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The effects of moderate intensity continuous and interval training on physical fitness in obesity

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Abstract---The objectives of this study were to study and compare the effects of moderate-intensity continuous and interval training on physical fitness in obesity. The participants were 48 male and female (fat % over 20 in men and 30 in women, aged between 20 – 25 years) and were randomized into three groups: 12 weeks of continuous along exercise (CA), 60-65% MHR (7 men and 8 women); 12 weeks interval exercise (IG), 60-65% MHR (208 - (0.7 x Age) alternate with 70-75% MHR every 1 minute (9 men and 8 women); and control group (CG) (8 men and 8 women). At baseline VO_2max, total body weight, body fat percentage, and visceral fat data did not differ significantly between the three groups ($p > 0.05$). After 12 weeks of exercise intervention, both men and women participants in CA and IG had significantly improved in VO_2max, total body weight, body fat percentage, no significantly in CG. There is no significant between CA and IG in every variable but significantly between CA and CG and between IG and CG in both men and women participants. it could be concluded, that moderate intensity of continuous and interval exercise is possible to improve cardiovascular fitness and body composition in overweight men and women.

***Keywords*---**Aerobic Exercise, Physical Fitness Training, Targets Heart Rate.

Introduction

Obesity is a major health risk factor (Kenchaiah& et al., 2002; Okura& et al., 2005). It is associated with non-communicable diseases (NCDs) and leads to low quality of life. At present, the prevalence of obesity continues globally rise (Okura& et al., 2005; Ren, J. 2004). Lack of exercise and lower daily active activities is associated with obesity (Saif& Alsenany, 2015).

The obesity management guidelines emphasize the importance of exercise (Armstrong& et al., 2022). Although decreasing body weight is not the first outcome of exercise (Pinckard& et al., 2019). Several studies reported that aerobic exercise training does not always play an important role in weight loss (Okura& et al., 2005). But exercise can improve body composition including reducing the risk factors of obesity (Donnelly& et al., 2009) increasing fatty acid oxidation (Tao& et al., 2015), increasing glucose uptake, and improving muscle insulin secretion and sensitivity (Moghetti& et al., 2016), increased skeletal muscle metabolism and metabolic adaptations in other tissues (Thyfault& Bergouignan, 2020). endurance exercise an effective increase in total daily energy expenditure (TDEE), and possibly an increase in resting metabolic rate (RMR) (Sevits& et al., 2013).

Regular active exercise habits promote positive physical fitness. Whether to increase cardiovascular fitness, muscular endurance, muscular strength, and body composition and reduce the risk of non-communicable diseases (NCDs) (Aga, 2022; Löllgen& et al., 2009; Mazurek& et al., 2008). It was many pieces of evidence showing that habitual exercise is effective physically and promotes the quality of life (Rugbumrung& et al., 2022, Chodzko-Zajko& et al., 2009; Karlsen& et al., 2013; Martin& et al., 2009) On the other hand, never or lack of exercise for a long time the body will become weak and vulnerable to various diseases easily. Appropriate exercise programs including frequency, intensity, time, and type were important to improve physical fitness (ACSM., 2018; Mason& et al., 2013; Garber, & et al., 2011),

Aerobic exercise is the continuous physical activity that uses large muscle groups (Wahid& et al., 2016), it is the type of exercise that uses energy from amino acids, carbohydrates, and fatty acids such as cycling, dancing, hiking, jogging/long-distance running, swimming and walking (Patel& et al., 2017). Aerobic exercise reduces fat mass and causes decreased body weight (Okura& et al., 2005; Stasiulis& et al., 2010). The data from the meta-analysis, it was founded that aerobic exercise showed a statistically significant 9% increase in HDL-C and an 11% decline in triglycerides (TG), but no statistically significant changes in total cholesterol (TC) and LDL-C (Kelley& et al., 2006; Patel& et al., 2017).

