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The Effect of Five-Week Aerobic Interval Training on The Body Composition of Pencak Silat Elite Athletes

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ABSTRACT

Background: Background: The direction of coaching is emphasized as a factor affecting the physical conditions of pencak silat martial arts athletes in all categories. One of the physical exercises that affects body composition is aerobic activity**. Objective:** This study aimed to examine the effects of aerobic interval (AI) training performed for five weeks on the body mass index (BMI), basal heart rate, and the VO2max of elite athletes. **Methods:** The study used an experimental design involving total sampling. Thirty national-level pencak silat elite athletes (17 men and 13 women) were involved in this study. Of the participants, 23 had a normal BMI of 18.5 – 24.9 kg/m2, and 7 had a BMI above 25 kg/m2 (overweight). Their average age was 23.67 + 4.10 years with an average height of 166.03 + 7.15) cm and average initial weight of 64.84 + 12.65 kg. They were in the preparation phase of their training. This experimental research used a one-group pre-test and post-test design. The Mi Xiaomi Body Scale 2 was used for bioimpedance analysis (BIA), and body composition (body weight, BMI, body fat percentage, bone mass, protein percentage, total water body percentage, visceral fat, body age, muscle mass, and basal metabolic rate [BMR]) and VO2max measurements were acquired using a multistage fitness test (MFT). The athletes lived in a dormitory where the food, type of training and exercise, and sleeping time were controlled to the exact condition. The AI training lasted 67–77 minutes per session, twice a week for five weeks, with vigorous intensity at 80–85% of the maximal heart rate, 5 minutes per interval, and 1 minute of rest between each interval. **Results:** The weight, BMI, body fat percentage, basal heart rate, and VO2max showed significant differences ($p < 0.05$) after five weeks of AI training. However, AI training did not significantly alter muscle mass, percentage of water, percentage of protein, bone mineral density, or biological age. **Conclusion:** AI training performed for five weeks improved VO2max and decreased basal heart rate, body weight, and fat percentage.

Key words: Aerobic Interval Training, Vigorous-Intensity, Body Composition, Heart Rate, Oxygen Consumption

INTRODUCTION

Martial arts competitions are always dependent on body weight, so athletes whose weights are not within a certain bodyweight range are not eligible to compete. Classifying an athlete as underweight, normal weight, overweight, or obese can be done using the body mass index (BMI) (DiFrancisco-Donoghue et al., 2020). According to BMI, underweight is considered below 18.5 kg/m^2, normal weight is between 18.5 and 24.9 kg/m^2, and overweight is between 25 and 30 kg/m^2 (Di Cesare et al., 2016). An increased BMI is associated with a risk of depression, especially among unhealthy, obese individuals (Malmir et al., 2019). It has also been reported that aging has an impact on increases in BMI, waist circumference, body fat, visceral fat, and muscle loss in both men and women (Liang et al., 2018). In female athletes, being overweight has an impact on aggression levels, as over-

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weight female athletes tend to not hesitate to express feelings of irritation (Urzeală et al., 2014). Overweight athletes are predicted to experience musculoskeletal dysfunction, which results in mobility limitations (Naderi et al., 2021).

Since athletes should match a certain bodyweight range, attempts to lose weight are frequently made. Some experts have suggested that the best method to lose weight is to combine a healthy diet, regular exercise, and behavior modifications. However, repeated rapid weight gain and loss have negative consequences, and such efforts should be undertaken with caution (Yen, 1992). Physical training can cause significant changes in body composition parameters, especially body fat and lean mass, which are important factors in regulating and maintaining body mass (Castelli Correia De Campos et al., 2013; Ubago-Guisado et al., 2017).

One of the physical exercises that affects body composition is aerobic activity. Aerobic exercise is not only associated with decreased obesity, decreased overweight, improved quality of life, and decreased fat profile, but if done properly, aerobic exercise is effective for treating toxicity, and it is accompanied by no other risks (Bortolozo et al., 2020). Aerobic interval (AI) training has been assessed as an effective method for increasing aerobic capacity and the recovery of the heart rate (HR), as well as improving cardiac and psychosocial functions (Molmen-Hansen et al., 2012; Hannan et al., 2018). Furthermore, AI exercise for pencak silat athletes is needed in the preparation phase because this type of exercise reduces BMI and body fat but does not significantly change lean mass. It even increases VO2max (Tjønna et al., 2009). In addition, after six weeks of AI training, there was an effect on body weight, waist circumference, BMI, triglycerides, total cholesterol, HDL cholesterol, LDL cholesterol, and VO-2max (Farsani & Rezaeimanesh, 2011).

