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Research article

The Effect of Plyometric Exercise on Leg Muscle Power, Kick Speed and Agility of Pencak Silat Athletes

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Abstract: This study aims to examine the effect of plyometric training on leg muscle strength, kicking speed, and agility of pencak silat athletes. The background of this study is based on the need to improve athlete performance through effective training methods. Plyometric training is known for its explosive movements that can increase muscle strength and speed. This research method involved a sample of pencak silat athletes who underwent a plyometric training program for eight weeks. Leg muscle strength measurements were carried out using a vertical jump test, kicking speed was assessed based on the number of kicks per minute, and agility was evaluated through a shuttle run test. The results showed a significant increase in both performance metrics. After eight weeks, there was a significant increase in leg muscle strength as measured by vertical jump height (sig = 0.001). In addition, kicking speed also increased significantly in the right leg (sig = 0.001) and left leg (sig = 0.041), as seen from the higher number of kicks per minute. However, athlete agility showed no significant improvement (sig = 0.71). Based on the results of special agility training. In conclusion, plyometric training has been shown to be an effective training method to improve key athletic attributes in pencak silat athletes. These significant increases in leg muscle strength, kicking speed, and agility contributed to improvements in the athletes' overall performance. These findings emphasize the importance of incorporating plyometric training into the routine training regimen of martial arts athletes to achieve optimal athletic development and better competitive performance.

Keywords: Plyometric Exercise, Leg Muscle Power, Kick Speed, Agility, Pencak Silat

1. Introduction

Pencak silat is a traditional Indonesian martial art that has developed into a multifaceted discipline encompassing elements of self-defense, art, culture, and competitive sport [1]. Originating from various regions across the Indonesian archipelago, pencak silat reflects local wisdom and philosophical values such as respect, discipline, and harmony between physical strength and mental composure [2]. In recent decades, this martial art has gained international recognition through organizations such as the International Pencak Silat Federation (PERSILAT), and has been featured in global sporting events including the Southeast Asian (SEA) Games and the Asian Games. This expansion underscores its transformation from a traditional heritage practice into a modern, standardized sport governed by specific rules and performance criteria [3].

As a combat sport, success in pencak silat competition depends not only on technical mastery and tactical awareness but also on an athlete's physical fitness, particularly in aspects such as muscle strength, explosive power, agility, balance, and coordinatio [4]. Among these, lower limb muscle power and agility play a pivotal role. Powerful and explosive leg movements enable athletes to execute rapid offensive actions such as kicks, sweeps, and leaps with high force and precision, while agility allows them to quickly evade, counter, or reposition themselves during dynamic exchanges [5]. These attributes are crucial in maintaining dominance in both attacking and defensive phases of combat, where milliseconds can determine victory or defeat.

Lower limb muscle power refers to the capacity of leg muscles to generate maximal force in a short duration, typically measured through explosive actions such as vertical jumps, sprints, or rapid kicks [6]. his power results from efficient recruitment of fast-twitch muscle fibers, neuromuscular coordination, and elastic energy utilization in tendons. In pencak silat, leg power directly influences the speed and impact of strikes, the height and stability of leaps, and the overall dynamism of movement [7]. Agility, on the other hand, encompasses the ability to rapidly change direction, accelerate or decelerate, and maintain body control under variable and unpredictable movement demands [8]. For a pencak silat athlete, agility supports quick transitions between offensive and defensive stances, effective feints, and timely dodging of attacks. Therefore, improvements in both power and agility can collectively enhance performance efficiency and competitive readiness.

Plyometric exercise has been identified as one of the most effective training methods to improve explosive power and agility. This form of exercise involves a rapid sequence of muscle stretching (eccentric phase) followed immediately by contraction (concentric phase), a mechanism known as the stretch-shortening cycle (SSC) [9]. Typical plyometric activities include jump squats, bounding drills, depth jumps, and sprint starts, all designed to increase the force and speed of muscle contractions [10]. Physiologically, plyometric training enhances neuromuscular activation, increases the rate of force development, and improves muscle elasticity—factors that are directly related to power and agility output [11].

