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Optimizing Leg Muscle Strength of Pencak Silat Athletes through Plyometric Training

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ABSTRACT

This study aims to determine the effect of plyometric training on improving leg muscle strength in Pencak Silat athletes at Paguron GEPAK. The research employed an experimental method with a One Group Pretest-Posttest Design, which is classified as a quasi-experimental type. The sample consisted of 15 Pencak Silat athletes selected using a purposive sampling technique. The data collection instrument used was the Vertical Jump test (Miller, 2010), which measures lower-limb explosive power. The plyometric training program was conducted over six weeks with a frequency of three sessions per week, including exercises such as squat jumps, box jumps, lateral jumps, depth jumps, and standing broad jumps. Data were analyzed using a Paired Sample t-test with the assistance of SPSS version 26.0. The results showed a significant difference between the pretest and posttest scores of the Vertical Jump, with an average improvement of 16.33 cm. The calculated t-value was -6.336 with a significance level of 0.000 (< 0.05), indicating that plyometric training had a significant effect on increasing leg muscle strength. It can be concluded that plyometric training is effective in enhancing leg muscle strength and explosive power among Pencak Silat athletes. The improvement occurred due to neuromuscular and mechanical adaptations resulting from the Stretch Shortening Cycle (SSC) principle in plyometric exercises. Therefore, this training program is recommended as part of physical conditioning to improve explosive performance in Pencak Silat athletes.

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INTRODUCTION

Sports play a crucial role in developing physical fitness, motor skills, endurance, and overall health. In the context of competitive sports, every discipline requires the development of specific physical abilities suited to the nature of the movements involved in competition. One of the most fundamental components of athletic performance is physical conditioning, particularly muscle strength (Bompa Tudor, O., & Haff, 2009).

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Muscle strength is essential for producing force, maintaining body stability, and supporting technical efficiency across various sports. In martial arts such as pencak silat, leg muscle strength is especially important because most offensive and defensive techniques rely heavily on lower-body movements, such as kicks, stances, and push-offs (et al., 2024). A powerful and precise kick depends not only on technical mastery but also on the explosive power and strength of the leg muscles as the main driving force. Therefore, enhancing leg strength is a primary focus in the training programs of pencak silat athletes.

One of the most effective methods to improve muscular strength and power is plyometric training. Plyometrics involves exercises that combine an eccentric muscle action (stretching) followed by a rapid concentric contraction, known as the stretch-shortening cycle (Chu, D. A., & Meyer, 2013). The core principle of plyometrics is to utilize the elastic energy stored in muscles and tendons during the stretching phase and release it during the explosive phase to generate greater power output. Typical plyometric exercises include jump squats, box jumps, bounding, and depth jumps, all designed to develop lower limb power (Markovic & Mikulic, 2010).

In martial arts, plyometric training enhances athletes' ability to perform explosive movements such as kicks, jumps, and quick direction changes, which are vital in competitive situations. Previous research has shown that plyometric training can significantly improve power, speed, and leg muscle strength among athletes from various sports, including football, volleyball, and martial arts (Davies et al., 2015). However, the effectiveness of this method depends on factors such as training intensity, frequency, and the alignment of the program with the athletes' characteristics and the demands of their specific sport.

Paguron GEPAK, as one of the active pencak silat training centers, emphasizes physical conditioning as a key component of its athlete development program. However, preliminary observations indicate that some athletes still display limitations in lower-body strength and explosive power, which affects their kicking performance. This condition highlights the need for a more specific and measurable training method to develop these capabilities.

Therefore, the implementation of plyometric training is considered a promising alternative to improve the leg muscle strength of pencak silat athletes at Paguron GEPAK. When designed systematically and based on sound training principles such as specificity, overload, and progression, plyometric exercises are expected to enhance athletes' explosive ability and technical performance during competition.

Based on this rationale, the present study aims to analyze the effect of plyometric training on the improvement of leg muscle strength in pencak silat athletes at Paguron GEPAK. The findings are expected to contribute to the development of more effective physical training methods for martial arts coaches and sports practitioners, particularly in optimizing lower-body strength and explosive performance.

