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Original Article

Does aerobic interval training induce a decrease in body weight in pencak silat elite athletes?

JOHANSYAH LUBIS[1], EKO JULI FITRIANTO[2], SUKIRI[3], ARIDHOTUL HAQIYAH[4], YASEP SETIAKARNAWIJAYA[5], AGUNG ROBIANTO[6], SLAMET SUKRIADI[7], RIZKY NURULFA[8], ASTRI AYU IRAWAN[9], SRI SUMARTININGSIH[10]
[1,2,3,,5,6,7,8,]Universitas Negeri Jakarta Jl. Rawamangun Muka Raya, Jakarta 13220, INDONESIA
[9]Universitas Singaperbangsa Karawang Jl. HS. Ronggo Waluyo, Karawang 41361, INDONESIA
[4]Universitas Islam 45 Jl. Cut Meutia No. 83, Bekasi 17113, INDONESIA
[10]Universitas Negeri Semarang, Jalan Raya Sekaran-Gunungpati Semarang 50229, INDONESIA
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Abstract:
Competition in martial art sports depends on body weight of the athletes so they can compete in the right weight class. The purpose of this study was to determine the effect of aerobic interval training on overweight national elite athletes based on their body mass index (BMI), VO2max, and basal pulse rate. This study used purposive sampling of eight national Pencak Silat elite athletes (6 males and 2 females who were 23.75±4.55 years old with heights of 171.63±6.32 cm), who were in the sub phase of special preparation, as the subjects. The athletes lived in the athlete village, and the food was the exact condition. The Aerobic Interval (AI) training was 67-77 min per session twice a week for 5 weeks and with warm-up and cool down for 10-15 min for each session. AI training was performed for 5 min with 80–85% intensity of HRmax (controlled by Polar) and a rest interval of 1 min or with a 5:1 ratio of training to rest. Polar produces a series of heart rate monitoring devices and accessories for sports training and fitness, as well as measuring heart rate variability. The weight, BMI, body fat percentage, muscle mass, basal metabolic rate, and VO2max showed significant differences ($p < 0.05$) after five weeks of AI training. However, the AI training did not produce significant differences in the measured variables, i.e. the percentage of water, protein, visceral fat, bone density, biological age, and basal pulse, in the overweight Pencak Silat elite athletes. The AI training for five weeks improved VO2max and decreased body weight and fat percentage.
Key Words: **Aerobic interval training, overweight, body composition, heart rate, VO2Max, pencak silat**

Introduction

Pencak Silat is a martial arts sport that consists of several categories, and one of them is Match. It is categorized based on the athlete's body weight, which is further categorized into several numbers/classes. An athlete will be disqualified if their body weight is not compliant with the class they compete in whether because of being overweight or underweight. However, in measuring an athlete's body weight using Body Mass Index (BMI), they will be categorized as underweight if the BMI is below 18.5 kg/m^2, normal weight if they are between 18.5 and 24.9 kg/m^2, and overweight if they are between 25 and 30 kg/m^2(Cesare et al., 2016; DiFrancisco-Donoghue, Werner, Douris, & Zwibel, 2020). Thus, when a competition nears, athletes will try to lose their weight without taking care of their diet with a combination of training and behaviour modification. The process of losing and gaining repeatedly can affect athletes negatively (Yen, 1992) . Being overweight, according to WHO reports, is a part of society's health agenda and is a health risk factor, which is often associated with lifestyle ("WHO. 916," 2003). Obesity is often related to the depression risk (Malmir et al., 2019). Overweight female athletes will most likely become more aggressive and more expressive in conveying their feelings when upset (Urzeală, Popescu, & Predoiu, 2014). Disorders, such as musculoskeletal dysfunction, in athletes could limit their movements (Naderi, Goli, Shephard, & Degens, 2021). Aging is also one of the reasons for an increase in BMI, body fat, visceral fat, waist size, and the muscle mass of males and females (Liang, Chen, Li, Yan, & Yang, 2018)

