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RESEARCH ARTICLE

The effect of six-week plyometric, functional, and interval trainings on body composition, power, and kicking speed in male Pencak Silat University Athletes

Johansyah LUBIS [1*], Arıdhotul HAQIYAH[2,5], Agung ROBIANTO[1], Srı Indah IHSANI[1], Hendro WARDOYO[1], Shela GINANJAR[1], Astrı Ayu IRAWAN[3], Srı SUMARTININGSIH[4], Ikhwan SETIAWAN[1], Raka Ardıansyah LUBIS[1], Kadek Herı SANJAYA[5] and Dwi Esti KUSUMANDARI[5]

[11]Universitas Negeri Jakarta, Sport Science Department, Jakarta / Indonesıa
[2]Universitas Islam 45, Physical Education Health and Recreation, Bekasi / Indonesıa
[3]Universitas Singaperbangsa Karawang, Physical Education Health and Recreation, Karawang / Indonesıa
[4]Universitas Negeri Semarang, Sport Science Department, Semarang / Indonesıa
[5]Badan Riset dan Inovasi Nasional (BRIN), Research Centre for Smart Mechatronics, Bandung / Indonesıa
*Corresponding author: johansyah.sport@unj.ac.id

Abstract
This study was aimed at investigating the effects of six-week Plyometric, Functional, and Interval training on body composition, power, and kicking speed. The study employed an experimental research design involving twenty male university students who were practitioners of Pencak Silat sports, following informed consent (average age 20.2 ± 1.32 years, height 168.9 ± 5.70 cm, body weight 63.74 ± 11.54 kg). The students were not isolated; their food intake and sleep patterns were not controlled, but they were advised not to stay up late and to avoid smoking and consuming alcoholic beverages. Participants engaged in Plyometric training once a week on Mondays, functional training once a week on Wednesdays, and interval training once a week on Fridays. Plyometric, Functional training and Interval training (PFIT) was performed for 70-80 minutes per session, for six weeks, with low intensity and moderate volume on 90 -120 contacts. There were significant improvements ($p < 0.05$) in flexibility, force and pear power, jump height and left kick speed. Body fat, muscle mass, visceral fat and bone density also experienced significant changes ($p < 0.05$). However, the PFIT training did not cause significant changes in right kick speed, as well as fat content, protein content and basal metabolism ($p > 0.05$).

Keywords
Plyometric, Functional Training, Interval Training, Body Composition, Power, Kick Speed

INTRODUCTION

To achieve optimal performance in Pencak Silat martial arts competitions, a combination of speed, strength, and power is essential for point generation (Lubis et al., 2021). Nearly all sports disciplines require explosive power (Bompa & Buzzichelli, 2019), and one training approach that shows potential for enhancing muscle strength, power, hypertrophy, and endurance is High Intensity (Lubis et al., 2021).

Functional Training (HIFT). However, due to the metabolic stress effects of this training, a proper dosage of exercises needs to be determined (Neto & Kennedy, 2019). HIFT also impacts the recovery of the Autonomic Nervous System (ANS) (Kliszczewicz et al., 2018), as it emphasizes multi-joint functional movements that

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can be adapted to fitness levels, such as CrossFit exercises (Feito et al., 2018). When combined with Heart Rate Variability (HRV), HIFT can enhance aerobic capacity, strength, cardiovascular adaptation, and body composition, although additional time is required (Deblauw et al., 2021). Static and proactive balance can be improved through functional traning, combined with sensory substitution (SS) stimulation based on neuroplasticity principles (Lynch & Monaghan, 2021). Plyometric training involves rapid and explosive movements that encompass both lengthening and shortening of muscles in a stretch-shortening cycle (SSC) (Chen et al., 2023). Plyometric training methods are often utilized to enhance kicking power, including plyometric standing jumps and box drills, which have proven effective in increasing lower limb power among junior taekwondo athletes (Susianti et al., 2022). In the realm of Physical Education instruction at schools, plyometric exercises have been reported to improve motor performance skills and muscle strength in elementary school students (Sortwell et al., 2021), as well as increasing kicking frequency (Nitzsche & Siebert, 2015). Pencak Silat athletes need to possess excellent change-of-direction (COD) abilities, and combining plyometric training with strength exercises and running techniques can greatly benefit them (Martín-Moya et al., 2023).

