unpredictable nature of modern badminton.

ACKNOWLEDGMENTS

We extend our sincere gratitude to the PB Remaja Jombang badminton team for authorizing the execution of this study. Appreciation is also due to the Center of Excellence Sport and Exercise Research Center for their invaluable support during the data acquisition phase.

AI DISCLOSURE STATEMENT

During the preparation of this manuscript, the authors used Gemini (Gemini 3.1 Pro, Google) to check grammar, improve linguistic clarity, and refine the academic English phrasing of the text. All AI-generated outputs were critically reviewed and thoroughly edited by the authors to ensure factual accuracy, clarity of expression, and compliance with academic standards. The authors take full responsibility for the integrity and content of this manuscript.

DATA AVAILABILITY

All data supporting the findings of this study are included in the article. Additional datasets are available from the corresponding author upon reasonable request.

FUNDING

No external financial support was received for the conduct of this research.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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