Body composition, especially body fat and lean mass, may change significantly through physical training (Campos et al., 2013), which is the main factor in regulating and maintaining body mass (Ubago-Guisado et al., 2017)). One of the methods of physical training is aerobic activity, where the right aerobic training will not produce any risks of toxicity. It even reduces obesity or overweight status, improves the lipid profile, and improves quality of life (Bortolozo et al., 2020). Another effect of aerobic training for six weeks is a decrease in weight, waist size, body mass index, total cholesterol, HDL cholesterol, LDL, triglycerides, and increase VO2max (Farsani & Rezaeimanesh, 2011; Romanchuk & Dolgier, 2017). Aerobic training can be conducted with "Aerobic Interval" (AI) methods, which are effective for increasing aerobic capacity, HR recovery, and heart function (Molmen-Hansen et al., 2012). AI also has an impact on psychosocial factors

Corresponding Author: JOHANSYAH LUBIS, E-mail: johansyah.sport@unj.ac.id

(Hannan et al., 2018) The heart function and body composition of overweight athletes can be improved through AI training (França et al., 2020) Not only can overweight athletes benefit from AI training but also people who suffer from Coronary Artery Disease (CAD), where it is used as cardiac rehabilitation (CR) as an alternative to psychology and physical health (Terada et al., 2019) Through AI training, BMI and body fat mass may decrease, and VO2max may increase, but the body weight will remain the same (Tjønna et al., 2009). A study reported that HIIT training could decrease total fat mass by 28.5% more than moderate-intensity continuous training, which is also effective for weight loss for young males who suffer from obesity (Nafar, Fathei, & Ziaaldini, 2020; Viana et al., 2019) and effective training protocol to increase the maximal aerobic capacity with a minimum of 4 weeks of exercise duration of 18-30 minutes per session (Syamsudin, Dyah, Wungu, & Qurnianingsih, 2021).

The system energy requirements in Pencak Silat martial arts for the match category during a competition of 2 min in 3 rounds with 1-min rest are mostly aerobic (Lubis et al., 2021; Lubis & Wardoyo, 2014); however, resistance training is a key foundation for the preparation phase (Bompa & Buzzichelli, 2018). In AI training, intensity training is the main factor in which AI training should meet the lactate threshold or higher (Baquet, Van Praagh, & Berthoin, 2003; Tjønna et al., 2009). AI activity reaches ‘almost maximum’ when the heart rate (HR) is 80% of the HRmax; thus, AI training done in high volume and low intensity (90% VO2max) is called ‘threshold’ training or velocity or pace training (Seiler, Jøranson, Olesen, & Hetlelid, 2013; Weston, Wisløff, & Coombes, 2014). Regardless of the methods, AI training should trigger physiological adaptation while stimulating athletic performance, which can be twice a week for 4 weeks (Laursen, Shing, Peake, Coombes, & Jenkins, 2002) The recommended duration for AI training is 20–40 min, depending on the total duration, with 80–100% heart rate intensity of HRmax or 70–100% (VO2max) 1-2 times a week (Bompa & Buzzichelli, 2018) When it comes to designing AI training, it is recommended to gradually increase the intensity to determine the athlete’s maximum heart rate, maximum speed, or strength output in terms of VO2max and lactate threshold. The resting interval is set to reach 65% of the athlete’s maximum heart rate or a decrease in intensity that is lower (Laursen et al., 2002). AI training is appropriate to use to increase the intensity of Pencak silat movements because there is a change in the intensity of the movement every certain time interval that is repeated during training. This exercise program can have a positive effect on the body, functional, and motor changes such as providing significant benefits to physical fitness (Rýzková, Labudová, Grznár, & Šmída, 2018), overcoming the lack of mastery of attack techniques and fatigue in Pencak silat. Physiological and psychological pressure will appear because of AI training, and the athlete’s performance will be affected by the better BMI. Physical training is considered a potential clinical intervention treatment for public health regulations (Porras-Segovia et al., 2019). The purpose of this study was to determine the AI training effect on the body composition, BMI, VO2max, and basal pulse rate of overweight Pencak Silat athletes.

