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The Effects of Plyometric Hurdle Hops and Jump Squat Training on Vertical Jump Performance

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ABSTRACT

This study aimed to analyze the effects of plyometric hurdle hops and jump squat training on vertical jump performance and to compare the effectiveness of both methods among male U-16 basketball athletes. Vertical jumping ability is an essential physical component in basketball because it supports decisive game actions such as rebounding, blocking, lay-ups, and jump shooting. This study employed a quasi-experimental method with a two-group pretest-posttest design. The participants were 20 male basketball athletes aged 15–16 years from Mahameru Basketball Club Surabaya, divided into two groups: the jump squat group and the hurdle hops group, with 10 athletes in each group. Vertical jump performance was measured using the Jump MD device. Data were analyzed using the Shapiro-Wilk normality test, Paired Sample T-Test, and Independent Sample T-Test with SPSS version 26. The results showed that both training methods significantly improved vertical jump height. The jump squat group increased from 58.8 cm to 64.3 cm, with an average improvement of 9.35% and a moderate effect size (Cohen's d = 0.64). Meanwhile, the hurdle hops group increased from 58.6 cm to 63.9 cm, with an average improvement of 9.04% and a moderate effect size (Cohen's d = 0.63). The independent sample t-test showed no significant difference between the two methods in the post-test result ($p > 0.05$). Therefore, both plyometric jump squat and hurdle hops training are equally effective for improving vertical jump performance in adolescent basketball athletes.

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INTRODUCTION

Sports development plays a strategic role in improving the quality of human resources by fostering physical fitness, psychological resilience, and competitive excellence. In Indonesia, basketball has become one of the most popular sports among adolescents and serves as an important medium for developing athletic talent. The increasing competitiveness of youth basketball requires athletes to possess not only technical and tactical proficiency but also high levels of physical fitness, particularly explosive lower-limb power. Among the physical attributes required in basketball, vertical jump performance is considered one of the most critical determinants of

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success because it directly influences rebounding, shooting, blocking, and overall game dominance (Salsabilla, 2025; Mikolajec et al., 2025).

The U-16 developmental stage represents a crucial period in athlete preparation because physical qualities established during adolescence can significantly influence future athletic performance. During this phase, coaches are expected to implement evidence-based training programs that effectively improve neuromuscular function and sport-specific physical abilities. Previous studies have demonstrated that explosive power is strongly associated with basketball performance indicators, including acceleration, change-of-direction ability, sprint performance, and jumping capacity (Hammami et al., 2022; Ramirez-Campillo et al., 2022). Consequently, optimizing lower-body power through systematic training interventions becomes a fundamental objective in youth basketball development programs.

Explosive power is generally defined as the ability to generate maximal force within the shortest possible time. This capability results from the interaction between muscular strength and movement velocity, both of which contribute substantially to vertical jump performance (Zheng et al., 2025). Athletes with superior explosive power can execute basketball-specific actions more effectively, particularly during contested rebounding situations where jump height and reaction speed determine ball possession. Therefore, developing training strategies capable of enhancing explosive lower-limb performance is essential for improving competitive outcomes among youth basketball athletes.

Despite the recognized importance of vertical jump ability, observations conducted during the Surabaya U-16 Regional Championship in April 2025 revealed that male athletes from Mahameru Basketball Club experienced difficulties in rebounding situations. Several players demonstrated limited jump height when competing for aerial balls, resulting in reduced effectiveness during offensive and defensive rebounds. This performance limitation suggests that the athletes' lower-limb explosive power remains suboptimal. Furthermore, the club's existing conditioning program primarily consists of conventional strengthening exercises that may not sufficiently stimulate neuromuscular adaptations necessary for enhancing vertical jump performance. Such conditions indicate the need for alternative training methods that are scientifically supported, practical, and applicable within youth basketball settings.

Plyometric training has been widely recognized as one of the most effective approaches for improving explosive power and athletic performance. This training method emphasizes rapid transitions between eccentric and concentric muscle actions through the Stretch-Shortening Cycle (SSC), allowing athletes to utilize stored elastic energy and neuromuscular reflexes to produce greater force output (Jo et al., 2025). The effectiveness of plyometric training has been documented across various sports, including basketball, volleyball, soccer, and athletics.

Recent studies have reported significant improvements in vertical jump performance following structured plyometric interventions. Hammami et al. (2022) found that plyometric exercises significantly enhanced lower-limb power and neuromuscular efficiency among adolescent athletes. Similarly, Rahman et al. (2023) demonstrated that plyometric programs

improved explosive strength and vertical jump height through increased motor unit recruitment and improved muscle-tendon stiffness. These findings support the theoretical framework that plyometric exercises facilitate adaptations within both muscular and neural systems, leading to enhanced performance in explosive movements.