Exercise intensity is an important factor in the implementation of AI programs (Tjønna et al., 2008), where the intensity needs to be at the lactate threshold or slightly above (Baquet et al., 2003). When performing AI exercises, it is also recommended to gradually determine the maximum heart rate (HRmax), maximal power output (VO2max), and lactate threshold (Laursen & Jenkins, 2002). It is recommended that the AI exercise be performed for 20–40 minutes of the total training duration at 80–100% of HRmax (Bompa & Buzzichelli, 2019), as this type of training needs to be performed at the near maximal or >80% of HRmax (Weston et al., 2014). AI training is also called threshold training or speed or tempo training, as it involves a high intensity (100% HRmax) or a higher volume than low intensity interval training (90% VO2max) (Seiler et al., 2013). Competitive cross-country (XC) skiers could definitely encounter improvements in time-trial (TT) efficiency after a bout of high-intensity interval training (HIIT) (Winegarden et al., 2021). A meta-analysis suggested that HIIT results in a 28.5% greater reduction in total fat mass than moderate-intensity continuous training (MICT) (Viana et al., 2019). AI training is also able to restore heart function in overweight athletes and improve body composition (França et al., 2020). HIIT was found to be effective for weight loss and reducing body fat in obese young men (Hemmatinafar et al., 2020). AI training is also used in cardiac rehabilitation (CR) training as an alternative to improve the psychological and physical health of patients with coronary artery disease (CAD) (Terada et al., 2019) and can be used to help children achieve an optimal body fat percentage and improve some physical fitness indices (Rad et al., 2019).

The direction of coaching is emphasized to be an important factor affecting the physical condition of pencak silat martial arts athletes of all categories, especially for the match *(tanding)* category, because the pencak silat martial arts category must finish three rounds of 6 minutes for each match (Lubis, 2014). In this category, an athlete directly competes against an opponent, so the athlete must be ready when hit or kicked, although there is equipment that will protect the athletes during the match. This equipment comes in the form of a body protector, gentle cup (for male athletes), and so on (Tangkudung et al., 2020). The risk of injury in one match *(tanding)* category is greater than in another (tunggal, ganda, and regu) category.

In the preparatory phase of the exercise program, endurance training creates an important foundation (Bompa & Buzzichelli, 2019). AI training is an alternative exercise for pencak silat martial arts athletes, who are predominantly anaerobic athletes (Lubis et al., 2021). A better BMI affects athletic performance, and there is a relationship between BMI and decreased physical activity. Physical exercise should be considered a potential intervention for clinical treatments, disease prevention, and public health regulation (Porras-Segovia et al., 2019). Few studies have discussed the effects of exercise on BMI, especially in athletes. Thus, this study bridges this gap and offers an important contribution, especially because match category athletes are very dependent on body weight and body weight maintenance. This study aims to examine the effects of AI training performed for five weeks on the BMI, basal HR, and VO2max of pencak silat elite athletes who were preparing for the 2022 SEA Games in Vietnam.

METHOD

Participants and Study Design

This research involved an experimental study with a one-group pre-test and post-test design. A total of 30 elite national pencak silat athletes were called to the National Training Center, and all were taken as samples (total sampling). The independent variable was AI training, and the dependent variable was body composition (weight [kg], BMI [kg/m2], fat mass (%), muscle mass (kg), total body water, protein profile, basal metabolic rate [BMR], visceral fat (%), bone density (%), body age (y), VO2max (ml/kg/min), and basal pulse [per minute]).