Material and methods

Participants

This study involved 30 national elite Pencak Silat athletes who are prepared for multi-events in the SEA Games 2021 as participants. They were then selected purposively; 22 participants in the normal BMI category (18.5–24.9 kg/m^2) and 8 participants in the overweight category (25 kg/m^2) were used as the sample for this study. The average age of those 8 participants (6 males and 2 females) was 23.75 $\pm$ 4.55 years old with an average height of 171.63 $\pm$ 6.32 cm, and a baseline body weight of 80.4 $\pm$ 11 kg. Before the experiment, athletes were gathered and provided an explanation about the study implementation and the process of data collection. After knowing and understanding that this study will not affect national team selection as part of their agreement to participate in this study, they signed an informed consent form.

Preliminary procedure

All participants in this study lived in the same dorm, and the food types provided to them were the same (the amount of food consumed was uncontrolled). The following health examinations were conducted by the medical team: antigen SWAB for COVID-19, ECG, complete blood count (CBC), respiratory examination, and osteoarthritis examination. For initial data, BMI was measured, and VO2max was tested on all athletes. All participants were asked to use Polar and not allowed to smoke or drink alcohol. The AI experiment was conducted for 67–77 min twice a week for five weeks. Polar was used to measure AI training activity. Athletes had to wear sports shoes and apparel. Inclusion criteria: the BMI was overweight, healthy, and tested negative for COVID-19. Exclusion criteria included tested positive for COVID-19. Participants that did not meet the requirements or were not compliant with this instruction were excluded from the experiment.

Experimental protocol

Before and after AI training

The VO2max of participants was measured with a multistage fitness test (MFT), and their body compositions were measured using a Mi Xiaomi Body Scale 2/BIA (bioimpedance analysis) that was connected to a smartphone with each athlete’s height and date of birth data provided. The following data were collected: body weight, BMI, body fat percentage, bone mass, protein percentage, body water percentage, visceral fat, body age, muscle mass, and BMR (basal metabolic rate). The basal heart rate and resting heart rate were measured with Polar.

AI training program protocol

All participants that took part in the AI training selected for this study with a duration of 67-77 min per session twice a week for 5 weeks and with warm-up and cool down for 10-15 min for each session. AI training was performed for 5 min with 80–85% intensity of HRmax (controlled by Polar) and a rest interval of 1 min or with a 5:1 ratio of training to rest (adapted from (Laursen et al., 2002)) (Weston et al., 2014)

Instrumentation and measured parameters

Measurement was conducted on all national elite athletes selected whose BMI showed they were overweight. Before training, their temperatures were checked using an infrared thermo gun on the forehead at a 10 cm distance. Body composition was measured with BIA (bioimpedance analysis) (Mi Body Scale Composition 2, Xiaomi) (Walter-Kroker, Kroker, Mattiucci-Guehlke, & Glaab, 2011) which is believed to be one of the most efficient methods to estimate body composition for its easy accessibility, portable, cost-efficiency, quick assessment procedure, and high validity of DXA (Huang et al., 2018) (Pulse was measured using a Polar (OH1 heart rate monitor). The Polar monitor was attached to the upper arm and monitored through an iPad (Apple) for team Polar data. Polar produces a series of heart rate monitoring devices and accessories for sports training and fitness, as well as measuring heart rate variability. Polar Fitness Test is a non-exercise fitness test that measures your aerobic (cardiovascular) fitness. It estimates your maximal oxygen uptake, VO2max, in millilitres per kilogram of body mass per minute TheVO2max was measured using MFT at a distance of 20 m by running with rhythm.

