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Original Article Research

The Effect of Six-week Low Intensity Plyometrics Training on Leg Muscles Power of Young Pencak Silat Athletes

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Abstract

Pencak silat is a martial sport that requires high explosive power of the leg muscles to support kick effectiveness, position change, and quick movement response during matches. The purpose of this study was to determine the effect of low-intensity plyometric training for six weeks on the power ability of leg muscles in young pencak silat athletes. The sample in this study was 20 male pencak silat athletes at Garuda Silat Academy with an average age of 15.35 years (SD = +- 0.58). This study uses a quasi-experimental method with a one group pretest–posttest design. Leg muscle power is measured using a standing broad jump. The difference test used a paired samples t-test with a significance level of 0.05 and the data was analyzed using SPSS version 27.0.1.0. The results showed a Sig. (2-tailed) value of <.001 which means there was a significant improvement after the intervention, leg muscle power measured using the standing broad jump increased by an average of 13.2-centimeters. In conclusion, six weeks of low-intensity plyometric training using a jumps-in-place model effectively enhanced lower-limb explosive power in adolescent pencak silat athletes. It is recommended that coaches consider incorporating progressively designed low-intensity plyometric exercises into long-term training programs, as they are safe, practical, and appropriate for supporting neuromuscular development while minimizing injury risk in young athletes.

Keywords: low intensity, pencak silat, plyometrics, leg power

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1. INTRODUCTION

Pencak silat is a martial sport that requires high explosive power of the leg muscles to support kick effectiveness, position change, and quick movement response during matches (Nugroho et al., 2021). Leg muscle power is one of the main determinants of performance, especially in young athletes who are still in the phase of developing basic physical capacity. Therefore, it is necessary to have an effective training method that is safe and in accordance with the growth characteristics of adolescent athletes (Yu et al., 2025).

Plyometric exercises are known to be effective in increasing leg muscle power through stretch–shortening cycle optimization (Jo & Lee, 2023; Sáez de Villarreal & Ramírez-Campillo, 2022). However, the application of high intensity plyometrics in young athletes has the potential to pose a risk of injury if not adjusted to the level of biological maturity and basic ability of the athlete (Behm, 2018; Weisskopf et al., 2021). Low-intensity plyometric exercises are a rational alternative because they emphasize movement quality, neuromuscular control, and gradual adaptation without placing excessive mechanical load on the developing musculoskeletal system (Franco-Márquez et al., 2025). Low intensity plyometrics in the form of jumps in place is a relevant approach. Jumps in place are jumps that are performed by landing at the same point as the starting point, done repeatedly with a very short time of foot contact with the ground before immediately making the next jump. This characteristic allows athletes to learn to perform rapid rebounds from the ground surface, thus stimulating increased neuromuscular reactivity without excessive mechanical load (Chu & Myer, 2013).

In addition, jumps in place include various forms of static footwork exercises that do not demand linear distance transfers, making them suitable for pencak silat athletes who require stability, mass center control, and the ability to change direction quickly (Subekti et al., 2020). This exercise trains the ability of the legs to work away from the body's center of gravity and immediately return to a stable position, a biomechanical ability that is important in attack and defensive motion. With a short duration of training and low intensity, jumps in place can also be directed to stimulate the ATP-PC energy system as well as improve kinesthetic awareness and response to contact with the ground.

Several studies report that short-term plyometric programs are able to increase leg muscle power in adolescent athletes, but most still focus on moderate to high intensity or combined with weight training (Noutsos et al., 2024; Rodríguez-Rosell et al., 2016). Empirical evidence on the effectiveness of low intensity plyometrics with short intervention durations, particularly in young pencak silat athletes, is limited. In fact, this approach has the potential to be a safe, applicative, and relevant training strategy for early childhood coaching.