This study used a total sampling method involving 30 elite national Pencak silat athletes who were preparing for the 2022 SEA Games. Of the sample, 17 were men, and 13 were women; 23 had a normal BMI (18.5–24.9 kg/m2), and 7 had a BMI above 25 kg/m2 (overweight). Their average age was 23.67 + 4.10 years, average height was 166.03 + 7.15 cm, and average initial weight was 64.84 + 12.65 kg. Before the experiment started, the participants were informed about the research implementation protocol and the data collection process. Then, they were required to provide their informed consent to participate in the research process. The study was approved by the local ethics committee of Universitas Negeri Jakarta (No. B/349/UN39.14/PT/202), and written consent was obtained from all participants prior to testing.

Preliminary Procedure

Participants underwent several health examinations, including the rapid test (antigen) for COVID-19, an EKG, as well as complete blood, lung, and joint checks. In addition, participants' body composition was screened to determine their BMI and VO2max. During this study, participants were not allowed to smoke or drink alcoholic beverages. They were also required to perform AI training for 67–77 minutes twice a week for 5 weeks at 2 hours per session while wearing sportswear and shoes. During each training session, Polar was employed to monitor the participants' pulses. The inclusion criteria were as follows: healthy individuals who tested negative for COVID-19 and were willing to live in the dormitory. Exclusion criteria were as follows: those who did not follow the agreed-upon research procedure and participated in uncontrolled food intake.

Experimental Protocol (Before and After AI Training)

The participants' body composition was measured using the Mi Xiaomi Body Scale 2 for bioimpedance analysis (BIA), including body weight, BMI, body fat percentage, bone mass, protein percentage, total water body percentage, visceral fat, body age, muscle mass, and BMR. BMR and resting HR were measured using Polar. VO2max measurements were acquired using a multistage fitness test (MFT).

AI Training Program Protocol

The participants engaged in the AI training sessions twice a week for five weeks. Each training session was performed for 67–77 minutes. The duration included 15 minutes of warm-up. The full session included 8 intervals. Each interval featured 5 minutes of exercise at 80% intensity, peak power of VO2max was at 80–85% HRmax, and 1 minute of rest was allowed between each interval. This training program involved a 5:1 ratio of work-to-rest intervals. The session was concluded with a 10–15 minute cool-down period (Weston et al., 2014).

Instrumentation and Measured Parameters

Measurements were conducted for all participants. Body temperature was measured using an infrared thermogun 10 cm away from the forehead. Body composition was measured by BIA using the Mi Xiaomi scale (Walter-Kroker et al., 2011), which is considered one of the most practical methods for estimating body composition, as it is accessible, portable, affordable, practicable for rapid assessment procedures, and has high validity against DXA (Huang et al., 2018). Pulse rate was measured using Polar (OH1 HR monitor). Polar was tied to the upper arm, and HR was monitored using an iPad (Apple) and Polar team data.

Statistical Analysis

The statistical analysis was performed using SPSS v26.0 for Windows (SPSS Inc., Chicago, USA). A paired sample t-test was used to compare the mean and test the significance of all study variables. Measurements of body weight, BMI, fat percentage, bone mass, protein percentage, total water body percentage, visceral fat, body age, muscle mass, and BMR were performed using paired samples t-tests to determine the effects of AI training. Statistical significance was accepted at the level (two-tailed) of $P < 0.05$.

RESULT

Table 1 presents the descriptive statistics results for the research variables. Male and female athletes showed different average pre-test and post-test values.

The Table 2 presents the hypotesis test results. For male and female athletes, the average body weight pre- and post-test (see Figure 1) was 64.84 + 12.65 and 64.10 + 12.47, respectively (t[29] = -5.430, p = 0.000), so there was a significant body weight loss. The average BMI pre- and post-test was (see Figure 2) 23.27 kg/m2 + 2.93 and 23.01 kg/m2 + 2.91 (t[29] = -4.479, p = 0.000), so there was a significant BMI decrease. The average fat mass pre- and post-test (see Figure 3) was 24.04% + 5.96 and 23.12% + 6.67 (t[29] = -3.415, p = 0.002), so there was significant fat loss. The average muscle mass pre- and post-test was (see Figure 4) 46.67 kg + 8.59 and 47.13 kg + 8.05 (t[29] = -0.605, p = 0.550), so there were no significant changes despite the fact that, descriptively, there was an increase in muscle mass.