Among the various forms of plyometric training, hurdle hops represent an exercise that emphasizes repeated jumping over obstacles while minimizing ground contact time. This movement pattern stimulates the SSC mechanism, enhances reactive strength, and improves dynamic balance. Hurdle hops also require coordinated activation of the ankle, knee, and hip extensors, making them highly relevant for basketball movements involving jumping and landing. Previous research suggests that hurdle-based plyometric exercises can improve power production, landing mechanics, and lower-extremity stability, thereby contributing to enhanced athletic performance and reduced injury risk (Cao et al., 2024).

Another training modality frequently used to develop explosive power is the jump squat. Unlike traditional resistance exercises, jump squats combine strength development with movement velocity, allowing athletes to generate maximal force rapidly. Research conducted by Rozi et al. (2025) reported significant improvements in lower-limb explosive power following jump squat training interventions. The exercise promotes neuromuscular adaptations through increased muscle activation and improved rate of force development. Furthermore, jump squats closely resemble sport-specific jumping mechanics, making them highly transferable to basketball performance.

Recent evidence also highlights the importance of muscular symmetry and balanced force production between limbs. Ramos et al. (2022) reported that athletes exhibiting lower inter-limb strength asymmetry demonstrated superior functional performance and jumping ability. In contrast, excessive muscular imbalance may contribute to inefficient movement patterns and increased injury susceptibility. Therefore, training methods that simultaneously enhance explosive strength and neuromuscular coordination are highly recommended for adolescent basketball athletes.

Although the benefits of plyometric training have been extensively documented, several important gaps remain within the existing literature. First, many previous studies have primarily focused on volleyball, soccer, or general athletic populations rather than youth basketball athletes. Consequently, evidence regarding the effectiveness of specific plyometric interventions within adolescent basketball contexts remains relatively limited. Second, previous investigations have generally examined plyometric training as a broad category without specifically comparing practical exercises such as hurdle hops and jump squats. While both methods are theoretically effective for improving explosive power, limited empirical studies have evaluated their combined implementation in basketball athletes, particularly within the U-16 age category. Understanding the effectiveness of these exercises is important because coaches require accessible and evidence-based training alternatives that can be implemented without sophisticated equipment. Third, most studies have been conducted in professional or collegiate athlete populations. Research involving Indonesian youth basketball athletes remains scarce despite the rapid growth of basketball participation

across the country. Differences in biological maturation, training experience, and environmental conditions may influence the effectiveness of training interventions, highlighting the need for context-specific investigations. Fourth, there is a lack of empirical evidence examining the effects of hurdle hops and jump squat training on athletes from Mahameru Basketball Club Surabaya. Considering the observed deficiencies in rebounding performance and vertical jump ability, scientific evaluation of these training methods is necessary to provide practical recommendations for athlete development programs. Based on the identified problems and research gaps, this study aims to analyze the effects of plyometric hurdle hops and jump squat training on vertical jump performance among male U-16 athletes of Mahameru Basketball Club Surabaya. Specifically, the study seeks to determine whether the implementation of these exercises can significantly improve jump height and lower-limb explosive power.

The novelty of this research lies in several aspects. First, the study focuses specifically on male U-16 basketball athletes, a population that has received limited attention in previous plyometric training research. Second, it investigates the application of two practical and affordable training methods hurdle hops and jump squats that can be easily integrated into youth basketball conditioning programs. Third, the study provides empirical evidence within the Indonesian basketball context, contributing to the development of localized scientific knowledge regarding athletic performance enhancement. Finally, the findings are expected to bridge the gap between theory and practice by offering coaches evidence-based strategies for improving vertical jump performance and overall basketball competitiveness among adolescent athletes.

In conclusion, vertical jump ability represents a fundamental component of basketball performance that requires systematic development through appropriate training interventions. While plyometric training has demonstrated substantial benefits for explosive power enhancement, limited evidence exists regarding the combined implementation of hurdle hops and jump squat exercises among Indonesian U-16 basketball athletes. Therefore, this study is expected to contribute both theoretically and practically by providing scientific evidence concerning effective training strategies for improving vertical jump performance in youth basketball players.

METHODS

This study employed a quantitative approach using a quasi-experimental method with a two-group pretest–posttest design. Group 1 performed jump squat exercises, while Group 2 performed hurdle hops exercises, without the inclusion of a control group. The study compared the pre-test and post-test results of vertical jump ability among male U-16 basketball athletes of Mahameru Basketball Club Surabaya. The Ordinal Pairing method was used to divide participants into the training groups.

