



Impact of plyometric training using step-up and lateral box jumps on the improvement of leg muscle power in youth school futsal athletes

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ABSTRACT

Background: Futsal is a high-intensity sport that requires leg muscle power, especially in aerial duels, anticipating the ball, and performing powerful kicks. Limited jumping ability can reduce leg muscle power and overall performance.

Objectives: This study aims to test the impact of plyometric training using step-up and lateral box jumps on the improvement of leg muscle power in youth school futsal athletes.

Methods: A quasi-experimental two-group pretest-posttest design was conducted with 40 male participants over a four-week plyometric training program. Leg muscle power was measured using a vertical jump test before and after the intervention. Data were analyzed using a t-test with the assistance of SPSS.

Results: Both step-up and lateral box jumps significantly increased leg muscle power ($p < 0.05$). The step-up group showed an average increase of 4.20 cm, while the lateral box jump group showed an average increase of 3.45 cm, with no statistically significant difference ($p = 0.326$).

Conclusions: Both training methods effectively enhance leg muscle power and can be integrated into school-based futsal training programs to improve performance.

Keywords: futsal, lateral box jump, leg muscle power, plyometric, school athletes, step-up training.

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INTRODUCTION

Futsal is a high-intensity sport that demands rapid and explosive movements such as sprinting, jumping, and powerful kicking. One of the key physical components required in this sport is leg muscle power, which refers to the ability to exert maximal force quickly. This quality is critical during actions such as aerial duels, fast directional changes, and shots on goal (Azis et al., 2020; Prasetyo & Rudiana, 2020). Leg muscle power determines the effectiveness of implementing basic futsal techniques, including shooting, heading, and agility (Bianchi et al., 2019; Ramirez-Campillo et al., 2023).

Futsal extracurricular activities in schools are a means of recreation and a medium for fostering achievement and developing students' physical potential (Savu et al., 2023; Suryadi et al., 2023). However, based on initial observations at State Senior High School 1 Mlonggo Jepara, Indonesia, it was found that students' leg muscle power abilities were still in the moderate to medium category. In extracurricular futsal activities at State Senior High School 1 Mlonggo Jepara, Indonesia, initial vertical jump test results indicated that the average level of leg muscle power among students was in the moderate category. According to the classification by Öztürk et al. (2025) and Pasaribu (2020), of the 20 students tested, only one student achieved a "good" score, while the remaining students fell into moderate or medium categories.

The classification of these results refers to the guidelines from (Pasaribu, 2020), which states that a vertical jump of 41–50 cm is classified as "moderate", and 31–40 cm is classified as "medium" for the male category.

This low vertical jump result shows that students do not have ideal leg muscle explosive power, even though this component is crucial in futsal games (Khoiriah et al., 2020; Kurniawan et al., 2021). One effective method supported by sports science is plyometric training to improve this physical ability. Plyometric training involves stretch-shortening cycles (SSC), which are rapid eccentric and concentric muscle contractions that stimulate the neuromuscular system to increase muscle power output (Susanti et al., 2022; Wahyudi et al., 2023). Among various types of plyometric training, step-up and lateral box jumps are particularly relevant for futsal because they target different movement patterns: vertical vs. lateral explosiveness. Two variations of plyometric training considered relevant in the context of futsal are the step-up box jump and the lateral box jump.

The step-up box jump focuses on vertical movements that train the quadriceps, hamstrings, gluteus, and calf muscles, and improve acceleration and body control when jumping (Pratama & Kunci, 2021; Shamshuddin et al., 2020). Meanwhile, the lateral box jump focuses more on lateral movements that mimic actual activities on the futsal field, such as blocking, lateral dribbling, or quick defensive reactions (Kustoro & Raya, 2023). This training also benefits the players' power, lateral stability, and agility.

Previous research shows that box jump training in its various variations significantly increases leg muscle power (Abi Permana et al., 2022; Puriana et al., 2022). However, studies that directly compare the effectiveness of the step-up and lateral box jumps among students are still minimal. Adolescence is ideal for developing maximum physical capacity (Prima & Kartiko, 2021).