The average body water pre- and post-test was (see Figure 5) 52.07% + 3.95 and 52.04% + 7.26 (t[29] = -0.815, p = 0.422), so there was no significant change. The average protein percentage pre- and post-test was (see Figure 6) 19.45% + 2.54 and 19.97% + 3.15 (t[29] = 1.479, p = 0.150), so there was no significant increase in body water. The average BMR pre- and post-test was (see Figure 7) 1377.79 kcal + 336.15 and 1442.87% + 227.14 (t[29] = 1.166, p = 0.253), so there was no significant BMR change. The average visceral fat pre- and post-test was (see Figure 8) 6.07% + 3.28 and 5.90% + 3.09 (t[29] = -1.000, p = 0.326), so there was an insignificant visceral fat loss. The average bone density pre- and post-test was (see Figure 9) 2.64 kg + 0.36 and 2.69 kg + 0.33 (t[29] = 0.362, p = 0.720), so there was an insignificant increase in bone density. The average body age pre- and post-test was (see Figure 10) 24.03 years + 7.12 and 22.25 years + 7.94 (t[29] = -1.945, p = 0.062), so there was an insignificant body age decrease.

The average VO2max pre- and post-test was (see Figure 11) 45.28 ml/kg/min + 7.68 and 49.79 ml/kg/min + 6.72 (t[29] = 6.502, p = 0.000), so there was a significant VO2max increase after the five weeks of AI training. The athletes' basal pulse was checked the next day after training before doing activities after each treatment. The average ini-

Table 1. Descriptive statistic

Variable	Pre-test		Post-test	
	Men (n=17)	Woman (n=13)	Men (n=17)	Woman (n=13)
Weight (Kg)	70.6±12.7	57.3±8.7	69.8±12.7	56.9±8.3
BMI (Kg/m2)	24.3±3	21.9±2.4	24±3	21.7±2.3
Fat Mass (%)	20.1±5.8	27.9±5.1	19.6±5.8	27.7±5.1
Muscle Mass (Kg)	52.9±5.7	38.5±3.8	52.6±5.7	40±4.5
Total Body Water	55±3.6	50.2±2.7	55.3±3.8	47.8±8.8
Protein Profile	20.8±2	17.7±2.3	21±1.8	18.6±4.1
Basal Metabolic Rate	1479.1±424.7	1245.3±91.8	1589.6±192.1	1250.9±96.6
Visceral Fat (%)	8.1±2.8	3.4±1.7	7.7±2.6	3.5±2
Bone Density (%)	2.8±0.3	2.4±0.3	2.8±0.3	2.4±0.3
Body Age (y)	24.6±7.5	21.5±9.4	22±9	20.9±9.2
VO2 max (ml.kg.min)	48.8±6.6	40.6±6.9	53.5±5.9	44.9±4.6
Basal Pulse (permin)	59.9±4.8	58±4.5	55.4±5.4	56.6±5.7

Table 2. Hypothesis test result

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Weight (Kg)	-0.73967	0.74609	0.13622	-1.01826	-0.46107	-5.430	29	0.000
Pair 2	BMI (Kg/m2)	-0.24733	0.30247	0.05522	-0.36028	-0.13439	-4.479	29	0.000
Pair 3	Fat Mass (%)	-0.36667	0.58800	0.10735	-0.58623	-0.14710	-3.415	29	0.002
Pair 4	Muscle Mass (Kg)	0.45933	4.15887	0.75930	-1.09362	2.01228	0.605	29	0.550
Pair 5	Total Body Water	-0.89333	6.00609	1.09656	-3.13604	1.34938	-0.815	29	0.422
Pair 6	Protein Profile	0.51533	1.90817	0.34838	-0.19719	1.22786	1.479	29	0.150
Pair 7	Basal Metabolic Rate	65.07723	305.78231	55.82796	-49.10376	179.25822	1.166	29	0.253
Pair 8	Visceral Fat (%)	-0.16667	0.91287	0.16667	-0.50754	0.17420	-1.000	29	0.326
Pair 9	Bone Density (%)	0.00333	0.05047	0.00921	-0.01551	0.02218	0.362	29	0.720
Pair 10	Body Age (y)	-1.72367	4.85405	0.88622	-3.53620	0.08887	-1.945	29	0.062
Pair 11	VO2 max (ml.kg.min)	4.50500	3.79515	0.69290	3.08787	5.92213	6.502	29	0.000
Pair 12	Basal Pulse (permin)	-3.16667	5.90198	1.07755	-5.37050	-0.96283	-2.939	29	0.006