The research was conducted at the Marvel Basketball Court, Jalan Ngagel No. 123, Wonokromo District, Surabaya City, and Golden City Mall, Jalan KH Abdul Wahab Siamin No. 2–8, Dukuh Pakis District, Surabaya City, East Java. The population consisted of all basketball athletes from Mahameru Basketball Club Surabaya, totaling 40 athletes. The

inclusion criteria were athletes aged 15–16 years, having participated in training for at least one year, being physically healthy without illness or injury, and willing to participate in the nine-week research program conducted twice a week.

The research instruments consisted of preparation, implementation, and final stages. The preparation stage included determining the research subjects, scheduling the implementation, submitting permission letters to the head of the department, and preparing the equipment needed for testing and treatment. The implementation stage involved recording participant attendance, explaining the testing procedures, conducting warm-up sessions, administering the tests according to the procedures, recording the best results from two attempts, and implementing the jump squat and hurdle hops training treatments over 18 sessions within nine weeks. Finally, the concluding stage focused on processing the research results and comparing the pre-test and post-test data to evaluate the effects of plyometric training on the athletes' vertical jump ability.

RESULTS AND DISCUSSION

Result

Descriptive Analysis of Vertical Jump Performance

This study examined the effects of two plyometric training methods, namely jump squat and hurdle hops, on the vertical jump performance of male U-16 athletes from Mahameru Basketball Club Surabaya. A total of 20 athletes participated in the study and were equally divided into two treatment groups consisting of 10 athletes each. Vertical jump performance was assessed using the Jump MD test before and after the training intervention.

Table 1.
Descriptive Statistics of Vertical Jump Performance

Variable	Jump Squat Pre-test	Jump Squat Post-test	Hurdle Hops Pre-test	Hurdle Hops Post-test
N	10	10	10	10
Mean (cm)	58.8	64.3	58.6	63.9
Standard Deviation	8.483	8.693	8.168	8.724
Minimum	47	52	48	53
Maximum	71	79	70	76
Cohen's d	-	0.64	-	0.63
Average Improvement (%)	-	9.35%	-	9.04%

The descriptive analysis revealed a substantial increase in vertical jump performance following both training interventions. In the jump squat group, the mean vertical jump score increased from 58.8 cm during the pre-test to 64.3 cm in the post-test, representing an average improvement of 9.35%. The highest score increased from 71 cm to 79 cm, while the minimum score improved from 47 cm to 52 cm.

Similarly, the hurdle hops group demonstrated positive improvements, with the mean vertical jump score increasing from 58.6 cm to 63.9 cm, corresponding to an

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average increase of 9.04%. The maximum score improved from 70 cm to 76 cm, whereas the minimum score increased from 48 cm to 53 cm.

The effect size analysis indicated moderate practical significance for both interventions. The jump squat training produced a Cohen's d value of 0.64, while hurdle hops training generated a Cohen's d value of 0.63. These findings suggest that both training methods effectively enhanced lower-limb explosive power, although jump squat training demonstrated a slightly greater practical effect.

Vertical Jump Performance Classification

To provide a clearer interpretation of athletes' performance, post-test scores were categorized according to the established vertical jump norms.

Table 2.
Distribution of Vertical Jump Performance Categories

Category	Frequency (n)	Percentage (%)
Very Good	9	45
Good	7	35
Fair	4	20
Poor	0	0
Very Poor	0	0
Total	**20**	**100**

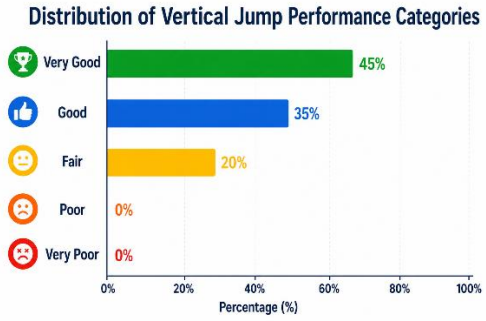

Figure 1.
Distribution of Vertical Jump Performance Categories

The frequency distribution analysis demonstrated that the majority of athletes achieved favorable performance levels after completing the training program. A total of 9 athletes (45%) were classified in the Very Good category, while 7 athletes (35%) were categorized as Good. Only 4 athletes (20%) remained in the Fair category, and no athletes were classified as Poor or Very Poor. These findings indicate that both plyometric training methods successfully elevated the athletes' vertical jump performance to higher performance categories.