Statistical analysis

The statistical analysis was performed using SPSS v26.0 for Windows (SPSS Inc., Chicago, USA). The paired sample t-test was used to determine the training effect by comparing the average and testing the significance of all study variables. Variables of body weight, BMI, fat percentage, bone mass, protein percentage, body water percentage, visceral fat, body age, muscle mass, and BMR (basal metabolic rate) were analysed using a paired sample t-test to determine the effect of aerobic interval training. The acceptable level (2-tailed) of statistical significance was <0.05.

Table 1. Descriptive statistics

Variable	Group	
	Pre-test (n=8)	Post-test (n=8)
Weight (Kg)	80.4± 11	79.6± 11
BMI (Kg/m^2)	27.1±2.1	26.8±2.1
Fat Mass (%)	28.4±5.1	28±5
Muscle Mass (Kg)	54.5±8.1	54.3±8.3
Total Body Water	50.1±2.7	50.1±2.7
Protein Profile	17.8±2.4	18.1±2.4
Basal Metabolic Rate	1675.4±224.9	1686.1±226.7
Visceral Fat (%)	9.4±2.7	9±2.3
Bone Density (%)	3±0.3	3±0.3
Body Age (y)	28.9±13.1	24.5±15.9
VO2max (mL.kg.min)	42.3±3.6	46.5±3.2
Basal Pulse (per min)	58.4±4.5	57.3±4.1

Table 2. Hypothesis test results

		Paired Sample Test							
		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Weight (Kg)	-.79875	.46707	.16513	-1.18923	-.40827	-4.837	7	.002*
Pair 2	BMI (Kg/m^2)	-.27750	.15691	.05548	-.40868	-.14632	-5.002	7	.002*
Pair 3	Fat Mass (%)	-.40000	.37033	.13093	-.70960	-.09040	-3.055	7	.018*
Pair 4	Muscle Mass (Kg)	-.21000	.22590	.07987	-.39885	-.02115	-2.629	7	.034*
Pair 5	Total Body Water	.02500	.50639	.17904	-.39835	.44835	.140	7	.893
Pair 6	Protein Profile	.37500	.77965	.27565	-.27681	1.02681	1.360	7	.216
Pair 7	Basal Metabolic Rate	10.75000	5.65054	1.99777	6.02603	15.47397	5.381	7	.001*
Pair 8	Visceral Fat (%)	-.37500	.51755	.18298	-.80768	.05768	-2.049	7	.080
Pair 9	Bone Density (%)	.01125	.01458	.00515	-.00094	.02344	2.183	7	.065
Pair 10	Body Age (y)	-4.33875	9.18715	3.24815	-12.01940	3.34190	-1.336	7	.223
Pair 11	VO2max (mL.kg.min)	4.21250	3.41671	1.20799	1.35606	7.06894	3.487	7	.010
Pair 12	Basal Pulse (per min)	-1.12500	5.71808	2.02165	-5.90543	3.65543	-.556	7	.595

