THE EFFECT OF HIGH-INTENSITY INTERVAL TRAINING, MODERATE-INTENSITY INTERVAL TRAINING, AND CONTINUOUS TRAINING ON ANAEROBIC AND AEROBIC CAPACITY*

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ABSTRACT

The purpose of this research is to study and compare the effects of high-intensity interval training (HIIT), moderate-intensity interval training (MIIT), and continuous training (CT) on anaerobic and aerobic capacity in Bangkokthonburi university students. Methods: 21 male students aged 20-24 years who are now studying in the Faculty of Sports Science and Technology of Bangkokthonburi university volunteered to participate in this study. Subjects were divided into 3 groups of 7 subjects who participated in 8 weeks of exercise training for 3 days/per week. The HIIT group (n=7) conducted a 20-second sprint exercise with 45 seconds of walking for 5 sets. The MIIT group performed 4 minutes of moderate-intensity running exercise alternating 4 minutes of walking for 4 sets, and the CT group performed 45 minutes of continuous running exercise training with pre and post-test. Data were analyzed with statistics mean, and standard deviation. Differentiated by one-way ANOVA and Tukey's test. Results: Anaerobic capacity; HIIT (7.67±0.76 $W.kg^{-1}$) was indifferent from MIIT (8.06±0.70 $W.kg^{-1}$) ($p>0.05$) but significant difference from CT (7.81±0.54 $W.kg^{-1}$) ($p<0.05$) while the aerobic capacity for HIIT (3.81±0.441 ml/kg/min) was indifferent from MIIT (3.95±0.39 ml/kg/min) ($p>0.05$), but HIIT (3.81±0.441 ml/kg/min) was significant difference from CT (4.42±0.72 ml/kg/min) ($p<0.05$).

Keywords : Interval and continuous exercise training; Anaerobic capacity; Aerobic capacity

1. Statement of Problem and Significance of Research

Physical fitness is a state of health and well-being and, more specifically, the ability to perform aspects of sports, occupations, and daily activities. Physical fitness is generally achieved through proper nutrition (Tremblay M.S, et. al, 2010). Interval

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training is a form of exercise training that involves intervals of high-intensity workouts alternating with rest periods. The high-intensity periods are generally close to anaerobic exercise, while the recovery periods involve lower-intensity activity (Gibala M. J, Gillen, J. B, and Percival, M.E., 2014 ; Osawa Y, Azuma A, and Tabata S, 2014). The intensity of exercise stimulates the heart muscle, and cardiovascular system to adjust and enhance aerobic performance, resulting in the body being able to exercise harder or for longer. It can be said that interval exercises are exercises that can improve the cardiovascular system to be more effective. (MacInnis M.J, and j. M. Gibala., 2016, pp. 2915-2930; Mayo Clinic, 2014, online). High-intensity interval training is less time-consuming than continuous endurance of moderate-intensity exercise (Gist, N. H, et. al, 2014).

Gentil and Del Vecchio, F B, et.al, (2017) suggest that Intermittent-intensity exercise affects the cardiovascular system, where the intensity of the exercise is unclear with the exercise training and the degree of improvement in the anaerobic and aerobic of all 3 forms of exercise training.

Therefore, the researcher is interested in studying the effects of high-intensity interval training. with moderate-intensity interval training, and continuous training on anaerobic and aerobic capacity.

2. Objectives of the Research

2.1 To study the effect of High-intensity interval training (HIIT) on Anaerobic Capacity (AnC) and Aerobic Capacity (AC).

2.2 To study the effect of Moderate-intensity interval training (MIIT) on Anaerobic Capacity (AnC) and Aerobic Capacity (AC).

2.3 To study the effect of Continuous training (CT) on Anaerobic Capacity (AnC) and Aerobic Capacity (AC).

2.4 To compare the effect of high-intensity interval training (HIIT), moderate-intensity interval training (MIIT), and continuous training (CT) on anaerobic capacity and aerobic capacity.

3. Expected Results

3.1 Know the effects of anaerobic and aerobic capacity levels as a result of high-intensity interval training (HIIT) 3 days a week for 8 weeks.

3.2 Know the effects of anaerobic and aerobic capacity levels as a result of moderate-intensity interval training (MIIT) 3 days a week for 8 weeks.

3.3 Know the effects of anaerobic and aerobic capacity levels as a result of Continuous training (CT) 3 days a week for 8 weeks.