METHODS

This study employed an experimental method with a One Group Pretest-Posttest Design, which is classified as a quasi-experimental type experiment (Auliya et al., 2020). This design involves a single group of subjects who are given a pretest to measure their initial condition before the treatment is applied. Afterwards, the same group receives a plyometric training program as the treatment, which serves as the focus of the study. Subsequently, a posttest is conducted to determine the changes or effects resulting from the treatment. The purpose of this design is to examine the extent to which plyometric training influences the improvement of leg muscle strength among Pencak Silat athletes at Paguron GEPAK. This design allows researchers to compare the results before and after the treatment within the same group, thereby providing a clear picture of the treatment's effect, even in the absence of a control group for comparison.

The population in this study consisted of all pencak silat athletes from Paguron GEPAK who actively participated in regular training sessions. The research sample was selected using a purposive sampling technique, which involves selecting participants based on specific considerations relevant to the research objectives (Muhid, 2019). The total sample consisted of 15 athletes who met the following criteria: Actively participated in pencak silat training for at least the last three months, did not suffer from lower limb muscle injuries during the research period, and willingly participated in the entire plyometric training program until completion.

The instrument used to measure leg muscle strength is the Vertical Jump test (Miller, 2010). This test aims to measure the explosive power of the leg muscles, which reflects the muscles' ability to generate force quickly and maximally. The equipment used includes a measuring tape or measuring stick attached to a wall, chalk for marking the point of touch, and a wall with adequate height. The testing procedure consists of: 1) The participant stands upright beside the wall and measures their standing reach height; 2) The participant then jumps as high as possible to touch the wall using chalk-marked fingertips; and 3) the difference between the standing reach and the highest touch point is recorded as the vertical jump height. Each participant is given three attempts, and the highest score is taken as the final result. Measurements are expressed in centimetres (cm). This test has a validity of 0.78 and a reliability of 0.93. The test is conducted on a flat, non-slippery surface, and participants are required to wear appropriate sports attire.

The research was conducted in three stages, namely:

1. Initial Measurement Stage (Pretest): Before the training began, all samples underwent a vertical jump test to measure leg muscle strength. The results were used as baseline data before the treatment.
2. Treatment Stage (Plyometric Training):
   The participants underwent a six-week plyometric training program with three sessions per week (Potach, David H., and Chu, 2008), each lasting 20–30 minutes, plus 10–20 minutes for warm-up and cool-down (Chu, D. A., & Meyer, 2013; Powers & Howley, 2021). The exercises included squat jumps, box jumps, lateral jumps, depth

jumps, and standing broad jumps, aimed at developing lower-limb explosive power. Training intensity and jump height were adjusted weekly based on each athlete's ability and fatigue level, while movements were performed across multiple planes to simulate pencak silat techniques. Reactive drills such as quick step jumps and rebound jumps were incorporated to improve stretch-shortening cycle (SSC) efficiency and rate of force development (RFD). Each session also integrated core stability and balance exercises to enhance postural control and reduce injury risk. The overall training followed the principle of progressive overload, gradually increasing intensity, volume, and complexity to ensure optimal muscular and neural adaptation and effective transfer to pencak silat performance.

3. Final Measurement Stage (Posttest): After completing the training program, all samples took the vertical jump test again using the same procedure as the pretest to determine the changes that occurred after the treatment.

The data from the pretest and posttest were analyzed using a paired sample t-test with the assistance of SPSS software version 26.0. This test was used to determine whether there was a significant difference between the results before and after the treatment (Nuryadi et al., 2017). The decision-making criteria were as follows: if the Sig. (2-tailed) A value was < 0.05 indicated a significant difference between the pretest and posttest results. Conversely, if the Sig. (2-tailed) value was ≥ 0.05, it indicated no significant difference.