While both forms of training are widely used, studies directly comparing their effectiveness—especially among adolescent athletes—are still limited. Therefore, this study aims to analyze the effect of step-up and lateral box jump training on leg muscle

power in futsal extracurricular students. The results are expected to provide scientific input for school sports coaching programs and contribute to optimizing the training of young athletes. Despite the proven benefits of plyometric training in various athletic contexts, there is still a lack of research directly comparing the effectiveness of step-up and lateral box jump training among adolescent futsal players. Previous studies have focused on one type of plyometric training or different sports populations, leaving a gap in understanding which method is more suitable for school-level futsal athletes. This research addresses that gap by directly comparing and offering practical insights for coaches and educators to optimize training programs. The novelty of this study lies in its specific focus on adolescent extracurricular futsal athletes, an underrepresented group in existing literature, and the integration of vertical and lateral movement training within a school sports setting.

The urgency of this research lies in the importance of providing scientific and applicable physical training alternatives to improve students' leg muscle abilities, especially in extracurricular futsal activities. This research also supports school efforts in shaping fit and competitive students, as well as Law of the Republic of Indonesia Number 11 of 2022 concerning Sports (Undang-Undang Republik Indonesia Nomor 11 Tahun 2022 tentang Keolahragaan), which emphasizes the importance of fostering educational sports and developing a culture of active living.

As a result, this study aims to analyze the effect of step-up box jump and lateral box jump training on increasing leg muscle power in futsal extracurricular students of State Senior High School 1 Mlonggo Jepara, as a scientific and practical reference in developing a more effective physical training program in the school environment.

METHODS

Study Design and Participants

This study employed a quasi-experimental research design with a two-group pretest–posttest format to examine the effect of step-up box jump and lateral box jump training on the leg muscle power of male futsal extracurricular participants at State Senior High School 1 Mlonggo, Jepara, Indonesia. A total of 40 male students were selected through purposive sampling based on specific inclusion criteria: (1) active participation in futsal training, (2) no recent lower limb injuries, and (3) availability to attend all training sessions during the intervention period. Leg muscle power was assessed before and after the intervention using the vertical jump test, a widely recognized and reliable measure for evaluating explosive lower-limb performance.

Ethical approval statement

The study received approval from the Ethical Committee of the Faculty of Social Science and Sports Education (FPIPSKR), Universitas PGRI Semarang, with the assigned approval number No. 140/EC/FPIPSKR-UPGRIS/V/2024. All participants were given a detailed explanation of the study's objectives, procedures, and potential benefits or risks. Informed consent was obtained from each participant and their legal guardian before inclusion.

Research Instruments

The primary instrument used to collect data in this study was the vertical jump test, a standardized measurement for assessing leg muscle power. Participants

performed a maximal vertical jump from a stationary position, and the highest point reached was recorded using a Vertec device. This test is considered objective and efficient for evaluating explosive leg power.

The vertical jump test employed in this study has been previously tested for validity and reliability. Based on the results from Taufik et al. (2022), the validity coefficient was $r = 0.978$, and the reliability coefficient was $r = 0.989$, indicating a high level of accuracy and consistency. The same trained examiner took the measurements before and after the intervention to ensure standardized assessment and minimize inter-rater variability.

Data Analysis

The collected data were analyzed using quantitative statistical techniques. Before hypothesis testing, the data were subjected to a normality test using the Shapiro-Wilk method to verify the assumption of normal distribution.

Following confirmation of normality, an independent samples t-test was applied to examine the differences in vertical jump performance between the two groups (step up box jump vs. lateral box jump). A significance level of $\alpha = 0.05$ was set to determine statistical significance. All statistical analyses were performed using IBM SPSS Statistics version 25.0.

RESULTS

This study investigated the influence of step-up and lateral box jump training interventions on the leg muscle power of students participating in futsal extracurricular activities at State Senior High School 1 Mlonggo Jepara. The data collected were subjected to rigorous statistical analysis employing both paired sample t-tests within each experimental group and an independent sample t-test to compare the differential effects between the groups.

Table 1 presents the mean and standard deviation (SD) values of vertical jump measurements in both experimental groups for the pre-test and post-test phases.

Table 1. Descriptive Statistics of Vertical Jump Performance in the Pre-test and Post-test for both Experimental Groups

Group	Phase	Mean (cm)	SD
Lateral Box Jump	Pre-test	49.80	4.526
Lateral Box Jump	Post-test	53.25	5.646
Step-Up Box Jump	Pre-test	49.05	4.310
Step-Up Box Jump	Post-test	53.25	4.229

The findings from the descriptive statistical analysis revealed discernible improvements in both experimental groups. Specifically, participants in the Lateral Box Jump group demonstrated a mean pre-test vertical jump performance of 49.80 cm (SD = 4.526), which increased to 53.25 cm (SD = 5.646) upon intervention completion. Similarly, for the Step-Up Box Jump group, the mean score on the pre-test was recorded at 49.05 cm (SD = 4.310). Following the intervention period, this mean score increased to 53.25 cm (SD = 4.229) in the post-test phase.