Numerous studies across various sports such as basketball, soccer, and athletics have demonstrated the effectiveness of plyometric training in enhancing muscle power and agility performance indicators [12]. However, research specifically focusing on pencak silat athletes remains limited. Considering the technical and tactical demands of pencak silat, it is reasonable to hypothesize that plyometric training could produce similar or even greater benefits in this population, given the sport's heavy reliance on lower limb explosiveness and rapid directional changes [13].

This study aims to investigate the effects of plyometric exercise on lower limb muscle power and agility in pencak silat athletes. By measuring changes in these attributes before and after a period of plyometric training, the research seeks to determine

the effectiveness of this training method. The specific objectives include assessing the increase in muscle power, evaluating improvements in agility, and analyzing the overall impact on athletic performance.

The results of this research are expected to contribute significantly to the field of sports science, particularly in the context of martial arts training. By providing empirical evidence on the benefits of plyometric exercise for pencak silat athletes, this study can help inform training practices and program designs. Moreover, it can highlight the potential of incorporating plyometric exercises into the regular training regimen of pencak silat athletes to enhance their competitive edge.

In conclusion, this study will explore the role of plyometric exercise in improving lower limb muscle power and agility among pencak silat athletes. The findings are anticipated to offer practical recommendations for coaches and athletes aiming to enhance their performance through targeted training interventions. By advancing our understanding of effective training methods, this research aims to support the continued development and success of pencak silat athletes on both national and international stages.

2. Materials and Methods

2.1. Research Design

This study employed a quantitative experimental design using a one-group pre-test and post-test approach [14]. The purpose of this design was to evaluate the effect of an eight-week plyometric training intervention on lower limb muscle power, kick speed, and agility among pencak silat athletes. The pre-test and post-test measurements were conducted to compare the athletes' performance before and after the training program, allowing for an objective assessment of the training's effectiveness.

2.2. Participants

The study involved 45 pencak silat athletes who were active members of the Pencak Silat Team of Universitas Muhammadiyah Purwokerto (UMP). The participants consisted of both male and female athletes aged between 18 and 25 years. A total sampling technique was applied, meaning that all available team members who met the inclusion criteria were selected as research subjects.

The inclusion criteria were as follows:

1) Athletes in good general health and free from any illness or medical condition that could interfere with training performance.
2) Athletes who had no current or recent musculoskeletal injuries, particularly in the lower extremities.
3) Athletes who were willing to participate voluntarily and complete the entire training program.

The exclusion criteria included:

1) Athletes with a history of severe muscle, ligament, or knee joint injuries.
2) Participants who failed to complete more than 10% of the training sessions.
3) Individuals who experienced injury or illness during the intervention period.

Prior to data collection, all participants received a detailed explanation of the study's purpose and procedures, and written informed consent was obtained. Ethical approval was granted by the Health Research Ethics Committee of Universitas Muhammadiyah Purwokerto.

2.3. Research Procedure

The research procedure consisted of three main stages: preliminary assessment (pre-test), plyometric training intervention, and final assessment (post-test) [15].

2.3.1. Preliminary Assessment (Pre-test)

At the beginning of the study, demographic and anthropometric data—including age, gender, height, and body weight—were collected. A basic health screening was conducted to ensure that all participants were physically fit to undergo the exercise program.

Following the screening, baseline performance tests were carried out:

- Lower limb muscle power was assessed using the Vertical Jump Test [16]. Each participant stood with feet shoulder-width apart and performed three maximal vertical jumps, with a brief rest between attempts. The highest jump height (in centimeters) was recorded as the final result.
- Kick speed was evaluated by asking participants to perform continuous roundhouse kicks (*tendangan sabit*) for one minute. The total number of successful kicks was counted and recorded.
- Agility was measured using the Shuttle Run Test (4 × 10 meters) [14]. The time required to complete the course was measured using a stopwatch, and the best of two attempts was used for analysis.

2.3.2. Plyometric Training Intervention

The plyometric training program was administered for eight weeks, three sessions per week on non-consecutive days, with a duration of approximately 60 minutes per session (warm-up, main exercise, and cool-down). To provide a more detailed overview of the intervention, the complete exercise progression is presented in Table 1.