In the context of youth pencak silat development in Indonesia, training programs at the grassroots and academy levels often prioritize technical mastery and competition preparation, while structured physical conditioning, particularly power-oriented training, receives less systematic attention. At the Garuda Silat Academy, Sukoharjo, preliminary observations indicated that leg power development was addressed primarily through technical drills and general conditioning, without a clearly periodized neuromuscular training framework. Although this approach has not yet resulted in acute performance deficits or injury spikes, it may limit the long-term development of explosive capacity required for modern competitive pencak silat. As competition intensity and tactical speed continue to increase, insufficient early exposure to appropriate power stimuli may become a latent constraint on athlete progression. (Diekfuss et al., 2021).

Adolescence represents a critical phase for neuromuscular development, during which the nervous system demonstrates heightened sensitivity to coordination and power related stimuli. However, concerns regarding growth-related injury risks often lead coaches to either delay or substantially reduce power training exposure. While excessive mechanical loading is indeed contraindicated, overly conservative approaches may result in under-stimulation during key developmental windows. Low-intensity plyometric exercises offer a balanced solution by providing neuromuscular activation and stretch–shortening cycle stimulation without imposing excessive external loads. This approach aligns with developmental training principles that emphasize movement quality and gradual progression over maximal output.

The highlighted problem is not the absence of training but the lack of an evidence based, age appropriate plyometric model that can safely enhance lower-limb explosive power in young pencak silat athletes. Coaches face a practical dilemma which is avoiding high intensity plyometrics to reduce injury risk, while simultaneously needing to improve leg power that is essential for kicking effectiveness, balance recovery, and rapid directional changes. This condition creates a training gap between performance demands and the methods deemed safe for adolescent athletes.

From a theoretical perspective, low intensity plyometric exercises offer a plausible solution to this problem. Grounded in neuromuscular adaptation theory and the stretch–shortening cycle framework, low intensity plyometrics emphasize movement efficiency, reactive strength, and motor control rather than maximal force production (Booth & Orr, 2016). Such exercises align with long-term athlete development principles, which prioritize gradual loading, technical proficiency, and neuromuscular coordination before the introduction of higher mechanical stresses.

However, despite strong theoretical support, the existing literature shows a clear research gap. Most previous studies on plyometric training in youth athletes focus on moderate to high intensity protocols, longer intervention durations, or combinations with resistance training (Chekle, 2025; Singh et al., 2025). Empirical evidence examining the isolated effect of short-term, low intensity plyometric programs on leg muscle power in young pencak silat athletes remains scarce. This lack of context-specific evidence limits coaches' confidence in implementing such programs systematically.

From a long-term athlete development perspective, low-intensity plyometric training serves as an appropriate foundation phase before the introduction of higher-intensity or externally loaded power exercises (Balyi et al., 2013). Integrating such training during early adolescence supports the gradual development of reactive strength and motor control, reducing the need for abrupt increases in training load at later stages. This progression may help mitigate injury risk while ensuring continuous performance development. Therefore, low intensity plyometrics should be viewed not as a limitation, but as a strategic entry point in structured power training pathways.

Therefore, the objective of this study is to analyze the effect of a six-week low intensity plyometric training program using a jumps-in-place model on leg muscle power in young pencak silat athletes. By addressing this gap, the study aims to provide empirical support for a training approach that is not only effective but also safe, practical, and compatible with the growth characteristics of adolescent athletes, thereby contributing to evidence-based long-term athlete development in pencak silat.

2. METHOD

This study uses a quasi-experimental method with a one group pretest–posttest design, which aims to identify changes in leg muscle power after the administration of exercise interventions. This design was chosen because it allows direct measurement of the effects of the treatment by comparing the condition of subjects before and after the intervention in the same group, even without the control group (Capili & Anastasi, 2024).

2.1 Participants

The subjects of the study were male pencak silat athletes with an average age of 15.35 years (SD = +- 0.58) as many as 20 people, representing the adolescent age group with relatively homogeneous physical development characteristics. All samples participated in a full series of studies and were in good health and actively participated in regular pencak silat training at Garuda Silat Academy, Sukoharjo, Central Java, Indonesia.