3.4 Know the difference between aerobic and anaerobic fitness levels as a result of high-intensity interval training (HIIT) with moderate-intensity interval training (MIIT), and continuous training (CT) 3 days a week for 8 weeks.

3.5 Get a pattern and guidelines for exercise training to develop aerobic and anaerobic fitness appropriately.

3.6 Obtaining guidelines for the study of exercise training patterns for the health and/or performance of athletes appropriately.

4. Research Methodology

This research was experimental research with a sample of 21 male volunteers aged 20-24 years studying at Bangkokthonburi University. The protocol, purpose, and risks of the study were explained to all participants, and required to complete the Physical Activity Readiness Questionnaire (PAR-Q), and research consent before participating.

1) Research tools

1.1) Cycle ergometer (Monark Ergomedic 894 E, Sweden) for evaluating anaerobic capacity with the “Wingate Test”.

1.2) Cycle ergometer (Monark 928 G3, Sweden) is used for estimating VO_2max by the “Astrand and Rhyming test”.

1.3) Stopwatch (Memory 100, Seiko)

1.4) Weight scale (Inbody 570)

1.5) Computer & software (ASUS)

1.6) Stethoscope

1.7) Automatic blood pressure monitor (Raycome RBP-9000)

1.8) Test record form

In this study, volunteers were divided into three groups of seven subjects each group with average aerobic and anaerobic capacity that was not different Homogeneous. Three groups HIIT, MIIT, and CT were performed 3 days a week for 8 weeks and were pre and post-test with Astrand-rhyming for aerobic and Wingate tests for anaerobic before and after eight weeks of the exercise training program.

2) Pre and post-test

The subjects were screened of health risks and obtain informed consent. researcher prepared participation forms and wrote down their basic information of subject individually such as age, height, body weight, gender, and test conditions, measure resting heart rate, and blood pressure. After the subjects have screened of health risks and obtain informed consent, subjects were allowed for an appropriate

warm-up and follow by Pre-test of Astrand-rhyming Test followed by 30 minutes rest and then continued with Wingate Test and the pre-test data were collected immediately. Accordingly, the 3-training protocols have begun on the next day 3-days a week for 8-weeks as the following tables,

Table 1 High-intensity interval training (HIIT) Program 3 days a week for 8 weeks

Week	Warm-up	Set	Sprint	Recovery	Cool-down	Total time	Overload training
1-2	5 min	5 Set	20 Sec	45 Sec	5 min	15 min 25 Sec	-
3-4	5 min	5 Set	24 Sec	45 Sec	5 min	15 min 45 Sec	20%
5-6	5 min	5 Set	29 Sec	45 Sec	5 min	16 min 10 Sec	20%
7-8	5 min	5 Set	35 Sec	45 Sec	5 min	16 min 40 Sec	20%

Table 2 Moderate-intensity interval training (MIIT) Program 3 days a week for 8 weeks

Week	Warm-up	Set	Running	Active Recovery	Cool-down	Total time	Overload training
1-2	5 min	4 Set	4 min	4 min	5 min	42 min	-
3-4	5 min	4 Set	5 min	4 min	5 min	46 min	25%
5-6	5 min	4 Set	6 min 25 Sec	4 min	5 min	51 min 40 Sec	25%
7-8	5 min	4 Set	7 min 45 Sec	4 min	5 min	57 min	25%

Table 3 Continuous training (CT) Program 3 days a week for a total of 8 weeks

Week	Warm-up	Set	Continuous running	Cool-down	Total time	Overload training
1-2	5 min	1	40 min	5 min	50 min	-
3-4	5 min	1	44 min	5 min	54 min	10%

Week	Warm-up	Set	Continuous running	Cool-down	Total time	Overload training
5-6	5 min	1	48 min 40 Sec	5 min	58 min 40 Sec	10%
7-8	5 min	1	53 min 24 Sec	5 min	63 min 24 Sec	10%

3) Analysis of collected data

In this research, collected data and analyzed with statistics mean, and standard deviation. Data were differentiated by one-way ANOVA and Tukey's test for individual differences at the 0.5 level.

5. Discussion of Research Results

5.1 The effect of high-intensity interval training (HIIT) on anaerobic capacity (AnC) and aerobic capacity (AC).

Table 4 shows the results of the pre and post-test anaerobic capacity values for the High-Intensity Interval Training (HIIT) group.