Normality Test

Prior to conducting inferential statistical analysis, data normality was assessed using the Shapiro–Wilk test because the sample size was fewer than 50 participants.

Table 3.
Results of the Shapiro–Wilk Normality Test

Variable	N	Statistic	Sig.
Pre-test	20	0.930	0.152
Post-test	20	0.944	0.279

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The results showed significance values of 0.152 for the pre-test and 0.279 for the post-test. Since both values exceeded the significance level of 0.05, the data were normally distributed. Therefore, parametric statistical procedures were considered appropriate for subsequent analyses.

Independent Sample t-Test

An independent sample t-test was conducted to determine whether significant differences existed between the jump squat and hurdle hops groups before and after the intervention.

Table 4.
Independent Sample t-Test Results

Variable	Levene's Test (Sig.)	t-value	Sig. (2-tailed)	Mean Difference
Pre-test	0.819	0.054	0.958	0.200
Post-test	0.829	0.103	0.919	0.400

The independent sample t-test results revealed that the pre-test significance value was 0.958 ($p > 0.05$), indicating that no significant differences existed between the groups prior to the intervention. Likewise, the post-test significance value was 0.919 ($p > 0.05$), demonstrating that the two training methods produced statistically comparable outcomes.

These findings suggest that both jump squat and hurdle hops training methods were equally effective in improving vertical jump performance among male U-16 basketball athletes.

Paired Sample t-Test

To determine the effectiveness of each training method individually, paired sample t-tests were conducted within each treatment group.

Table 5.
Paired Sample t-Test Results

Group	Mean Difference	Std. Deviation	Correlation (r)	Sig.
Jump Squat	-5.500	1.506	0.985	0.000
Hurdle Hops	-5.300	1.252	0.991	0.000

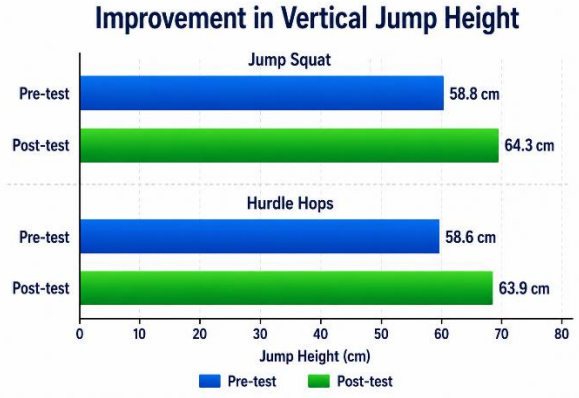

Figure 2.
Improvement in Vertical Jump Height

The paired sample t-test demonstrated statistically significant improvements in vertical jump performance for both groups. In the jump squat group, the mean difference

was –5.500 cm, indicating a substantial increase in jump height following the intervention. The correlation coefficient of 0.985 and significance value of 0.000 ($p < 0.05$) confirmed a strong relationship between pre-test and post-test scores and indicated a significant training effect.

Similarly, the hurdle hops group showed a mean difference of –5.300 cm with a correlation coefficient of 0.991 and a significance value of 0.000 ($p < 0.05$). These findings demonstrate that hurdle hops training also significantly improved vertical jump performance. Overall, both plyometric training methods significantly enhanced vertical jump ability among male U-16 basketball athletes. Although jump squat training produced slightly higher percentage improvements and effect size values, the independent sample t-test indicated that the differences between the two methods were not statistically significant. Therefore, both jump squat and hurdle hops training can be recommended as effective plyometric strategies for improving lower-limb explosive power and vertical jump performance in youth basketball athletes.

Discussion

Based on the findings of this study, the two plyometric training methods, namely jump squat and hurdle hops, demonstrated significant effects on improving the vertical jump height of male U-16 athletes from Mahameru Basketball Club. The nine-week training program conducted twice a week successfully enhanced the vertical jump ability of adolescent athletes. Statistically, both groups showed improvements in post-test scores, indicating that plyometric training is effective in increasing lower limb explosive power in young basketball athletes.

The improvement in vertical jump height in both the jump squat and hurdle hops groups can be explained through the Stretch-Shortening Cycle (SSC) mechanism. This process involves a rapid eccentric contraction followed by an explosive concentric contraction. During the eccentric phase, elastic energy is stored and subsequently released during the concentric phase to generate greater force in a short period of time, thereby increasing the efficiency of lower limb muscle contractions. The improvement in athletic performance is closely related to neuromuscular adaptations and consistent training programs. Such training enhances motor unit recruitment, muscular synchronization, and the speed of neural impulses transmitted to the muscles (Oliveira, 2021). hese adaptations enable athletes to perform vertical take-offs with greater force and speed. The body's efficiency in converting training stimuli into explosive movements is particularly important in basketball performance.