RESULTS AND DISCUSSION

Descriptive Analysis

This section presents the results of the descriptive analysis of the leg muscle strength data of pencak silat athletes who participated in the study. The descriptive analysis was conducted to provide a general overview of the pretest and posttest results after the implementation of the plyometric training program. A total of 15 pencak silat athletes from Paguron GEPAK were involved in this study. The descriptive analysis includes the mean (M), total score (ΣX), and standard deviation (σ) for the pretest, posttest, and gain (the improvement difference between posttest and pretest). These data were used to observe the general trend of leg muscle strength improvement following the plyometric training intervention. The complete descriptive analysis results of leg muscle strength are presented in the following table:

Table 1.
Descriptive Analysis

Variable	Source Statistics	Pretest	Posttest	Gain
Vertical Jump	N	15	15	15
	M	52,53	68,87	16,33
	ΣX	788	1033	245
	σ	6,79	6,93	9,98

Based on the results of the descriptive analysis in the table above, it is known that the total sample of the study consisted of 15 pencak silat athletes from Paguron GEPAK.

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The variable measured was leg muscle strength, assessed using the Vertical Jump test and expressed in centimetres (cm). The pretest results showed that the mean (M) vertical jump ability before the plyometric training program was 52.53 cm, with a standard deviation (σ) of 6.79 and a total score (ΣX) of 788. These values indicate that the athletes' initial leg muscle strength was at a moderate level, suggesting potential for improvement through appropriate training interventions.

After the plyometric training program was implemented during the intervention period, an increase was observed in the posttest results, with the mean score rising to 68.87 cm, a standard deviation of 6.93, and a total score (ΣX) of 1033. This indicates a considerable improvement in explosive leg power as shown by the descriptive data. The difference or gain between the pretest and posttest scores reached 16.33 cm, with a standard deviation of 9.98 and a total difference score (ΣX) of 245. These findings suggest that the plyometric training program had a positive effect on enhancing leg muscle strength among pencak silat athletes at Paguron GEPAK.

Overall, based on the descriptive analysis, it can be concluded that there was a noticeable improvement in vertical jump performance after the plyometric training was administered. Therefore, plyometric training is effective in improving the explosive power of the leg muscles, which is highly essential in the sport of pencak silat.

Normality Test Results

Before conducting hypothesis testing, it is necessary to perform a prerequisite analysis to ensure that the data meet the assumptions required for parametric statistical tests. One of the essential assumptions is that the data must be normally distributed. The normality test was conducted to determine whether the pretest and posttest data of leg muscle strength, measured through the vertical jump test, followed a normal distribution. In this study, both the Kolmogorov–Smirnov and Shapiro–Wilk tests were used to assess data normality. The Shapiro–Wilk test was used as the primary reference because the sample size was relatively small ($n < 50$). The results of the normality test for the pretest and posttest data are presented in the following table.

Table 2.
Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Preetest Vertical Jump	.160	15	.200*	.919	15	.184
Posttest Vertical Jump	.209	15	.078	.896	15	.083

Lilliefors Significance Correction

The data normality test was conducted using the Shapiro–Wilk test with a significance level of $\alpha = 0.05$. The analysis results showed that the pretest Vertical Jump data had a significance value of 0.184, while the posttest data had a significance value of 0.083. Since all significance values were greater than 0.05, it can be concluded that the data were normally distributed.

Results of Hypothesis Test

After confirming that the research data were normally distributed and met the assumptions required for parametric testing, the next step was to conduct a hypothesis test to determine the effect of plyometric training on improving leg muscle strength among pencak silat athletes at Paguron GEPAK. The hypothesis test in this study employed a Paired Sample t-test, as the analyzed data were derived from two related measurements—namely, the pretest and posttest results of the vertical jump ability within the same group. The results of the hypothesis test are presented in Table 3 below.

Table 3.