Functional training is a type of exercise that emphasizes multi-joint functional movements that can be modified to various fitness levels to yield greater muscle development compared to traditional methods (Feito et al., 2018). The demands of martial arts athletes during training necessitate rapid adaptations and come with a high risk of injury, underscoring the need for them to possess "tactical athlete" capabilities (Haddock et al., 2016). The specific requirements of martial arts athletes, particularly those in Pencak Silat, call for specialized forms of functional training. High-Intensity Functional Training (HIFT) serves as a crucial element in the recovery process of the autonomic nervous system (ANS) (Kliszczewicz et al., 2018).

Interval training consists of aerobic intervals and anaerobic intervals (Bompa & Buzzichelli, 2019). Training with a High-Intensity Interval Training (HIIT) protocol using a work-to-rest ratio of 1:2 produces significant and beneficial changes, especially during the pre-season phase, and aids in shortening the post-season or transition period (Stankovic et al., 2023). HIIT enhances VO2max (Astorino et al., 2012), contributes to a 28.5% reduction in body fat (Viana et al., 2019), and is effective in weight loss (Hemmatinafar et al., 2020).

Plyometric Training (PT) can enhance strength performance, but it is more advantageous when combined with resistance training rather than using a single form of training (de Villarreal et al., 2010). Therefore, the novelty of this research lies in examining the effects of Plyometric, Functional training, and Interval training, abbreviated as PFIT, within a single microcycle, a subject that has not been investigated by other researchers.

MATERIALS AND METHODS

Participants

The participants in this study were 20 male Pencak Silat university athletes who were enrolled in the Faculty of Sports Science, who also were preparing to participate in the multi-event West Sumatra POMNAS XVII (National Sport Week). The selection was done using total sampling. The student athletes involved in the study did not have any serious injuries, especially in the lower body. Their average age was 20.20±1.32 years old, with an average height of 168.93±5.7 cm, and an average weight of 63.74±11.54 kg. Prior to the intervention, the participants were provided with an explanation of the PFIT protocol (including pre and post-tests) and were asked for their willingness to participate in the program. Ethical clearance (No. KEP/II/2022/X/M060123JL/AKTR) for this research was obtained from the Research Ethics Commission of Bandung Institute of Technology, Bandung, Indonesia. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Preliminary procedure

After signing the informed consent, all participants were required to fill out a Health Condition Report, which included information about their health status, including their COVID-19 status. Then joint, height, weight, and blood pressure checks were carried out. Throughout the experiment, participants were prohibited from smoking and consuming alcoholic beverages. During the experiment sessions, which occurred three times a week for six weeks (excluding pre and post-tests), participants were instructed to wear a T-shirt and athletic shoes. Each session lasted for 120 minutes. Inclusion criteria for participation were being a student in the Faculty of Sports Science at Universitas Negeri Jakarta, being in good health, and actively preparing to participate in a national-level competition. Additionally, participants were required to have no significant lower extremity injuries. Exclusion criteria included being tested positive for COVID-19, having significant lower extremity injuries, missing three consecutive sessions, and non-compliance with instructions. It's important to note that food intake and accommodation were not controlled during the study.

Experimental protocol

Before and after PFT

Prior to conducting the initial and final tests, participants refrained from engaging in strenuous activities on the day before. Height, weight, basal heart rate, and resting heart rate were measured for each participant. Additionally, participants were required to perform warm-up exercises and stretches before the commencement of the initial and final test activities.

PFIT program protocol

Participants were required to attend all PFIT training sessions, with each session lasting for 120 minutes. The training schedule included plyometric exercises on Tuesdays, functional training on Wednesdays, and interval training on Fridays, all conducted over a span of 6 weeks. The PFIT training sessions commenced with a warm-up period of 10-15 minutes, followed by the core exercises lasting for 65-75 minutes, and concluded with a cooling-down period of 10-15 minutes. Rest intervals between exercises ranged from 1 to 5 minutes, and the intensity of plyometric training was categorized as low to low-medium. Meanwhile, functional training had a moderate to high intensity. It's important to note that the participants continued to train their techniques as part of their regular routine and were not subject to control.