2.2 Research Design

This study uses a quasi-experimental method with a one group pretest–posttest design. A total of 20 male athletes of Garuda Silat Academy with an average age of 15.35 years (SD = +- 0.58) were given low-intensity plyometric training treatment with a jumps in place training model for 6 weeks on the sidelines of routine training. Tests were conducted at the beginning and end of the experiment to measure the athlete's leg muscle power before and after the treatment. The test result data is tested using a paired samples t-test so that the effects of the treatment that has been carried out can be seen.

2.3 Instruments

Measurement of leg muscle power was carried out using the standing broad jump test, which is a valid ($R2 = 0.78$; $p < 0.001$) and reliable ($ICC = 0.94$) instrument to assess the explosive power of leg muscles (Marin-Jimenez et al., 2024). The test is carried out twice, namely before the intervention (pretest) and after the entire training program is completed (posttest). Each test is carried out 3 times and then the average is calculated. The difference in results between pretest and posttest was used as the basis for analysis to determine the effect of low-intensity plyometric exercises jump in place model on leg muscle power of Garuda Silat Academy pencak silat athletes.

2.4 Procedures

The intervention was in the form of low-intensity plyometric exercises jump in place, which were carried out as an additional exercise program during the study period, namely 18 meetings (6 weeks, 3 times a week). The exercise is designed to stimulate increased explosiveness of the leg muscles through a stretch–shortening cycle mechanism, with an emphasis on vertical and explosive jump movements without displacement. The jump in place training program consists of a (1) Four-square plyometric pattern, (2) Eight-square plyometric pattern, (3) Munoz Formation, (4) Krumrie Formation which can be seen in Figure 1 (Chu & Myer, 2013). The training program uses the principle of progressive overload with details that can be seen in Table 1.

To ensure training fidelity, all plyometric sessions were supervised by qualified coaches with experience in youth athletic development. Exercise execution was continuously monitored to maintain proper technique, minimize ground contact errors, and prevent excessive fatigue.

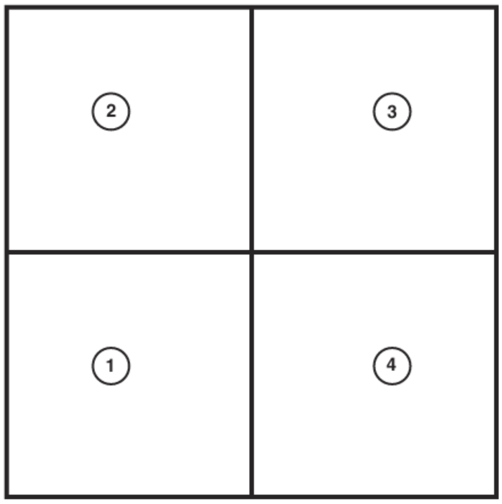
Attendance was recorded at each session, and all participants completed the full intervention without injury. This level of supervision ensured consistency in training exposure and strengthened the internal validity of the intervention outcomes.

2.5 Ethical Considerations

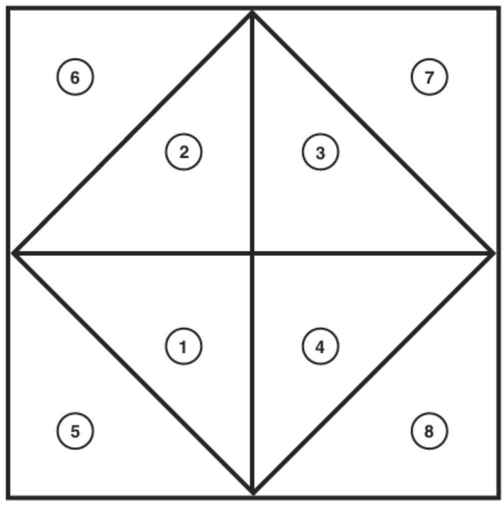
Ethical considerations were carefully addressed throughout the study. All participants and their parents were informed of the study objectives, procedures, and potential risks prior to participation, and written consent was obtained. The training program was designed to prioritize athlete safety by employing low mechanical loads and progressive volume increases. The study procedures adhered to ethical standards for research involving adolescent athletes and were conducted in accordance with established principles of sports science research.