tial basal pulse was (see Figure 12) 59.07 + 4.61 and 55.90 + 5.39 (t[29] = -2.939, p = 0.006), so there was a significant basal rate decrease.

DISCUSSION

The AI training lasted 67–77 minutes per session twice a week for five weeks, with vigorous intensity at 80–85% of HRmax. Each interval lasted 5 minutes with 1 minute of rest between each interval. The weight, BMI, body fat percentage, basal HR, and VO2max showed significant differences ($p < 0.05$) after five weeks of AI training. However, muscle mass, percentage of water, percentage of protein, bone mineral density, and biological age did not show significant differences. The AI training performed for five weeks improved VO2max and decreased basal HR, body weight, and fat percentage. This study revealed significant decreases in body weight, BMI, and body fat. This result is similar to one study on HIIT suggesting that AI training can reduce body weight and fat mass, especially in overweight athletes (De Feo, 2013), and create a longer-lasting decrease in blood pressure (Shakoor et al., 2020). The oxygen intake from the activity can contribute to long-term body weight maintenance and general health, and weight loss is possible if the training is done in a continuous and consistent manner (Berg, 2008). AI training was also considered effective in significantly reducing fat mass and secondary body weight, but it was not helpful in increasing significant muscle gain, although the training difficulty needs to be taken into consideration (Juránková et al., 2015). The AI training program was a high-intensity exercise that was supposed to decrease the pulse rate (Beijer