*significant

Results

Bodyweight data was taken before training with average body weights for the pre- and post-test of 80.4 ±11 and 79.6 ± 11, respectively, and the significance of the body weight analysis (2-tailed) was 0.002 < 0.05; thus, there was a significant decrease. For the average BMI for the pre- and post-tests (27.1 kg/m^2 ± 2.1; 26.8 kg/m2 ± 2.1), the significance of the BMI analysis (2-tailed) was 0.002 < 0.05; thus, there was a significant decrease. There was a decrease in the athletes' fat mass according to the pre- and post-test averages (28.4 ± 5.1%; 28 ± 5%), and the significance of the fat mass analysis (2-tailed) was 0.018 < 0.05; thus, there was a significant decrease in fat mass. For the average muscle mass in the pre- and post-tests (54.5 ± 8.1; 54.3 ± 8.3), the significance of the muscle mass analysis (2-tailed) was 0.034 < 0.05; thus, there was a significant decrease in muscle mass. For average body water in the pre- and post-tests (50.1 ± 2.7; 50.1 ± 2.7), the significance of the body water analysis (2-tailed) was 0.893 > 0.05; thus, it was not significant. For the average protein profile in the pre- and post-tests (17.8% ± 2.4; 18.1 ± 2.4), the significance of the body water analysis (2-tailed) was 0.216 > 0.05; thus, the increase in the protein profile was not significant. For the basal metabolic rate for the pre- and post-tests (1675.4 ± 224.9 kcal; 1686.1 ± 226.7), the significance of the basal metabolic rate (2-tailed) was 0.001 < 0.05; thus, the increase in the basal metabolic rate was significant. For the average visceral fat during the pre- and post-tests (9.4 ± 2.7; 9 ± 2.3), the significance of the visceral fat analysis (2-tailed) was 0.080 > 0.05; thus, the decrease in the visceral fat was not significant. For the average bone density during the pre- and post-tests (3 kg ± 0.3; 3 kg ± 0.3), the significance of the bone density analysis (2-tailed) was 0.065 > 0.05; thus, the increase in bone density was not significant. For the average body age during the pre- and post-tests (28.9 years ± 13.1: 24.5 years±15.9), the significance of the body age analysis (2-tailed) was 0.223 > 0.05; thus, the decrease in body age was not significant. For the average VO2max during the pre- and post-tests (42.3 ± 3.6 mL/kg/min; 46.5 ± 3.2 mL/kg/min), the significance of the VO2max analysis (2-tailed) was 0.010 < 0.05; thus, there was a significant increase in VO2max during the 5 weeks of aerobic interval training. Their basal pulse was checked on the next day after training before they did activities after each treatment. For the average initial basal pulse rate (58.4 ± 4.5; 57.3 ± 4.1), the significance of the basal pulse rate analysis (2-tailed) was 0.595 > 0.05; thus, the decrease in basal pulse rate was not significant.