An important physiological factor involved is the increase in the Rate of Force Development (RFD), which refers to the muscle's ability to generate maximal force within a short period of time. In vertical jumping, the short ground contact time makes rapid force production essential. Plyometric training is highly effective in improving RFD because it trains the neuromuscular system to respond rapidly to loading stimuli (Ramirez-campillo et al., 2022). Although both methods were equally effective, the findings showed that jump squat training produced a slightly greater improvement (9.35%) compared to hurdle hops

(9.04%), although the difference was not statistically significant. Both training methods may therefore be applied effectively, but jump squat tends to be slightly superior for improving vertical jump height.

Furthermore, the superiority of jump squat exercises can be explained biomechanically, as the movement pattern more closely resembles the mechanics of a vertical jump. The principle of specificity of training states that training adaptations are more effective when the exercises closely resemble the movement demands of the targeted sport activity (Weakley et al., 2021). n jump squat exercises, the take-off phase is performed vertically with emphasis on hip, knee, and ankle joint extension to improve vertical jumping performance. In contrast, hurdle hops are more complex than other forms of plyometric training. This exercise not only enhances explosive power but also develops reactive ability, coordination, movement rhythm, and landing control. Athletes are required to maintain body stability while repeatedly jumping with short ground contact times. Therefore, the adaptations resulting from hurdle hops are not solely focused on increasing jump height but also on improving motor control and dynamic balance. Although the increase in jump height was slightly lower, this exercise still provides high functional value for basketball performance.

The findings of this study are consistent with those of Lail & Fahmi (2025) who reported that plyometric training methods effectively improve lower limb explosive power, despite differences in effectiveness between methods, as also demonstrated in previous studies by Putera et al., (2020) and (Maylina & Hariyanto, 2024) Exercises such as hurdle hops and jump squat have been proven to enhance lower limb explosive strength and vertical jump height. These findings reinforce the validity of plyometric training as an effective method for improving the performance of young athletes. However, several previous studies suggested that hurdle hops were more effective than jump squat exercises. This difference may be attributed to the characteristics of the participants in the present study, who were basketball athletes aged 15–16 years and still undergoing neuromuscular development. At this developmental stage, the body tends to respond more rapidly to basic strength exercises such as jump squat compared to more complex reactive exercises like hurdle hops. In addition, differences in training experience among athletes may also have influenced exercise technique during the intervention period.

In basketball, improving vertical jump height is highly important for increasing the opportunity to secure rebounds. This is particularly relevant to the issue experienced by Mahameru Basketball Club, which lacked dominance in rebounding situations. Furthermore, improved lower limb explosive power also contributes to better performance in blocking, layups, jump shots, and aerial ball contests during games. Therefore, the results of this study are not only statistically significant but also highly relevant to competitive basketball performance. Although the study demonstrated positive outcomes, several limitations should be considered. The relatively small sample size limits the generalizability of the findings. Additionally, the nine-week training duration may not have been sufficient to evaluate the long-term effects of the training methods used. Other factors such as sleep patterns, nutritional intake, and individual motivation were also not fully controlled and may have influenced the results.

The findings of this study provide several practical implications for youth basketball coaches. First, jump squat exercises are recommended for improving vertical jump height. Second, hurdle hops are more suitable for developing explosive power, coordination, and reactive ability. Third, combining both exercises within a periodized training program is recommended to help athletes simultaneously develop strength, explosiveness, and motor control. This approach is highly relevant to the demands of modern basketball, which requires explosive ability and efficient movement performance. Overall, this study demonstrates that plyometric training is effective in improving the vertical jump ability of adolescent athletes, although jump squat exercises showed slightly superior results. Coaches should consider not only performance improvements but also movement characteristics, training objectives, and game demands when selecting training methods.

CONCLUSION

Based on the findings of this study, both jump squat and hurdle hops training methods had a significant effect on improving the vertical jump height of male U-16 athletes from Mahameru Basketball Club. Both exercises were able to stimulate physiological and neuromuscular adaptations that support lower limb explosive power. Comparatively, jump squat training produced a slightly greater improvement in vertical jump performance, namely 9.35% compared to 9.04%, although the difference was not statistically significant. These findings indicate that both methods are equally effective in improving the vertical jump ability of adolescent athletes. The improvement in vertical jump performance is highly important in basketball, particularly for rebounding, blocking, jump shooting, and aerial ball contests. Therefore, both training methods are recommended for inclusion in youth athlete development programs.

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