Instrumentation and measured parameters

The measurements conducted on the participants included several aspects. Firstly, lower limb power was measured using Accu Power version 1.5 (1999). Participants were positioned on a force plate and performed a vertical jump lasting 6 seconds. Additionally, the strength of the athletes' kicking technique was measured during a crescent kick. The crescent kick was chosen due to its dominance in the athletes' performance, and electromyography (EMG) data were collected using MyoPlus Pro (2022) as mentioned by Futaba et al. (2022). Measurements were also taken on both passive and active muscle groups, involved in executing the kick, specifically the gastrocnemius and quadriceps. Furthermore, the speed of the kick was measured using the Bushnell Velocity Speed Gun (Anand et al., 2017). Body composition was assessed using Mi Xiaomi Body Scale 2/BIA (Bioimpedance analysis), yielding data on weight, fat mass, muscle mass, total body water, protein profile, basal metabolic rate (BMR), visceral fat, and bone density.

Statistical Analysis

The statistical analysis was conducted using SPSS v26.0 for Windows (SPSS Inc., Chicago, USA). Paired sample t-tests were employed to compare means and assess significance of variables in this experiment. Measurements of weight, BMI, flexibility, kicking speed, force, power, vertical jump height, and body composition parameters such as fat percentage, bone mass, protein percentage, total body water, visceral fat, body age, muscle mass, and Basal Metabolic Rate (BMR) were subjected to paired sample t-test analysis to determine the impact of the aerobic interval training. Statistical significance was considered achieved at a level of p-value (2-tailed) < 0.05.

Table 1. Plyometric, Functional and Interval training Program

Plyometric program Monday	Week					
	W1	W2	W3	W4	W5	W6
Side to side ankle hops	12x2	12x2	12x2	12x12	12x2	12x2
Standing jump and reach	12x2	12x2				12x2
Front cone Hops	7x6					
Standing long Jump		7x6	7x6		8x6	
Lateral Jump Over Barrier			12x2	12x2	12x2	12x2
Double leg Hops				12x2		
Diagonal Cone Hops				8x6		6x5
Lateral cone Hops					12x2	
Plyo box jump 30 cm						5x4
Volume	90	90	90	120	120	120
Intensitas	Low	Low	Medium	Medium	High	High

Functional Training program Wednesday	Week					
	W1	W2	W3	W4	W5	W6
Squad Dead bug Climbing man Plank Bridge Chop lift Push up Pull up Med ball Throw	@Set : 1/rep: 16-20x Rest :30s Int : 50-70%	@Set : 1/rep: 16-20x Rest :30s Int : 50-70%	@Set : 1/rep: 14-18x Rest :40s Int : 50-70%	@Set : 1/rep: 14-18x Rest :40s Int : 50-70%	@Set : 1/rep: 12-14x Rest :50s Int : 50-70%	@Set : 1/rep: 12-14x Rest :50s Int : 50-70%

Interval Training	Week					
	W1	W2	W3	W4	W5	W6
On Friday	Sprint 20 second - walk 40 second (8 reps x 3 sets) rest between sets : 4 Minute	Sprint 20 second - walk 40 second (8 reps x 3 sets) rest between sets : 4 Minute	Sprint 30 second - walk 40 second (8 reps x 3 sets) rest between sets : 5 Minute	Sprint 30 second - walk 40 second (8 reps x 3 sets) rest between sets : 5 Minute	Sprint 40 second - walk 40 second (8 reps x 3 sets) rest between sets : 5 Minute	Sprint 40 second - walk 40 second (8 reps x 3 sets) rest between sets : 5 Minute

RESULT

The results of descriptive statistics and research hypotheses are presented in Table 2 and Table 3, respectively. The data on participants' age, body weight, and height were collected before the experiment started, with an average age of 20.20±1.32 years, average body weight of 63.74±11.54 kg, and average height of 168.93±5.70 cm. The analysis of flexibility showed an increase in flexibility with average pre and post-test values of 17.62±4.85 cm and 19.21±4.36 cm, respectively. The significance value (2-tailed) was 0.000 <0.05, indicating a significant increase in flexibility. The analysis of right kick speed showed average pre and post-test values of 34.45±10.46 km/h and 41.20±13.82 km/h, respectively.