Figure 1.

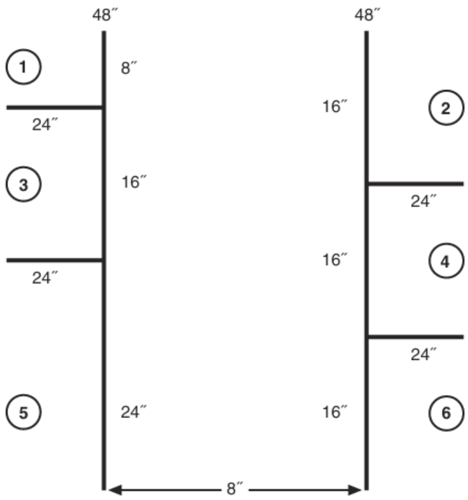
Variations of the plyometric exercise model Jumps in Place



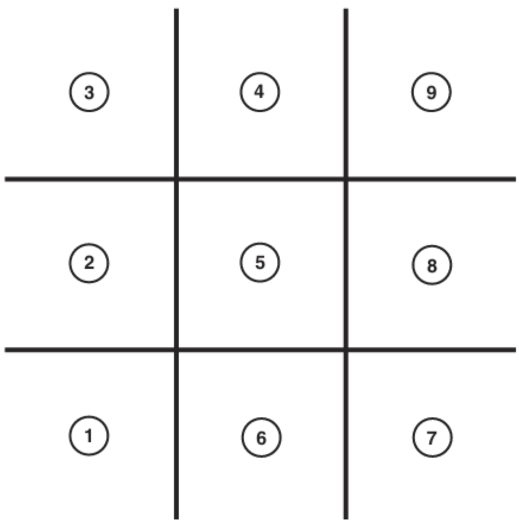
(1) Four Square Plyometric Pattern



(2) Eight Square Plyometric Pattern



(3) Munoz Formation



(4) Krumrie Formation

Table 1.

Training Program Volume

Week	Session	Repetition	Set	Rest beetwen sets	Repetition per session
			PRE-TEST		
1	1	4	3	3 Minutes	12
	2	4	3	3 Minutes	12
	3	4	3	3 Minutes	12
2	4	5	3	3 Minutes	15
	5	6	3	3 Minutes	18
	6	7	3	3 Minutes	21
3	7	8	3	3 Minutes	24
	8	9	3	3 Minutes	27
	9	10	3	3 Minutes	30
4	10	11	3	3 Minutes	33
	11	12	3	3 Minutes	36
	12	13	3	3 Minutes	39
5	13	14	3	3 Minutes	42
	14	15	3	3 Minutes	45
	15	12	4	3 Minutes	48
6	16	13	4	3 Minutes	52
	17	14	4	3 Minutes	56
	18	15	4	3 Minutes	60
			POST-TEST		

2.6 Data Analysis

The data taken in the pretest and the posttest were tested differently to determine the effect of low-intensity plyometric on the leg muscle power of Garuda Silat Pencak Silat athletes. Before the different tests were carried out, a prerequisite test was carried out in the form of a normality test using Shapiro Wilk. Differential tests were carried out using the paired samples t-test method to measure the difference between the initial test and the final test. Data analysis using SPSS Version 27.0.1.0 with a significance value of 0.05.

3. RESULTS

Prior to hypothesis testing, a prerequisite analysis was conducted to ensure that the data met the assumptions required for parametric testing. Normality of the pretest and posttest standing broad jump scores was examined using the Shapiro–Wilk test, as the sample size was fewer than fifty participants. Establishing data normality is essential to justify the use of paired samples t-test for detecting changes in leg muscle power following the intervention. The results of the normality test are presented in Table 2.

Table 2.