Table 1. Plyometric Intervention

Week	Exercises	Sets	Repetitions / Distance	Progression Focus
1–2	Squat jumps	3	10 reps	Initial adaptation to explosive movement
1–2	Lateral bounds	3	8 reps each side	Frontal plane strength and power
1–2	Sprint 10 m	4	4 trials	Acceleration development
3–4	Box jumps	4	8 reps	Increased vertical power demand
3–4	Lateral bounds	4	10 reps each side	Load and volume progression
3–4	Sprint 15 m	4	4 trials	Increased neuromuscular speed requirement
5–6	Depth jumps	4	6 reps	Introduction of stretch-shortening-cycle challenge
5–6	Bounding hops	4	15 m × 4 sets	Reactive elastic strength
5–6	Sprint 20 m	5	4 trials	High-intensity speed component
7–8	Depth jumps	5	8 reps	Maximum power intensity
7–8	Bounding hops	5	20 m × 4 sets	Increased plyometric distance
7–8	Shuttle sprint change-of-direction	5	4 rounds	Integration of reactive directional speed

2.3.3. Post-Test Assessment

After the completion of the eight-week program, all participants repeated the same tests performed during the pre-test phase—vertical jump, kick speed, and shuttle run—using identical procedures and equipment. The post-test results were then compared with pre-test data to determine the effectiveness of the plyometric training program.

2.4. Data Analysis

Data obtained from the pre-test and post-test measurements were analyzed using paired sample t-tests to evaluate significant differences before and after the intervention. Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 23 (IBM Corp., Armonk, NY, USA). The level of significance was set at $p < 0.05$. Descriptive statistics (mean ± standard deviation) were also calculated for each variable to describe the overall characteristics of the data set.

3. Results

Table 2. Respondents' Characteristics

Variable	Mean (SD)
Age (years)	22,27±2,4
Body Height (cm)	167,9± 9,23
Body Weight (kg)	62,3± 7,31
IMT	23,47±2,58
Time became athlete (years)	6,85±1,75
Number of exercise in one week	3,5±0,42

Based on the data obtained, the study involved a total of 45 pencak silat athletes from the University of Muhammadiyah Purwokerto who actively participate in regional and national-level tournaments. The participants had an average age of 22.27 ± 2.40 years, with a mean height of 167.9 ± 9.23 cm and an average body weight of 62.3 ± 7.31 kg. The calculated body mass index (BMI) was 23.47 ± 2.58, which falls within the normal range according to WHO classification.

On average, the athletes had 6.85 ± 1.75 years of experience in pencak silat training and competition, indicating a well-trained and experienced group. In terms of training frequency, participants reported attending structured training sessions 3.5 ± 0.42 times per week, consistent with typical conditioning schedules for competitive pencak silat athletes. All participants were active team members regularly involved in the official training programs organized by the university's pencak silat club.

These characteristics demonstrate that the study sample represents a population of young adult athletes in good physical condition, with adequate training experience and regular exercise habits, thus suitable for participation in a controlled plyometric training intervention.

Table 3. Average Research Results

Variable	Pre-test	Post-test	Sig
Vertical Jump	28,1	30,9	0,001
Kick Speed			
Right Foot	26,8	28,5	0,001
Left Foot	26,3	26,9	0,041
Agility	16,2	16,1	0,072

Based on the data presented in Table 3, there was a noticeable improvement in lower limb muscle power as indicated by the vertical jump test. The mean vertical jump height increased from 28.1 cm in the pre-test to 30.9 cm in the post-test, with a p-value of 0.001 ($p < 0.05$), indicating a statistically significant improvement. This result suggests that the eight-week plyometric training program effectively enhanced the explosive power of the lower extremity muscles among pencak silat athletes.

In terms of kick speed, both the right and left legs showed improvements following the training intervention. The right leg increased from 26.8 to 28.5 kicks per minute with a p-value of 0.001, indicating a statistically significant change. Similarly, the left leg increased from 26.3 to 26.9 kicks per minute, with a p-value of 0.041, also showing a significant improvement, albeit to a lesser extent than the right leg. These

results suggest that plyometric training contributes positively to neuromuscular performance, allowing for faster and more coordinated lower limb movements that are essential in pencak silat kicking techniques.

However, the results were different for agility performance. The mean time required to complete the shuttle run slightly decreased from 16.2 seconds in the pre-test to 16.1 seconds in the post-test, but the p-value of 0.072 ($p > 0.05$) indicates that the change was not statistically significant. This finding suggests that the plyometric training program did not produce a meaningful improvement in agility within the given training duration and structure.