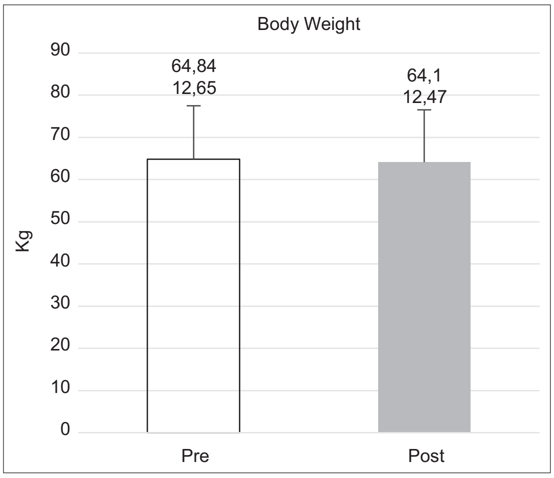

Figure 1. Body weight diagram

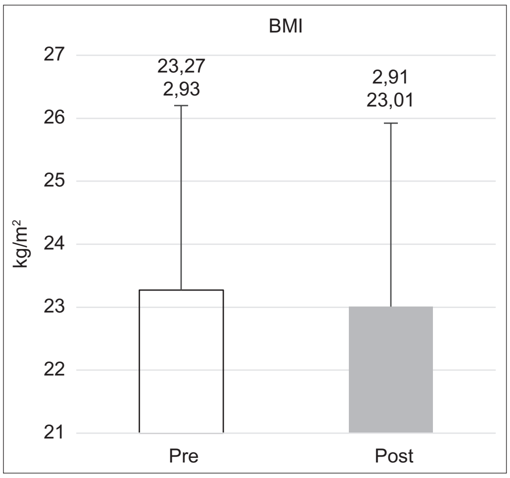

Figure 2. BMI diagram

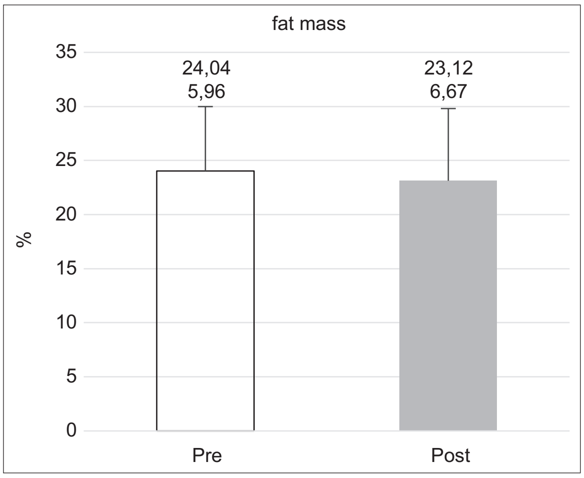

Figure 3. Fat mass diagram

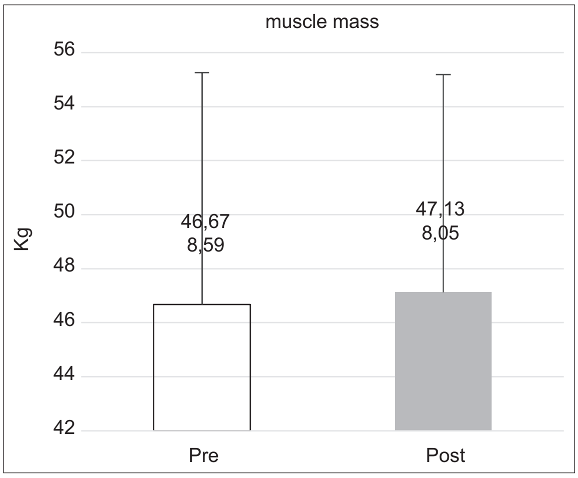

Figure 4. Muscle mass diagram

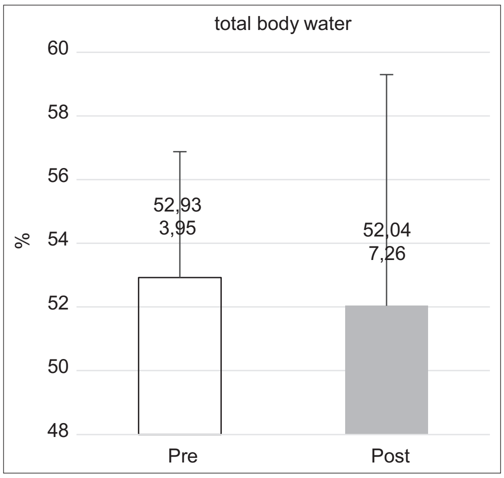

Figure 5. Total body water diagram

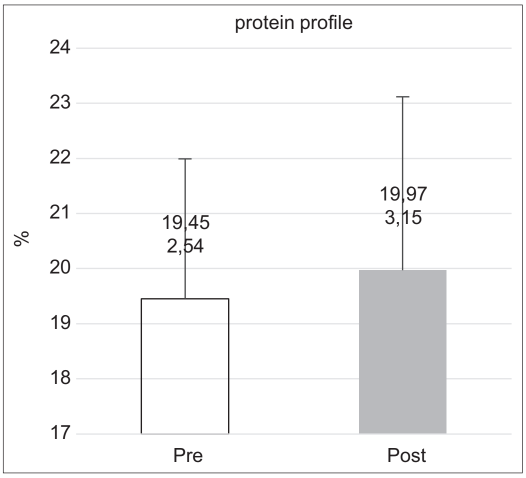

Figure 6. Protein profile diagram

et al., 2018). However, this study showed that the basal pulse rate was stable. In a similar study that involved overweight individuals, AI training resulted in reduced body fat and visceral fat (Boutcher, 2011), although a direct comparison cannot be made since this study only involved 30% overweight participants. Moreover, the main concern of this study is not specifically weight loss. This study also revealed that the participants experienced an increase in VO2max after participating in the AI training for 5 weeks. Meanwhile, HIIT training for 2 weeks could increase VO2max and the average and peak strength output but did not affect resting HR or muscle strength production (Astorino et al., 2012). However, in this study, AI training for 5 weeks had an effect on VO2max and basal pulse rate, but not on muscle mass. A progressive