Normality test results

	Shapiro-Wilk		
	Statistic	Df	Sig.
Standing Broad Jump Pre Test	.980	20	.932
Standing Broad Jump Post Test	.942	20	.265

Source: Primary Data

The Shapiro–Wilk test results indicate that both pretest and posttest standing broad jump data were normally distributed, as reflected by significance values exceeding 0.05. This finding confirms that the distribution of the data did not deviate significantly from normality. Consequently, the assumptions for conducting a paired samples *t*-test were satisfied. This allowed further analysis to focus on evaluating the effect of the six-week low-intensity plyometric training intervention on leg muscle power.

After confirming data normality, a paired samples *t*-test was performed to examine changes in leg muscle power following the training intervention. This analysis aimed to determine whether the low-intensity plyometric program produced a statistically meaningful improvement in standing broad jump performance. The results of the paired comparison between pretest and posttest measurements are summarized in Table 3.

Table 3.

Paired samples t-test results

Paired Samples T-Test						
		Mean	Std. Deviation	t	df	Sig. (2-tailed)
Pair 1	Standing Broad Jump Post Test-Standing Broad Jump Pre Test	13.20	12.90	4.576	19	<.001

Source: Primary Data

The paired samples t-test revealed a statistically significant improvement in standing broad jump performance following the intervention ($p < 0.001$). This result indicates that the observed increase in leg muscle power was unlikely to have occurred by chance and can be attributed to the training program. The magnitude of improvement suggests that even low-intensity plyometric stimuli, when applied progressively, are sufficient to elicit meaningful neuromuscular adaptations in adolescent athletes. Overall, these findings demonstrate the effectiveness of a six-week jumps-in-place plyometric program in enhancing lower-limb explosive power in young pencak silat athletes.

Beyond statistical significance, the observed mean improvement of 13.2 cm in standing broad jump performance represents a meaningful enhancement in lower-limb explosive capacity for adolescent athletes. In practical terms, such an increase reflects improved force application and neuromuscular coordination, which are directly relevant to sport-specific actions such as kicking and rapid directional changes. Considering the relatively short duration and low intensity of the intervention, the magnitude of improvement underscores the responsiveness of young athletes to appropriately designed plyometric stimuli. These findings highlight the practical effectiveness of low-intensity plyometric training for performance enhancement in youth populations.

4. DISCUSSIONS

The results of this study demonstrated that six weeks of low-intensity plyometric training using a jumps-in-place model produced a significant improvement in leg muscle power in young pencak silat athletes. This improvement indicates that plyometric stimuli does not necessarily need to be high in intensity to elicit meaningful neuromuscular adaptations during adolescence. The findings support the notion that appropriately designed low-load exercises can effectively enhance explosive performance when applied consistently and progressively. Such outcomes are particularly relevant for youth athletes who are still undergoing musculoskeletal and neuromotor development.

The performance improvements observed in this study are likely driven primarily by neural and neuromechanical adaptations rather than structural muscular changes. Low intensity jumps in place exercises emphasize rapid force production, efficient utilization of elastic energy, and reduced ground contact time, all of which enhance stretch–shortening cycle efficiency. Such adaptations improve motor unit recruitment timing and intermuscular coordination, enabling athletes to generate explosive force more effectively. These mechanisms are particularly relevant in adolescent athletes, whose neuromuscular systems adapt rapidly to coordination-focused stimuli.

The observed increase in leg muscle power can be explained by improvements in stretch–shortening cycle (SSC) efficiency and neuromuscular coordination. Jumps-in-place exercises emphasize rapid ground contact, elastic energy utilization, and immediate force reapplication without excessive external loading. This type of stimulus promotes motor unit recruitment synchronization and improves the ability of the neuromuscular system to generate force quickly. Consequently, the gains observed in the standing broad jump likely reflect enhanced neuromechanical efficiency rather than increases in maximal muscle strength.

Compared with previous studies, the present findings are consistent with reports showing that plyometric training improves explosive performance in adolescent athletes (Singh et al., 2025). However, most existing research has focused on moderate to high intensity plyometric protocols or combined plyometric–resistance training programs. In contrast, the present study provides evidence that low-intensity plyometric training alone, when structured progressively, is sufficient to induce performance improvements (Walsh et al., 2025). This distinction is important, as it challenges the prevailing assumption that higher mechanical loads are necessary to improve leg muscle power in youth athletes.