Continuous and interval training is the most popular aerobic exercise because they are easy to work out anywhere and anytime. Continuous exercise is the activity, for example, walking or running continuously along the distance without a break up to the given time or distance (Smart& Steele, 2012; Mazoochi& et al., 2013) with moderate intensity of exercise (around 50-69 % of maximum heart rate or heart rate zone 1-2). While continuous training is a long period of moderate intensity of exercise, Interval training is the exercise with alternate periods of high and low intensity of exercise, for example, running at 60-65% MHR alternate with 80-85% MHR every 30 seconds or every 1 minute. This exercise is powered by an anaerobic system as well as aerobic systems. Meanwhile, the periods of high and low-intensity between exercises are a time to restore the energy sources. (Borel& et al., 2010; Katch& et al., 2010)

Thus, the objective of this study was to study and compare the effects of moderate-intensity continuous and interval training on Maximum Oxygen Consumption and Body Composition in obesity. Moreover, the data from the study will useable able to design an appropriate exercise program for each individual.

Methods

Study design and participants

This study is a 12-weeks randomized controlled trial research. The participants were 48 male and female young adults recruited from the students and staff and general public age between 20 – 25 years old. All subjects had body fat % over 20 in men and 30 in women without coronary heart disease; or cardiovascular,

pulmonary, or metabolic disease (ACSM., 2018). All participants pass the ed Physical Activity Readiness Questionnaire Plus – PAR-Q+.
The sample size was calculated by G*Power 3.1 software. Base on, power of test (β) at 0.8, probable error; (α) at 0.05 and effect size at 0.5 (Cohen,1988; Leppink& et al, 2016; Mendonça& et al., 2022). The minimum sample size was 11 people per group. To prevent drop-out during follow-up, we added 18 people per group. Total the sample group was 54 people. The participants were randomized into groups. 1) Control group (CG); 9 male 9 female, 2) Continuous along group (CA); 9 male 9 female, 3) Interval group (IG); 9 male 9 female.

The study team consisted of fitness coach assistants, 4^{th} year of sports science bachelor degree students, who assisted the fitness coach to deliver the exercise training program; Fitness coach graduated in sports science or physical education, delivered the exercise training program, and the researchers, who prescribed and controlled exercise training program and analyzed the results. Data were collected at two time points; 1) @baseline, 72 h before the start of the exercise training program 2) @ post- exercise training program 72 h after the last session of the exercise training program (Mendonça& et al., 2022).

Exercise Intervention

The experimental group trained 4 days a week, for 12 weeks at the sport and exercise science fitness center; at Phayao University. Group 1) Continuous along group (CA), trained exercise program with 5-minute warm-up by treadmill walking at 3-4 km/hr., follow by 30 minutes of treadmill exercise at 60-65% MHR (208 - (0.7 x Age)) in 1st – 4th week then, 45 minutes in 5th -12th week and 10 minutes cool down with dynamic and static stretching. The total volume of training is 120 minutes/ week in the 1st – 4th week and 180 minutes/ week in the 5^{th}-12^{th} week. Group 2) Interval group (IG), trained exercise program with 5-minute warm-up by treadmill walking at 3-4 km/hr., followed by 20 minutes of treadmill exercise at running at 60-65% MHR (208 - (0.7 x Age)) alternate with 70-75% MHR every 1 minute in 1st – 4th week then, 45 minutes in 5th -12th week and 10 minutes cool down with dynamic and static stretching. The total volume of training is 80 minutes/ week in the 1^{st} – 4^{th} week and 120 minutes/ week in the 5^{th} -12^{th} week. Each experimental group performed the exercise at the same time of day (3:30 p.m. and 7:00 p.m.) under the control of fitness coach assistants, fitness coach, and the researchers. All-time heart rate monitor (Polar H10) during exercise.