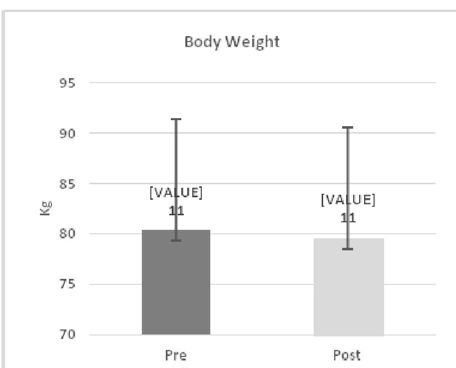

Fig.1. Body weight diagram

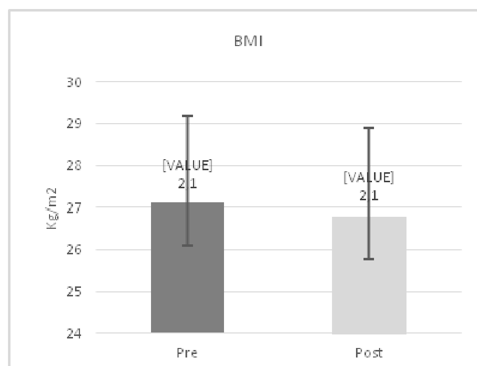

Fig.2. BMI diagram

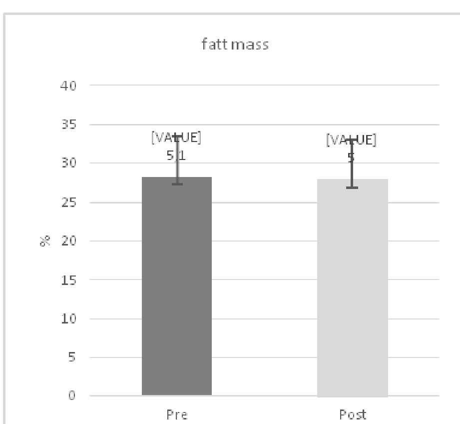

Fig.3. Fat mass diagram

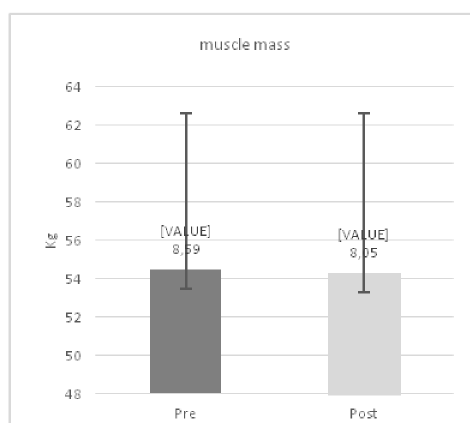

Fig.4. Muscle mass diagram

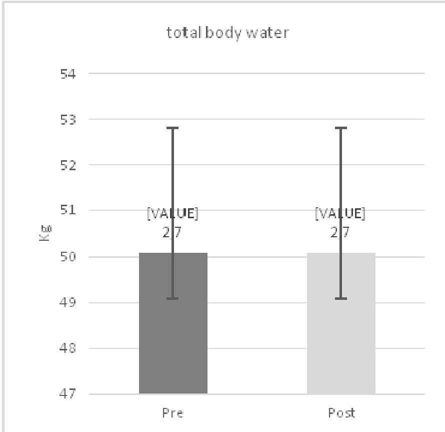

Fig.5. Total body water diagram

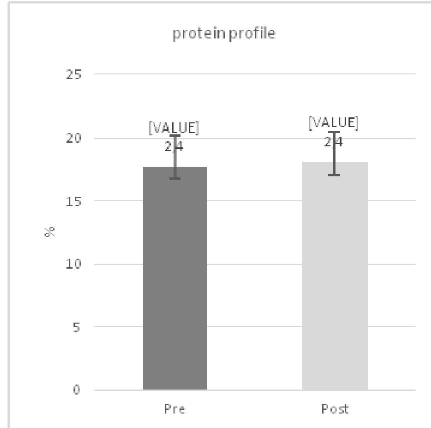

Fig.6. Protein profile diagram

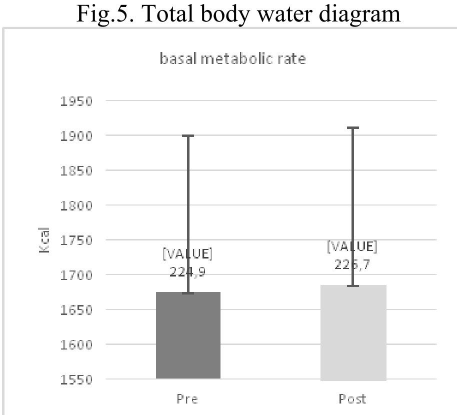

Fig.7. Basal metabolic rate diagram

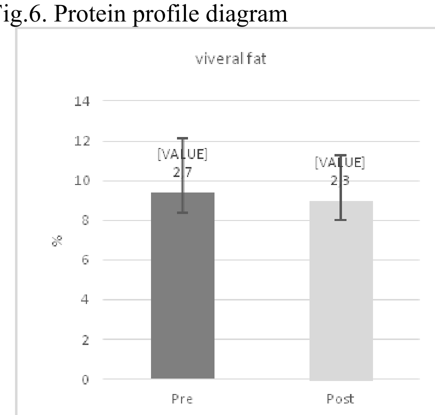

Fig.8. Visceral fat diagram

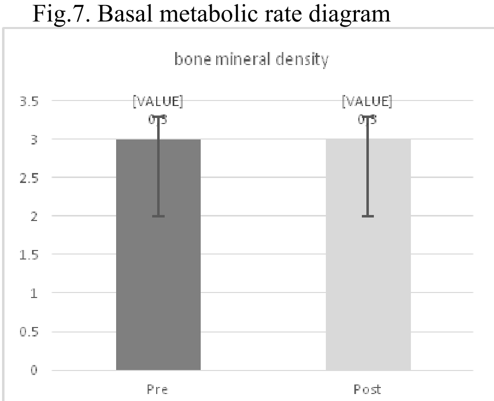

Fig.9. Bone mineral density (BMD) diagram

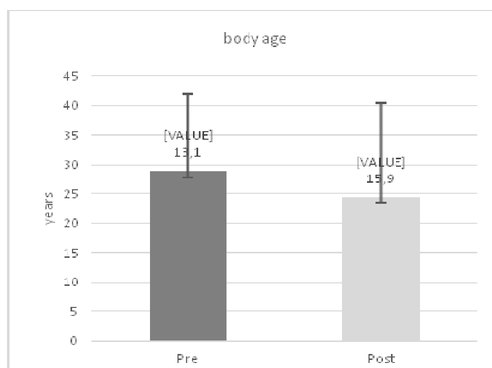

Fig.10. Body age diagram

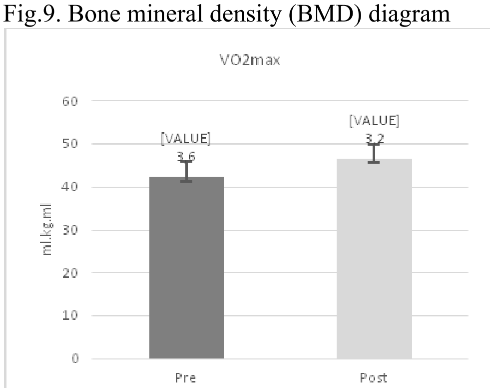

Fig.11. VO2max diagram

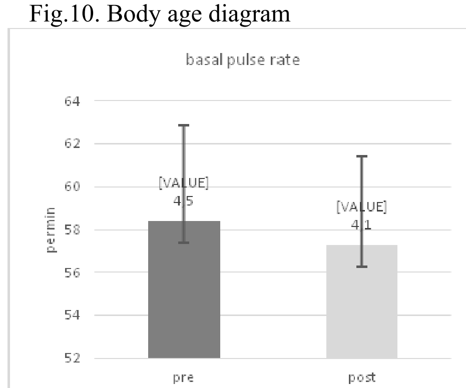

Fig.12. Basal pulse rate diagram

Discussion

The athletes who were overweight when given AI training for 5 weeks showed a significant weight loss (see Figure 1), and the training also resulted in changes in BMI even though they were still categorized as overweight (see Figure 2). In this study, AI training reduced body weight and fat mass, especially in athletes who were overweight, as in prior study referenced (Feo, 2013). This also applied to the management of body weight and overall health, which can be carried out for a long time and continuously, including the requirement of oxygen from activities (Berg, 2008). The findings showed that the body fat of the overweight elite athletes also decreased significantly. This in accordance with HIIT research indicating that HIIT can reduce the accumulation of abdominal fat mass and visceral fat, although there was no explanation regarding the HIIT protocol that was carried out (Maillard et al., 2018). Similarly, the effect of training will result in a reduction in body fat and abdominal fat in overweight individuals (Boutcher, 2011) (The findings of this study indicated that muscle mass was significantly decreased in overweight athletes (see Figure 3). In accordance with research reports, the muscle mass size of individuals who were overweight or obese underwent significant changes (Blue Malia N et al., 2020). However, this differs from other research reports that showed that there was no evidence of a significant increase in muscle mass, though AI training is considered the training type that is relevant for reducing body fat and weight significantly. However, in that report, there were difficulties in the level of sample readiness that had to be considered by the researchers (Juránková, Bílý, & Hrazdíra, 2015).