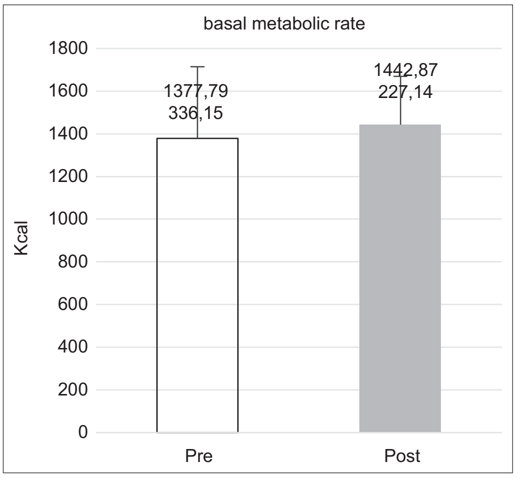

Figure 7. Basal metabolic rate diagram

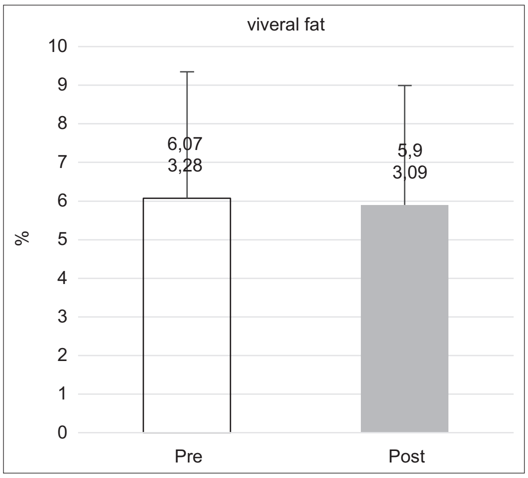

Figure 8. Visceral fat diagram

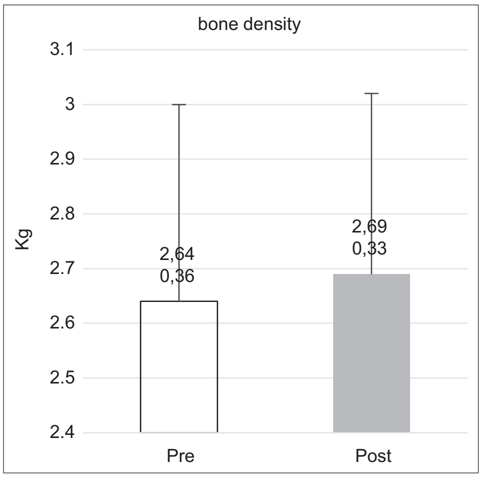

Figure 9. Bone density diagram

increase was also seen in the dominance of VO2max, whose baseline was below 45 ml/kg/min.

This experiment also found that there were no significant changes in muscle mass, in contrast to a study that showed a significant change in the muscle mass of overweight and obese individuals (Blue Malia et al., 2020). This is because the study involved only 30% overweight participants.