Testing

The participants were recommended to avoid alcohol, tobacco use, and vigorous physical activity at least 48 hours before the physical fitness testing. Consume a meal 2–3 hours before testing. The baseline testing was conducted 72 hr. before the start of the exercise training program. And the post-test was conducted 72 hr. after the last session of the exercise training program

Maximum Oxygen Consumption

The Astrand-Rhyming cycle ergometer test was selected for the participant. Because it is a safe protocol with a constant load for overweight. This protocol had a high relationship with gas analysis in both healthy cases and health problem cases (Reed& et al., 2020; Noonan & Dean, 2000; Astrand, 1960).

Body composition and height

Body composition was measured without shoes and performed using bioelectrical impedance analysis (BIA) by ACCUNIQ BC380 (Yang, Kim& Choi,2018) to assess the body weight, body fat %, and visceral fat.

Statistical analysis

The data were collected focusing on maximum oxygen consumption, body weight, body fat %, and visceral fat. Data analysis was conducted using three statistical values: percentage, Mean, and Standard Deviation. Paired sample test was used to compare the effects of the time with the exercise training program within the group at baseline and post-intervention. One-way repeated ANOVA was used to compare the effects of an exercise intervention on maximum oxygen consumption, body weight, body fat percentage, and visceral fat between groups post-intervention. When the F test identified interaction, the Bon-ferroni post hoc was used to identify the means differences (Mendonça& et al., 2022). Effect sizes between groups were calculated by Cohen. The thresholds considered were: insignificant (<0.19); small (0.20; 0.49); moderate (0.50; 0,79); and large (>0.80) (Cohen,1988; Mendonça& et al., 2022). The SPSS version 25 software was used for data analysis. And the GPower 3.1 software was used for effect size calculations. The significance alpha levels are set at $p < 0.05$(Cohen,1988; Mendonça& et al., 2022).

Results

At the end of 12 -weeks, thirty-two of a trained group (7 men and 8 women, Continuous exercise; 9 men and 8 women Interval exercise) completed the exercise training program. Due to the injury concerned, four participants of the trained group withdrew from the study and two of the control group doesn't continue the study because their daily physical activity had changed. This is the results of 32 participants with continuous exercise and interval exercise and 16 of the control group.

Table 1 Participants' general information, separated by gender at the baseline

Item	Men (n=24)			Women (n=24)		
	CG (n =8)	CA (n =7)	IG (n =9)	CG (n =8)	CA (n =8)	IG (n =8)
Age	21.39 ± 0.53	21.20 ± 0.72	20.13 ± 0.45	20.32 ± 0.52	21.15 ± 0.63	20.35 ± 0.45
Height	171.85 ± 3.13	170.63 ± 3.72	172.50 ± 2.51	160.36 ± 4.87	161.62 ± 3.45	161.48 ± 4.78
Weight	81.23 ± 10.78	82.26 ± 12.03	81.27 ± 11.47	70.26 ± 9.43	71.25 ± 11.27	72. 48 ± 10.77

* CG = control group, CA = continuous along group, IG = interval group

At the baseline men participants in CG, CA and IG had the baseline average age: 21.39 ± 0.53 yrs., 21.20 ± 0.72 yrs. and 20.13 ± 0.45, respectively; average height: 171.85 ± 3.13 cm, 170.63 ± 3.72 cm and 172.50 ± 2.51 cm, respectively; average weight: 81.23 ± 10.78 kg, 82.26 ± 12.03 kg and 81.27 ± 11.47 kg.

The women participants in CG, CA, and IG had a baseline average age: of 20.32 ± 0.52 yrs., 21.15 ± 0.63 yrs. and 20.35 ± 0.45, respectively; average height: 160.36 ± 4.87 cm, 161.62 ± 3.45 cm and 161.48 ± 4.78 cm, respectively; average weight: 70.26 ± 9.43 kg, 71.25 ± 11.27 kg and 72. 48 ± 10.77 kg.