In this study, the significant increase in BMR in the overweight athletes (see Figure 7) was in accordance with a research report, which stated that lifestyle among other things, such as physical activity intensity, dietary aspects, and smoking habits, could affect BMR (Porras-Segovia et al., 2019)). The national training athletes were required to live in dormitories had the same diet, even though the portions eaten by each individual were different and adjusted to their needs; thus, in this case, we did not control it. However, the sleeping schedule for athletes was controlled, and athletes were not allowed to smoke. Our results are supported by research reports that showed that BMI is closely related to BMR. In one study, it was stated that the increase in BMI that recovered to a normal level would be in line with the process of recovering BMR to a healthy level for 3 to 4-year-old children suffering from narcolepsy (Wang et al., 2016). The findings of this study showed that VO2max had a significant increase in overweight athletes after AI training for 5 weeks (see Figure 11). Thus, HIIT training for 2 weeks could increase VO2max, and the average and peak strength output but did not affect resting heart rate or muscle strength production (Astorino, Allen, Roberson, & Jurancich, 2012)). However, we were concerned by the significant increase in low baseline increase, i.e., 42.3 mL/kg/min, in the overweight athletes; thus, the increase was quite significant.

The total body water of the athletes who were overweight in this study was not significant (see Figure 5). These findings differ from the findings of researchers who stated that "the lower the body fat percentage, the higher the total body water" (Mastria & Adyaksa, 2014). Physiologically, the need for fluids and electrolytes is a basic human need. Although the percentage of human body fluids and electrolytes vary depending on age, body fat, and sex, researchers need to suggest further research on total body water because the number of participants in the study was small, and there was no gender classification. Another finding was the insignificant decrease in visceral fat after 5 weeks of performing AI training (see Figure 8), even though the athletes in this study showed significant body weight loss.

This finding was in contrast to the finding that visceral fat and liver fat could be reduced along with weight loss (Tiikkainen et al., 2003). One research report showed that HIIT did not show a decrease in visceral fat, but there was a significant decrease in visceral fat after MICT training for 12 weeks, especially in young women who were obese (Zhang et al., 2017) According to another study, the degree of visceral fat in obese people 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 amount of visceral fat (Sumarni, 2019) AI training for 5 weeks in our study did not decrease the visceral fat in overweight athletes; thus, further research with a longer study period and more participants is needed.

This study showed no significant increase in bone mineral density (BMD) (see Figure 9), although AI training for 5 weeks resulted in a decrease in fat mass and muscle mass (see Figures 3 and 4). In contrast to research reports that showed that BMD was positively related to lean mass in the female population in Korea, it was found that fat mass did not show a consistent correlation with BMD (Kim et al., 2009). Other research reports showed that for strength athletes, such as weightlifting or judo athletes (judo is a martial arts sport similar to Pencak Silat), they had better bone density than endurance athletes, such as long-distance running, cycling, and swimming athletes (Hinrichs, Chae, Lehmann, Allolio, & Platen, 2010). Bone density can be affected by a weight lifting process focused on the bones; thus, training activities that involved weight affected bone density in contrast to endurance sports, which did not require athletes to lift weights (Bellew & Gehrig, 2006) (We hope that there will be further research on functional AI training that focuses on weight lifting to determine the bone density increase. However, for the findings in research related to basal pulse rate, AI training in overweight athletes had a decreasing effect but was not significant (see Figure 12), which is in contrast to research reports that showed that AI training decreases basal pulse rate (Beijer et al., 2018).

Conclusions

Aerobic interval training for 5 weeks had effects on overweight athletes, i.e., weight loss, a decrease in body mass index, body fat, muscle mass, and an increase in basal metabolic rate and VO2max. The insignificant results were for total body water, protein profile, visceral fat, bone density, body age, and basal pulse. So, through aerobic interval training, body composition (body mass index, body fat, muscle mass), basal metabolic rate, and $VO2_{max}$ of Pencak silat athletes can be controlled.

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Ethics

Ethics Committee for Higher Education in this study No. B/349/UN39.14/PT/202

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