Variable	Test	$\overline{X}$ ± SD	N
HIIT Anaerobic Capacity	Pre-test	7.67 ± 0.76	7
	Post-test	8.69 0.94	

Table 4 has shown the pre-test anaerobic capacity mean±sd was 7.67±0.76 (W.kg-1) and the post-test mean±sd was 8.69±0.94 (W.kg-1).

Table 5 shows the results of the VO_2max values after the pre and post-test of the High-Intensity Interval Training (HIIT) group.

Variable	Test	$\overline{X}$ ± SD	N
HIIT Aerobic Capacity	Pre-test	3.3 ± 0.47	7
	Post-test	3.81 ± 0.44	

Table 5 has shown the pre-test VO_2 max, mean±sd was 3.30±0.473 (ml/kg/min), and the post-test mean±sd was 3.81±0.441 (ml/kg/min).

5.2 The effect of moderate-intensity interval training (MIIT) on anaerobic capacity (AnC) and aerobic capacity (AC).

Table 6 shows the anaerobic capacity results after the pre and post-test of the moderate-intensity interval training (MIIT) group.

Variable	Test	$\bar{X}$ ± SD	N
MIIT Anaerobic Capacity	Pre-test	7.58 ± 0.63	7
	Post-test	8.06 ± 0.70	

Table 6 has shown the anaerobic capacity after the pre-test was 7.58 ± 0.63 (W.kg-1), and the post-test mean±sd was 8.06 ± 0.70 (W.kg-1).

Table 7 has shown the VO_2max value after the pre and post-test of the moderate-intensity interval training (MIIT) group.

Variable	Test	$\bar{X}$ ± SD	N
MIIT Aerobic Capacity	Pre-test	2.85 ± 0.47	7
	Post-test	3.95 ± 0.39	

Table 7 has shown the VO_2max after the pre-test mean±sd was 2.85±0.47 (ml/kg/min), and the post-test mean±sd was3.95±0.39 (ml/kg/min).

5.3 The effect of continuous training (CT) on anaerobic capacity (AnC) and aerobic capacity (AC).

Table 8 Shows the anaerobic capacity results after the pre and post-test of the continuous training (CT) group.

Variable	Test	$\bar{X}$ ± SD	N
CT Anaerobic Capacity	Pre-test	7.69 ± 0.64	7
	Post-test	7.81 ± 0.54	

Table 8 has shown the anaerobic capacity after the pre-test mean±sd was 7.69±0.64 (W.kg-1), and the post-test mean±sd was7.81±0.54 (W.kg-1).

Table 9 Shows the value of VO_2max after the pre-test and post-test of the continuous training (CT) group.

Variable	Test	$\bar{X}$ ± SD	N
CT Aerobic Capacity	Pre-test	3.35 ± 0.92	7
	Post-test	4.42 ± 0.72	

Table 9, it has shown the VO_2max after the pre-test mean±sd was 3.35±0.92 (ml/kg/min), and the post-test, mean±sd was 4.42±0.72 (ml/kg/min).

5.4 Compare the effect of high-intensity interval training (HIIT), moderate-intensity interval training (MIIT), and continuous training (CT) on anaerobic capacity and aerobic capacity.

Table 10 Shows compare the differences in anaerobic capacity (ANOVA).

Variable		SS	df	MS	F	P
HIIT	Between groups	3.682	1	3.682	5.005	0.045*
	Within group	8.829	12	0.736		
	Total	12.511	13			
MIIT	Between groups	0.821	1	0.821	1.838	0.2
	Within group	5.358	12	0.447		
	Total	6.179	13			
CT	Between groups	0.05	1	0.05	0.143	0.71
	Within group	4.237	12	0.353		
	Total	4.288	13			

***p<0.05.**

Table 10 has shown that the anaerobic capacity for HIIT group were significantly different between MIIT, and CT groups.

Table 11 Shows compare the difference in anaerobic capacity

Variable	Group		MD	Std. Error	P
Anaerobic Capacity	HIIT	MIIT	0.63	0.40003	0.133
		CT	.88143*	0.40003	0.041*
	MIIT	HIIT	-0.63	0.40003	0.133
		CT	0.2514	0.40003	0.538
	CT	HIIT	-.8814*	0.40003	0.041*
		MIIT	-0.2514	0.40003	0.538

*****p<0.05

Table 11 has shown that HIIT was significantly different from CT (p<0.05), but not significantly different from MIIT group (p>0.05).