Table 2. Descriptive statistic

Variabel	Pre-test	Post-test
	Men (n=20)	
Age (years)	20.20 ± 1.32	
Weight (Kg)	63.74 ± 11.54	
High (cm)	168.93 ± 5.70	
Flexibility (cm)	17.62 ± 4.85	19.21 ± 4.36
Right kick Speed (km/h)	34.45 ± 10.46	41.20 ± 13.82
Left Kick Speed (km/h)	32.25 ± 12.70	39.35 ± 12.15
Force (N)	3153.38 ± 777.22	3413.53 ± 853.95
pear power+ (W/kg)	58.03 ± 6.94	59.81 ± 6.94
Jump (cm)	38.13 ± 4.99	39.92 ± 5.35
Fat Mass (%)	21.32 ± 5.12	20.87 ± 4.96
Muscle Mass (Kg)	46.61 ± 7.58	47.25 ± 7.56
Total Body Water	52.55 ± 8.34	52.64 ± 7.04
Protein Profile	20.82 ± 2.91	20.25 ± 1.90
Basal Metabolic Rate	1309.08 ± 360.63	1427.15 ± 192.67
Visceral Fat (%)	5.75 ± 3.26	4.55 ± 2.74
Bone Density (%)	2.57 ± 0.35	2.68 ± 0.41

Table 2. Hypothesis test result

		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Flexibility (cm)	1.59500	1.53262	.34270	.87771	2.31229	4.654	19	.000*
Pair 2	Right kick Speed (km/h)	6.75000	16.61285	3.71475	-1.02505	14.52505	1.817	19	.085
Pair 3	Left Kick Speed (km/h)	7.10000	9.00818	2.01429	2.88404	11.31596	3.525	19	.002*
Pair 4	Force (N)	260.15350	257.69538	57.62244	139.54835	380.75865	4.515	19	.000*
Pair 5	Pear Power+ (W/Kg)	1.77950	2.56297	.57310	.58000	2.97900	3.105	19	.006*
Pair 6	Jump (cm)	1.79500	1.78517	.39918	.95952	2.63048	4.497	19	.000*
Pair 7	Fat Mass (%)	.45000	.36201	.08095	.28057	.61943	5.559	19	.000*
Pair 8	Muscle Mass (kg)	.63800	.54314	.12145	.38380	.89220	5.253	19	.000*
Pair 9	Total Body Water (%)	.09000	9.81717	2.19518	-4.50457	4.68457	.041	19	.968
Pair 10	Protein Profile (%)	-.57800	2.33012	.52103	-1.66853	.51253	-1.109	19	.281
Pair 11	Basal Metabolic Rate (kcal)	118.06585	370.95810	82.94875	-55.54788	291.67958	1.423	19	.171
Pair 12	Visceral Fat	1.20000	1.23969	.27720	.61981	1.78019	4.329	19	.000*
Pair 13	Bone Density (kg)	.10900	.10882	.02433	.05807	.15993	4.480	19	.000*

*significant

The significance value (2-tailed) was 0.085>0.005, indicating that there was no significant increase in right kick speed. On the other hand, the analysis of left kick speed showed average pre and post-test values of 32.25±12.70 km/h and 39.35±12.15 km/h, respectively. The significance value (2-tailed) was 0.002<0.05, indicating a significant increase in left kick speed. The analysis of Force showed average pre and post-test values of 3153.38±777.22 N and 3413.53±853.95 N, respectively. The significance value (2-tailed) was 0.000<0.05, indicating a significant increase in force. The analysis of Peak Power showed average pre and post-test values of 58.03±6.94 W/kg and 59.81±6.94 W/kg, respectively. The significance value (2-tailed) was 0.006<0.05, indicating a significant increase in peak power. The analysis of Jump showed average pre and post-test values of 38.13±4.99 cm and 39.92±5.35 cm, respectively. The significance value (2-tailed) was 0.000<0.05, indicating a significant increase in jump height. The analysis of Fat Mass showed average pre and post-test values of 21.32±5.12% and 20.87±4.96%, respectively. The significance value (2-tailed) was 0.000 <0.05, indicating a significant decrease in fat mass. The analysis of muscle mass showed average pre and post-test values of 46.617±.56 kg and 47.25±7.56 kg, respectively.