Table 2 Participants' VO_2max and Body Composition of the (men)

Variable	Control Group (CG)			Continuous Group(CA)			Interval Group (TG)			post hoc
	Before	After	t	Before	After	t	Before	After	t	
VO2max (ml/kg/min)	28.1 ± 4.1	27.7 ± 3.89	.84	28.02 ± 3.95	30.49± 4.14	2.74*	29.32 ± 4.20	31.98 ± 4.54	2.72*	CA>CG* TG>CG*
BW (kg)	81.23 ± 10.78	81.93± 10.53	.31	82.26 ± 12.03	79.89± 12.88	2.14*	81.27 ± 11.47	78.48± 12.93	2.89*	CA>CG* TG>CG*
fat %	32.71 ± 5.28	33.45± 6.08	1.07	31.70± 4.14	27.70± 5.17	3.54*	30.31± 5.89	28.70± 6.17	2.45*	CA>CG* TG>CG*
V-Fat (%)	12.00± 2.94	12.98± 3.18	.32	12.75± 4.35	12.14± 2.27	.21	11.95± 3.59	11.5± 3.44	.18	-

*$p < 0.05$ ** BW = body weight, fat % = body fat percentage, V-Fat = visceral fat

In the continuous exercise program men participants, the VO_2max significant increased from the baseline of 28.02 ± 3.95 ml/kg/min to 30.49 ± 4.14 ml/kg/min at the end of the exercise program, total body weight was significantly decreased from 82.26 ± 12.03 kg to 79.89 ± 12.88 kg, body fat percentage was significant decreased form 31.70 ± 4.14 % to 27.70 ± 5.17. But there was no significant change in the visceral fat data. Regarding the interval exercise program for men, the VO_2max significant increased from the baseline of 29.32 ± 4.20 ml/kg/min to 31.98 ± 4.54 ml/kg/min at the end of the exercise program, total body weight was significantly decreased from 81.27 ± 11.47 kg to 78.48± 12.93 kg, body fat percentage was significant decreased form 30.31 ± 5.89 % to 28.70± 6.17. No significant change in the visceral fat data. There was no significant change in the VO_2max, the total body weight, the body fat percentage, and the visceral fat in the control group.

The data from the study showed no significant difference in the VO_2max, the total body weight, body fat percentage, visceral fat between continuous exercise and interval exercise. But significant differences between continuous exercise and control group and interval exercise and control group in the VO2max, the total body weight, and the body fat percentage variable.

Table 3 Participants' VO_2max and Body Composition of the (Women)

Variable	Control Group (CG)			Continuous Group(CA)			Interval Group (TG)			post hoc
	Before	After	t	Before	After	t	Before	After	t	
VO2max (ml/kg/min)	25.18 ± 3.41	24.98± 3.97	.42	24.92 ± 3.56	27.25± 4.89	2.58*	25.93 ± 4.20	28.08 ± 4.54	2.42*	CA>CG* TG>CG*
BW (kg)	70.26 ± 9.43	71.35± 10.13	.30	71.25 ± 11.27	68.09± 11.28	2.41*	72.48 ± 10.77	68.41± 11.95	2.67*	CA>CG* TG>CG*
fat %	37.21 ± 5.08	37.58± 5.42	.32	38.27± 5.56	35.17± 5.83	2.74*	38.31± 6.12	35.29± 5.17	2.65*	CA>CG* TG>CG*
V-Fat (%)	12.00± 1.38	12.45± 2.35	.76	11.98± 2.24	11.53± 2.17	.55	12.68± 2.95	12.15± 2.58	.34	-

*$p < 0.05$ ** BW = body weight, fat % = body fat percentage, V-Fat = visceral fat

Regarding women participants, in the continuous exercise group, the VO_2max significant increased from the baseline of 24.92 ± 3.56 ml/kg/min to 27.25 ± 4.89 ml/kg/min at the end of the exercise program, total body weight was significantly decreased from 71.25 ± 11.27 kg to 68.09 ± 11.28 kg, body fat percentage was significant decreased form 38.27 ± 5.56 % to 35.17 ± 5.83. But there was no significant change in the visceral fat data. Interval exercise program group, the VO_2max significant increased from the baseline of 25.93 ± 4.20 ml/kg/min to 28.08 ± 4.54 ml/kg/min at the end of the exercise program, total body weight was significantly decreased from 72.48 ± 10.77 kg to 68.41 ± 11.95 kg at the end of exercise program, the body fat percentage was significant decreased form 38.31 ± 6.12 to 35.29 ± 5.17. No significant change in the visceral fat data. There was no significantly changed in the VO_2max, the total body weight, the body fat percentage, and the visceral fat in the control group.