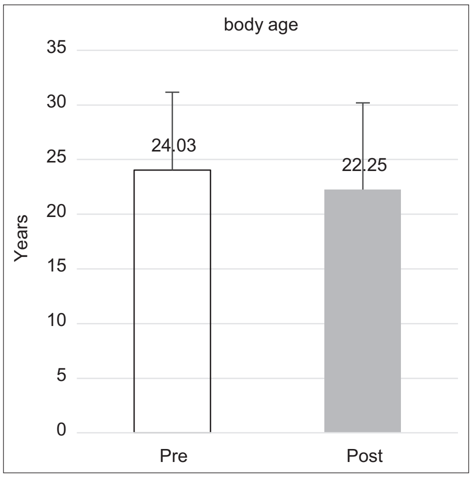

Figure 10. Body age diagram

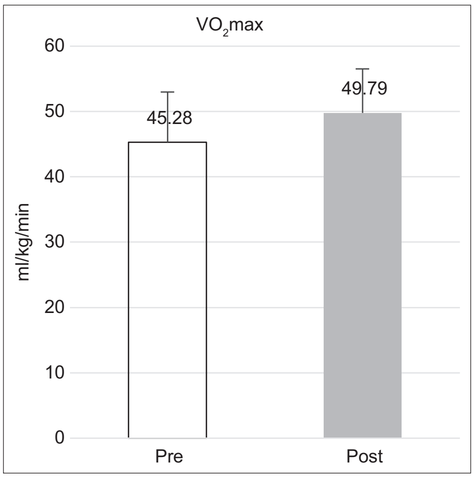

Figure 11. Vo2max diagram

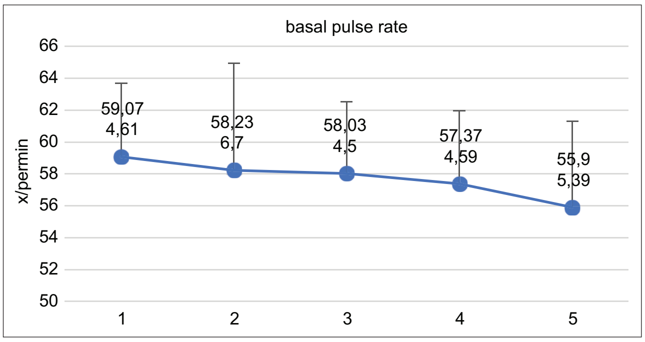

Figure 12. Basal pulse rate diagram

Further research is needed to take into account the muscle characteristics and the characteristics of the overweight population. This study also found that there was no significant change in visceral fat. This is similar to a study that revealed no significant changes in visceral fat after participants underwent HIIT, but there was a significant change in visceral fat in obese young females after participating in MICT for 12 weeks (Zhang et al., 2017). This suggests that further study is needed to examine visceral fat loss following a more intense volume and longer period of AI training. The ineffectiveness of AI training in reducing visceral fat is in line with one study that reported that the degree of visceral fat in obese adults was higher than in adults who were not obese. In addition, total cholesterol, triglycerides, LDL cholesterol, and the TG/HDL ratio were correlated with the degree of visceral fat (Salazar et al., 2014). This study also revealed that there was no significant change in bone density, as AI training is endurance training. This is in line with a study that suggested that endurance athletes, such as marathon runners, 800 m runners, cyclists, and swimmers, have a lower bone density than weightlifting or judo athletes (Hinrichs et al., 2010). Bone density can be affected by the weight lifting process, so training activities that involve weights affect bone density, unlike endurance sports (Bellew & Gehrig, 2006). Thus, to increase bone density, the incorporation of strength training or weightlifting into AI training programs is recommended.

During this 5-week study, the participants also underwent a national pencak silat training program. They lived in the same dormitory and had the same meals, although the portions for each participant were not controlled. During this period, the participants experienced an increase in BMR, although it was not significant, as BMR is strongly affected by lifestyle, including physical activity, diet, and smoking habits (López-Sánchez et al., 2020). This finding is different from one study that involved children suffering from narcolepsy, suggesting that BMR is heavily correlated with BMI. In 3 to 4 years, the increase in BMI to a normal level would be in line with the process of recovering the BMR to a healthy level (Wang et al., 2016). In this study, there was a significant increase in BMI but not in BMR. It can be assumed that the duration of the study was not adequate for examining the increase in BMR.

A limitation of this study is the athletes' uncontrolled food intake. Despite this limitation, our study adds valuable evidence that can eventually inform pencak silat training and practice. Coaches and sports educators should be encouraged to teach pencak silat athletes how to engage in five-week AI training to decrease body weight, BMI, fat mass, and basal pulse rate, as well as to increase VO2max. Recommendations for further research are to control for athletes' calorie intake to determine changes in muscle mass, total body water, protein profile, BMR, and bone density.

CONCLUSION

This study concluded that a five-week AI training program resulted in a significant decrease in body weight, BMI, fat mass, and basal pulse rate, as well as an increase in VO2max. Since there was no control in the participants' caloric intake, muscle mass, total body water, protein profile, BMR, and bone density did not show significant changes. It also revealed that overweight participants experienced more significant changes compared to participants whose BMI was normal. AI training for a duration of 67–77 minutes twice a week for five weeks significantly decreased body weight, BMI, body fat, and basal HR, as well as increased VO2max.

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