These descriptive results underscore a consistent upward trend in leg muscle power across both groups, as evidenced by the increased vertical jump measurements, indicating a positive response to the respective training protocols.

Before conducting parametric analyses, data normality assumptions were tested using the Shapiro-Wilk test. The obtained significance values exceeded 0.05 across

the two groups' pre-test and post-test datasets. These results confirm that the data for each group were normally distributed, thus satisfying one of the fundamental prerequisites for applying parametric statistical procedures. Consequently, further analyses used paired and independent sample t-tests to evaluate the hypotheses.

Table 2. Results of Normality Test using Shapiro-Wilk

	Group	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	Lateral	0.113	20	0.200*	0.963	20	0.595
	StepUp	0.120	20	0.200*	0.968	20	0.710
Posttest	Lateral	0.197	20	0.040	0.907	20	0.056
	StepUp	0.112	20	0.200*	0.953	20	0.419

The normality test using the Shapiro-Wilk method (Table 2) revealed that all datasets, including both pretest and posttest scores from the Step-Up and Lateral Box Jump groups, exhibited significance values above the 0.05 threshold. Specifically, pretest scores for both groups demonstrated p-values of 0.595 and 0.710, respectively, indicating strong adherence to normal distribution. Although the posttest score for the Lateral group was marginally close to the 0.05 cutoff ($p = 0.056$), it still met the assumption for normality. These findings confirm that the data were normally distributed, allowing the use of parametric statistical tests such as paired and independent t-tests for hypothesis testing.

The paired sample t-test (Table 3) showed a significance value of $p = 0.000$ (< 0.05), indicating a significant increase from pre-test to post-test. The mean increase was 3.45 cm. This result proves that lateral box jump training significantly improved lower limb power. The paired sample t-test (Table 4) also showed a significance value of $p = 0.000$ (< 0.05), with a mean increase of 4.20 cm. This indicates that step-up box jump training also significantly improved lower limb power.

Table 3. Paired Sample Statistics in the Lateral Box Jump Treatment Group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	49.80	20	4.526	1.012
	Posttest	53.25	20	5.646	1.263

Table 4. Paired Sample Statistics in the Step-Up Box Jump Treatment Group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	49.05	20	4.310	0.964
	Posttest	53.25	20	4.229	0.946

The independent sample t-test was used to compare the effectiveness of both training methods. The mean increase (gain) in the lateral group was 3.45 cm, and in the step-up group was 4.20 cm. However, the significance value was $p = 0.326$ (> 0.05), which means the difference between the two groups was not statistically significant.

Table 5. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Gain	Lateral	Lateral	20	3.45	2.929
	Step-Up	StepUp	20	4.20	1.673

This finding suggests that while both training methods effectively improved leg muscle power, neither showed superiority. From a practical perspective, this provides flexibility for coaches to choose between the two based on training preferences, equipment availability, or specific performance goals.

DISCUSSION

The primary objective of this research was to empirically examine the influence of step-up box jump and lateral box jump training interventions on the enhancement of leg muscle power among futsal extracurricular students at State Senior High School 1 Mlonggo Jepara. The findings of this study confirm that both types of training programs had a statistically significant effect on increasing the vertical jump height of the participants, which is commonly recognized as an indicator of leg muscle power. These results are consistent with prior studies, which emphasize the efficacy of plyometric exercises in improving muscular power, power, and neuromuscular performance (Susanti et al., 2022; Wahyudi et al., 2023).

The statistical analysis utilizing paired sample t-tests within both experimental groups demonstrated significant improvements from pre-test to post-test in each group. Specifically, the lateral box jump group exhibited a mean increase of 3.45 cm, while the step-up box jump group demonstrated a higher mean increase of 4.20 cm. Although the independent sample t-test showed that the difference in improvement between the two groups was not statistically significant ($p > 0.05$), the step-up box jump group descriptively achieved slightly better results. This suggests that both interventions were equally effective in promoting leg muscle power improvements.

These findings align with the principles of plyometric training, which highlight the role of stretch-shortening cycle (SSC) mechanisms in optimizing muscular adaptations. The stretch-shortening cycle, characterized by rapid eccentric-concentric muscle contractions, has been widely acknowledged as a fundamental physiological basis for enhancing explosive muscular performance (Wahyudi et al., 2023). Both step-up and lateral box jump exercises stimulate these cycles, albeit through different movement patterns, thus contributing to increased lower limb power.