From a sport-specific perspective, the jumps-in-place model has high relevance to the biomechanical demands of pencak silat (Syaifullah & Maghribi, 2023). Pencak silat techniques require athletes to maintain postural stability while generating explosive force for kicks, followed by rapid recovery of balance for defensive or counter-attacking movements. Jumps performed without horizontal displacement encourage control of the center of mass, precise foot placement, and efficient force transfer. These qualities directly support technical execution in pencak silat while minimizing unnecessary movement complexity (Taher et al., 2021).

The novelty of this study lies in its focus on a short-term, low-intensity plyometric intervention specifically applied to young pencak silat athletes. While theoretical frameworks support the use of low intensity plyometrics in youth training, empirical evidence within martial arts contexts remains limited. This study bridges that gap by demonstrating that a simple, safe, and sport-relevant plyometric model can effectively enhance leg muscle power without exposing athletes to high injury risk. As such, it contributes practical evidence to long-term athlete development strategies in combat sports.

The practical implications of these findings are significant for coaches and practitioners. Low-intensity jumps-in-place plyometrics can be easily integrated into regular training sessions without requiring specialized equipment or extensive recovery periods. This approach allows coaches to develop explosive capacity early while maintaining athlete safety and adherence to growth-sensitive training principles. Moreover, the simplicity of the exercises increases the likelihood of consistent implementation in youth training environments.

From a long-term athlete development perspective, low-intensity plyometric training serves as an appropriate foundation phase before the introduction of higher-intensity or externally loaded power exercises. Integrating such training during early adolescence supports the gradual development of reactive strength and motor control, reducing the need for abrupt increases in training load at later stages. This progression may help mitigate injury risk while ensuring continuous performance development. Therefore, low intensity plyometrics should be viewed not as a limitation, but as a strategic entry point in structured power training pathways.

However, this study has limitations, especially in the design of a one-group pretest–posttest without a control group, so that other factors such as adaptation of routine pencak silat training cannot be completely eliminated. In addition, the measurement of leg muscle power only uses standing broad jump, so it does not reflect the aspect of reactivity or unilateral force which is also important in pencak silat. Further research is recommended to use experimental designs with control groups, variations of measurement instruments using tests and momentum measurements that can quantify the destructive power of pencak silat kicks (Maghribi et al., 2024), as well as analysis of the long-term effects on engineering performance and injury risk.

Future research should employ randomized controlled designs to compare low-intensity plyometric training with other training modalities or intensity levels. Further studies are also encouraged to include biomechanical and sport-specific performance measures, such as reactive strength index, unilateral jump tests, and kick velocity or momentum analysis. Longitudinal investigations examining injury incidence and performance progression across developmental stages would provide deeper insight into the long-term benefits and safety of low-intensity plyometric training for young pencak silat athletes.

5. CONCLUSIONS

This study concludes that six weeks of low intensity plyometric training using a jumps-in-place model is effective in improving leg muscle power in young pencak silat athletes. The significant enhancement in standing broad jump performance indicates that meaningful neuromuscular adaptations can be achieved without reliance on high-intensity or high-load training stimuli. These findings support the application of age-appropriate, low-risk plyometric exercises as part of long-term athlete development programs. Incorporating progressively designed low intensity plyometrics may help coaches optimize explosive performance while minimizing injury risk in adolescent pencak silat athletes.

From a practical standpoint, the findings of this study suggest that coaches working with adolescent pencak silat athletes can safely implement low intensity jumps in place plyometric exercises as part of routine training. This approach enables the early development of explosive capacity without compromising athlete safety or recovery. Incorporating such exercises within youth training curricula may contribute to more systematic and sustainable long-term performance development. Consequently, low-intensity plyometrics represent a viable and evidence-based strategy for enhancing leg muscle power during critical developmental stages.

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