In the same way as men participants, the data of women no significant difference in the VO_2max, the total body weight, body fat percentage, and visceral fat between continuous exercise and interval exercise. But its significant differences between continuous exercise and control group and interval exercise and control group in the VO2max, the total body weight, and the body fat percentage variable.

Discussion and Conclusion

From the result of this study, we found that continuous exercise and interval exercise are effective for maximum oxygen consumption, total body weight, and body fat percentage. After completing a 12-weeks exercise program the continuous exercise and interval exercise led to significant changes in the various variable compared with non-exercise (control group). Both the continuous and interval exercise results also show a significant positive change in maximum oxygen consumption, total body weight, and body fat percentage from the baseline to the end of the program.

Regarding maximum oxygen consumption, aerobic exercise at 50-75% MHR is A positive influence on maximal oxygen consumption (Park& et al., 2003; ACSM., 2018; Gormley& et al., 2008). Aerobic exercise improves VO_2 max by increasing the cardiac output, stroke volume, and arterio-venous O_2 differences (Angane& Navre, 2015). In addition, exercise-induced vasodilation and angiogenesis (Hoier& Hellsten, 2014; Pinckard& et al, 2019; Olver& et al., 2015). These adaptations lead to positive changes in maximal oxygen consumption with regular exercise people. The finding of this study was that continuous exercise and interval training are similar in improving VO_2max. Some studies have found higher intensities of exercise are more effective for improving VO_2max than lower intensities (Gormley& et al., 2008) but they are a study on healthy men and women. For obesity, the concern about the intensity of the exercise program could affect body injury. We designed the intensity of exercise at 60 - 65% MHR for continuous exercise and 1 minute at 60 – 65 % and 1 minute at 70 – 75% for interval exercise. But in the healthy participant's study, the intensity of exercise is 4 min at 93% MHR for the interval group and 3 min at 70% MHR for the continuous group (Helgerud&, et al. 2007). Another study uses 4 min at 93% MHR and 3 min at 60% MHR for the interval group and 73% MHR for the continuous group (Wisloff & et al., 2007). With closely exercise intensity between continuous and interval in this study, could be a reason that cardiovascular fitness in the trained group was significantly improved but not different between groups.

According to body composition results, it showed a reduction in total body weight and body fat percentage. Because exercise improves metabolic rate (Hawley& et al., 2014). Aerobic exercise training plays an important role in weight loss factor by reducing the risk factors of obesity (Donnelly& et al., 2009), increasing fatty acid oxidation (Tao& et al., 2015), increasing glucose uptake, improving muscle insulin secretion and sensitivity (Moghetti& et al., 2016), increased skeletal muscle metabolism and metabolic adaptations in other tissues (Thyfault& Bergouignan, 2020). endurance exercise an effective increase in total daily energy expenditure (TDEE), and possibly an increase in resting metabolic rate (RMR) (Sevits& et al., 2013). low-intensity exercise without diet control is possible to improve improved body composition (Chiu& et al., 2017). In some studies, when the energy expenditure was equal high-intensity exercise seemed to be reduced the total body weight significantly more than low-intensity exercise (Chiu & et al., 2017; Lee& et al., 2012; Irving& et al., 2008). In this study, concerned about obese participants we adjust exercise intensity closely between continuous exercise and interval exercise. It could be a reason that total body weight and body fat percentage in the exercise intervention group were significantly improved but not different between groups.

From the data of this study, it could be concluded, that moderate intensity of continuous and interval exercise is possible to improve cardiovascular fitness and body composition in overweight. But it is necessary to design an appropriate exercise program due to individual for promoting physical fitness and possible to do in obesity.

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