The step-up box jump exercise emphasizes vertical force production, which is directly aligned with the vertical movement involved in the vertical jump test employed in this study. This specificity principle likely accounts for this group's marginally higher mean improvement. Vertical jump-oriented plyometric exercises predominantly target the quadriceps, hamstrings, gluteal muscles, and calves, all of which generate upward propulsion during jumping activities (Pratama & Kunci, 2021).

Conversely, the lateral box jump focuses on lateral force production and multidirectional stability. While it may not directly mimic the purely vertical trajectory of a standard vertical jump test, it remains highly relevant to the movement demands of futsal, which frequently requires lateral agility, rapid changes of direction, and explosive sideward movements (Kustoro & Raya, 2023). The statistically significant improvement in this group reinforces the notion that lateral plyometric exercises contribute not only to lateral agility but also to leg muscle power overall, corroborating findings from previous studies (Puriana et al., 2022).

The results of this study also reflect the efficacy of the training dosage applied, specifically three sessions per week over four consecutive weeks. This training frequency aligns with existing recommendations in sports science literature, which suggest that a minimum of two to three sessions per week is sufficient to elicit measurable improvements in neuromuscular performance, particularly in adolescent populations (Prima & Kartiko, 2021). Adolescence is recognized as a critical window for developing physical capacity due to heightened hormonal responses and

neuromuscular plasticity, making this population exceptionally responsive to power and power training interventions.

Furthermore, the absence of statistically significant differences between the two training methods suggests that coaches and physical education practitioners may have flexibility in selecting plyometric exercises based on practical considerations, such as available space, equipment, and specific movement patterns desired for training transfer. This flexibility aligns with the principle of variation in training, which posits that varied stimuli are beneficial for maintaining athlete motivation and preventing overuse injuries.

Limitations of the study

However, this study is not without limitations. Despite the positive results, the small sample size ($n = 20$ per group) may have limited the statistical power to detect more subtle differences between the interventions. Additionally, the study only utilized the vertical jump test as a performance outcome measure, which, while valid for assessing explosive power, may not fully capture other dimensions of athletic performance relevant to futsal, such as agility, speed, or endurance. Incorporating a battery of performance tests in future research could provide a more comprehensive understanding of the functional benefits of different plyometric exercises.

Another limitation relates to the short intervention duration of four weeks. While sufficient to produce observable improvements, more extended training periods could reveal more pronounced differences between interventions or uncover patterns related to training plateaus and fatigue management. Future studies might explore the effects of step-up and lateral box jump training over extended periods and include post-intervention retention tests to assess the longevity of training adaptations.

Furthermore, this study focused solely on male adolescent participants within a specific educational context. As such, generalizing these findings to female athletes or athletes from different sports or competitive levels should be cautiously approached. The sex-specific and sport-specific responses to plyometric training warrant further investigation to enhance training recommendations' ecological validity and applicability.

In addition, although participants were instructed and supervised by experienced trainers throughout the study to ensure proper technique and minimize injury risk, individual variations in exercise execution and intrinsic motivation could have influenced the outcomes. Future studies might incorporate objective monitoring tools, such as motion capture or force plates, to further standardize exercise execution and quantify mechanical outputs during training sessions.

CONCLUSIONS

In conclusion, the findings of this study contribute valuable insights to the body of knowledge concerning the application of plyometric training within school-based sports settings, particularly in extracurricular futsal programs. Both step-up box jump and lateral box jump exercises proved effective in enhancing lower limb power among adolescent athletes. Given the practical equivalence of these methods, coaches may opt to integrate both exercises interchangeably or in combination to foster comprehensive athletic development. This flexibility supports physical performance enhancement and aligns with educational sports objectives aimed at promoting lifelong physical activity and fitness among youth.

From a practical standpoint, this research suggests that school-based coaches and physical educators should consider incorporating varied plyometric exercises, including step-up and lateral box jumps, to improve lower limb power, an essential component for success in futsal and other sports requiring explosive lower body actions. Moreover, this study reinforces the importance of systematic, structured, and periodized training programs in youth athletic development.

Expanding sample sizes, including diverse demographic groups, extending intervention durations, and broadening performance measures are recommended for future research. Investigating the psychological and motivational impacts of different training modalities could also provide holistic insights into optimizing training programs for adolescent athletes.

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DATA AVAILABILITY

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

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CONFLICT OF INTEREST

The author officially certifies that there are no conflicts of interest with any party with respect.

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