Results of Hypothesis Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Vertical Jump (Pretest) - Vertical Jump (Posttest)	-16.333	9.983	2.578	-21.862	-10.805	-6.336	14	.000

The results of the hypothesis test using the Paired Sample t-test showed that there was a significant difference between the pretest and posttest results of the Vertical Jump performance of pencak silat athletes after being given plyometric training. The mean difference between the pretest and posttest scores was -16.333, indicating an average improvement of 16.33 cm in Vertical Jump performance after the intervention. The obtained t-value was -6.336 with degrees of freedom (df) = 14, and a significance value (Sig. 2-tailed) = 0.000 < 0.05. Therefore, it can be concluded that plyometric training had a significant effect on improving the leg muscle strength of pencak silat athletes at Paguron GEPAK. This result is supported by the 95% confidence interval (CI), ranging from -21.862 to -10.805, which does not include zero, thereby strengthening the evidence that the improvement is statistically significant.

The research results indicate that there was a significant difference between the pretest and posttest results of the Vertical Jump performance of pencak silat athletes after undergoing plyometric training, with a t-value = -6.336 and a significance value (Sig. 2-tailed) = 0.000 (< 0.05). This means that plyometric training had a positive and significant effect on improving the leg muscle strength of pencak silat athletes at Paguron GEPAK. The average improvement of 16.33 cm demonstrates a clear physiological adaptation following the implementation of the training program.

This finding is consistent with the theory stating that plyometric training is a form of exercise designed to enhance the muscle's ability to generate force in a short period of time through the utilization of the Stretch Shortening Cycle (SSC)—a rapid and sequential process of muscle stretching (eccentric) followed by shortening (concentric) (Jason C. Casey and Chris A. Bailey, 2021). The SSC mechanism plays a crucial role in improving explosive leg power, which is a key factor in vertical jump performance (Sole, 2018).

Plyometric training can enhance the efficiency of the neuromuscular system by increasing motor unit recruitment, intramuscular coordination, and the speed of nerve impulse transmission to the muscle fibres (Bompa & Buzzichelli, 2019). This allows the muscles to contract more forcefully and rapidly, ultimately improving vertical jump performance. Furthermore, systematically performed plyometric training can improve the muscle's ability to store and release elastic energy, leading to a significant increase in explosive strength (Wee, E et al., 2011).

The improvement in vertical jump performance in this study is also consistent with the findings of (Markovic & Mikulic, 2010), who, in their meta-analysis, concluded that plyometric training consistently produces significant increases in vertical jump height, particularly when performed for at least 6–8 weeks with a frequency of 2–3 sessions per week. The adaptations that occur include enhancements in the rate of force development (RFD), reactive strength, and the ability of the nervous system to generate maximal force in a short period of time.

In the context of pencak silat, leg muscle strength plays a crucial role in supporting various techniques such as kicking, jumping, and rapid body position changes (Jamal et al., 2024). The improvement in vertical jump performance indicates an enhancement in explosive leg power, which ultimately contributes to better movement performance during competition. Leg strength and explosive power are key biomotor components that must be developed in sports requiring quick and explosive movements, such as pencak silat (Bompa & Buzzichelli, 2019).

Physiologically, the adaptations resulting from plyometric training include increased muscle contraction strength, enhanced stretch reflex (myotatic reflex) efficiency, and improved tendon capacity to store elastic energy (Mănescu, 2025). The combination of these mechanical and neural factors forms the foundation for the improvement in explosive power following a plyometric training program (Potach, David H., and Chu, 2008). These adaptations explain why the average vertical jump performance showed a significant increase in this study

Thus, the results of this study support previous theories and empirical findings indicating that plyometric training is effective in enhancing leg muscle strength and explosive power. The implementation of a well-structured plyometric program, designed in accordance with proper training principles—including appropriate intensity, volume, and recovery time—has been proven to produce optimal improvements in the physical performance of pencak silat athletes.

CONCLUSION

The author would like to express sincere gratitude to Paguron GEPAK for the permission, support, and facilities provided throughout the research process. Special thanks are also extended to the coach and all pencak silat athletes of Paguron GEPAK for their enthusiastic participation in the plyometric training program and the data collection process.

The support and cooperation provided by the paguron greatly contributed to the smooth implementation of this study, from the planning stage and training implementation to the completion of the final report. The author hopes that the results of this research will provide a meaningful contribution to the development of pencak silat training, particularly in the application of plyometric exercises to improve the leg muscle strength of athletes.

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