The significance value (2-tailed) was 0.000<0.05, indicating a significant increase in muscle mass. The analysis of total body water showed average pre and post-test values of 52.55 ±8.34% and 52.64±7.04%, respectively. The significance value (2-tailed) was 0.968>0.05, indicating that there was no significant increase in total body water. The analysis of Protein Profile showed average pre and post-test values of

20.82±2.91% and 20.25±1.90%, respectively. The significance value (2-tailed) was 0.281>0.05, indicating that there was no significant change in protein levels. The analysis of Basal Metabolic Rate (BMR) showed average pre and post-test values of 1309.083±60.63 Kcal and 1427.17±192.67 Kcal, respectively. The significance value (2-tailed) was 0.171 >0.05, indicating that there was no significant increase. The analysis of Visceral Fat showed average pre and post-test values of 5.75±3.26 and 4.55±2.74, respectively. The significance value (2-tailed) was 0.000<0.05, indicating a significant decrease in visceral fat. The analysis of Bone Density showed average pre and post-test values of 2.57±0.35 kg and 2.68±0.41 kg, respectively. The significance value (2-tailed) was 0.000<0.05, indicating a significant increase in bone density.

DISCUSSION

The effect of PFIT training for 6 weeks was evident in the significant improvement in flexibility. Previous research has indicated that short-term strength training can enhance flexibility and strength in less active individuals (Liveira et al., 2011). Carefully applied strength training has the potential to contribute to the optimal development and maintenance of flexibility (Morton et al., 2011). The significant increase in left kick speed demonstrates the positive impact of PFIT training in enhancing the speed aspect of athletes' performance. This study also revealed significant changes in the Force parameter, indicating that Plyometric Training combined with Strength Training could yield greater benefits compared to using a single type of training. These findings align with previous research that suggests individuals with varying physical conditions can derive similar benefits from combined training (de Villarreal et al., 2010). The effect of 6 weeks of PFIT training also resulted in a significant change in Pear power. Similarly, a study found significant improvements in speed, power, and agility after 12 weeks of plyometric training (Mathiyazhagan & Sebastian, 2018). There was a significant increase in jump height among male student athletes, but not among female athletes, although jump height increased (Vescovi et al., 2008). This suggests the need for further research with larger sample sizes. The findings regarding Fat mass showed a significant decrease, similar to the results reported in a study that utilized a combination of low-intensity high-volume (80% of the total training volume) and high-intensity low-volume (20%) training to impact body composition, including fat mass (D'Alleva et al., 2023). There is a significant change in Muscle mass after undergoing PFIT, in line with other studies that have found effectiveness in increasing muscle size in overweight and obese individuals (Blue Malia N et al., 2020). Similarly, there is a significant change in Visceral fat after undergoing PFIT, consistent with findings from other research indicating that high-intensity interval training (HIIT) or moderate-intensity continuous training (MICT) over 8 weeks can reduce visceral fat index and enhance blood flow velocities (BFV) and wall shear stress (WSS) in the common carotid artery (Shi et al., 2022). There is a significant increase in bone density after undergoing PFIT for 6 weeks, consistent with references that mention higher bone density in athletes engaged in strength training such as weightlifting or judo compared to those engaged in endurance training like marathon, 800m run, cycling, or swimming (Bellew & Gehrig, 2006; Hinrichs et al., 2010). Providing aerobic interval training for 5 weeks also did not lead to a significant increase in bone density (Lubis et al., 2020).

An interesting observation is that the effect of PFIT on the right kick speed resulted in a change in speed, although not significant, unlike the significant change observed in the left kick speed. This difference could potentially be attributed to the dominant leg used during the activities, as 95% of the respondents reported their dominant leg to be the right one. Further research is needed to explore the influence of the dominant leg as other variables. Another finding is that Total Body Water did not experience significant changes throughout the study. In the case of Protein Profile, there was no significant change observed in this study. The results of this study regarding Basal Metabolic Rate did not show significant changes, which might be due to various factors related to the respondents' lifestyle habits, including uncontrolled dietary consumption during the study (López-Sánchez et al., 2020).

Conclusions

The 6-week PFIT program had a significant impact on power, strength, flexibility, and left kick speed. It also led to a reduction in body fat percentage, visceral fat, and an increase in muscle

mass, total body water, and bone density. However, the program did not have a significant impact on protein levels, basal metabolic rate, and right kick speed.

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Conflict of interest

The authors declare no conflict of interest.

Author Contributions

Study Design, JL and AH; Data Collection, JL, SII, HW, and IS; Statistical Analysis, AH, SS; Data Interpretation, SS, KHS, DEK; Manuscript Preparation, SG and AAI; Literature Search, JL, AR, and RAL. All authors have read and agreed to the published version of the manuscript.

Ethics Statement

Ethical clearance (No. KEP/II/2022/X/M060123JL/AKTR) for this research was obtained from the Research Ethics Commission of Bandung Institute of Technology, Bandung, Indonesia.

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