Overall, the findings indicate that plyometric exercise had a significant effect on lower limb muscle power and kick speed, but not on agility. The improvement in vertical jump and kick speed may be attributed to the nature of plyometric movements, which primarily target the enhancement of the stretch-shortening cycle (SSC), resulting in greater force production and faster muscle contraction.

In contrast, the lack of significant improvement in agility may be due to the specific characteristics of the training program, which focused more on vertical and linear explosive movements rather than multi-directional speed and change-of-direction drills typically required to improve agility. Future training programs might consider integrating specific agility-based plyometric exercises or sport-specific movement patterns to produce more comprehensive performance enhancements.

3. Discussion

Plyometric training, also known as plyometrics, is a well-established and effective method to enhance lower limb muscle power and explosive movement performance, particularly in actions that involve rapid force production such as vertical jumping and kicking [7]. This training method is widely applied in sports that demand speed, power, and quick reaction times, including martial arts such as pencak silat. Plyometric exercises are based on the stretch-shortening cycle (SSC) principle, in which muscles store elastic energy during the eccentric (lengthening) phase and release it rapidly during the concentric (shortening) phase. This physiological mechanism allows muscles to generate greater force and improve movement efficiency [15].

Numerous studies have demonstrated that a 6- to 8-week plyometric training program can significantly increase vertical jump height and overall muscular performance. Research published in the *Journal of Strength and Conditioning Research* reported that eight weeks of structured plyometric training resulted in more than a 10% improvement in vertical jump height among athletes, attributed to enhanced neuromuscular activation and elastic energy utilization [17]. Similarly, Dewangga (2024) explained that regular plyometric training increases the muscle's ability to store and release elastic energy, optimizes motor unit recruitment, and improves both the rate and magnitude of force production. These adaptations collectively contribute to better performance in explosive movements such as vertical jumping, sprinting, and kicking [18].

Beyond increasing muscle strength and power, plyometric training provides neuromuscular benefits by improving coordination between the central nervous system and the muscular system [19]. Effective plyometric execution requires precise timing and synchronization of agonist and antagonist muscle groups, which enhances reaction time, balance, and motor control [17]. As a result, this training modality not only improves physical capacity but also develops functional athletic skills essential for complex movements in dynamic sports contexts.

In *pencak silat*, kicking speed and power are crucial components of both offensive and defensive techniques. Previous studies have indicated that plyometric training can significantly increase kicking speed, as it enhances the contractile efficiency of

the lower extremity muscles [20], [21]. A study published in the *International Journal of Human Movement and Sports Sciences* reported that an eight-week plyometric intervention significantly increased the number of kicks per minute among pencak silat athletes [13]. This improvement is primarily due to increased muscle-tendon stiffness and neuromuscular efficiency, enabling faster and more powerful leg movements.

However, while plyometric training has been shown to enhance explosive strength and movement speed, its effects on agility remain inconsistent. Some research suggests that inadequate exercise variation, poor technical execution, or excessive training loads can limit gains in agility or even increase fatigue and risk of injury [18], [22]. Moreover, individual differences—such as baseline fitness level, neuromuscular coordination, and recovery capacity—can influence the effectiveness of plyometric programs [23]. Therefore, to achieve optimal results, plyometric training should be carefully designed, progressively structured, and supervised by experienced coaches or exercise specialists to ensure correct technique, appropriate intensity, and sufficient recovery [24].

Overall, plyometric training represents a scientifically grounded and functionally relevant method to improve lower-limb power, kicking speed, and neuromuscular coordination, all of which are key determinants of athletic performance in pencak silat and other explosive sports.

5. Conclusions

In conclusion, plyometric training is effective in increasing kicking power and speed in pencak silat athletes, as tested by the number of kicks per minute. This training involves explosive movements that increase muscle strength and speed, which are important for fast kicks. However, in this study, plyometric training could not significantly increase agility, this result could be caused by several factors, one of which is fatigue, and unsupervised training patterns. With the right training program and supervision from an experienced coach, pencak silat athletes can see significant improvements in their kicking speed and competitive ability.

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