Table 12 Shows compares the difference in VO_2max (ANOVA).

Variable		SS	df	MS	F	P
HIIT	Between groups	0.926	1	0.926	4.428	0.05
	Within group	2.509	12	0.209		
	Total	3.434	13			
MIIT	Between groups	4.235	1	4.235	22.151	0.001*
	Within group	2.294	12	0.191		
	Total	6.529	13			
CT	Between groups	4.018	1	4.018	5.829	0.033*
	Within group	8.271	12	0.689		
	Total	12.289	13			

*****p<0.05

Table 12, Compared VO_2max difference and found that HIIT group was not significant difference (p>0.05). But MIIT (p<0.05), and CT (p<0.05) groups had significantly difference.

Table 13 Shows compare the difference in VO_2max

Variable	Group		MD	Std. Error	P
Aerobic Capacity	HIIT	MIIT	-0.14286	0.2873	0.625
		CT	-.61429*	0.2873	0.046*
	MIIT	HIIT	0.14286	0.2873	0.625
		CT	-0.47143	0.2873	0.118
	CT	HIIT	.61429*	0.2873	0.046*
		MIIT	0.47143	0.2873	0.118

***p<0.05.**

Table 13 has shown that the comparison of aerobic capacity value (VO_2max) among the 3 groups resulted that the HIIT group had an indifferent from MIIT significantly (p>0.05), it was found that HIIT has a different effect from CT group (p<0.05).

6. Discussion of Research Results

6.1 The results of the study on the effects of high-intensity interval training (HIIT) resulted in a higher anaerobic capacity of post-test (8.69±0.94 W.kg-1) than pre-test (7.67±0.76 W.kg-1) significantly different (p<0.05). This is because HIIT has an effect on the development of the anaerobic power of the somatic muscles consistent with Chee., R. (2019) that described as HIIT of 10-15 seconds at 90-100% of your maximum heart rate (HRmax), with 3 intervals of 30-60 seconds of rest. Can affect the development of anaerobic power and HIIT training for more than 10 seconds at 90% of maximum heart rate (HRmax) with rest/pay installments in 3 periods of 3-5 minutes each. You can develop anaerobic glycolysis/ and lactic acid.

Aerobic capacity has no significant difference post-test (3.81±0.44 ml/kg/min) and pre-test (3.3 ± 0.47 ml/kg/min) (p>0.05). This is because high-intensity interval training (HIIT) affects the development of the anaerobic power of the muscles of the body. This is consistent with Chee, R. (2019), who described how aerobic glycolysis can be developed with constant exercise training.

6.2 The results of this study of moderate-Intensity interval training (MIIT) showed that there has no significant difference between post-test of anaerobic capacity (8.06±0.70 W.kg-1) and pre-test (7.58±0.63 W.kg-1) (p>0.05). This is due to the MIIT characteristics of the moderate-intensity interval training exercises being similar to those of the exercise training. However, the difference in the training style is that the

intensity is different, with the lower intensity of the exercise training, does not affect the anaerobic capacity according to Coswig, S. V. et al. (2020), who concluded that Exercise intensity is an important factor in your training goals.

In addition, research results have shown that aerobic capacity (VO_2max) of MIIT was significant difference between post-test (3.95±0.39 ml/kg/min) and; pre-test (2.85±0.47 ml/kg/min) ($p<0.05$), because MIIT training has a similar pattern and nature to HIIT training, but the intensity of each pattern has been difference that affected on the improvement of aerobic performance according to a study by Coswig, S. V. et al. (2020), which suggested that exercise intensity is an important factor in your training goals.

6.3 The results of the continuous training (CT) study showed that the mean anaerobic capacity of post-test (7.81±0.54 W.kg-1) and pre-test (7.69±0.64 W.kg-1) was not a significant difference ($p>0.05$) because anaerobic exercise training (HIIT) is a rapid burst with maximum energy over a short period of time according to Bubnis, D. and J. Chertoff (2018), which concluded that the breathing patterns and heart rate during aerobic exercise are different from anaerobic exercise in that aerobic training uses oxygen as a source. The main energy and have longer and deeper breathing than resting breathing. Oxygen is transported in the bloodstream. The pulse is elevated to pump more blood into the muscles and bring the blood back to the lungs for a quick blast using maximum energy for a short period of time. In contrast, Research results has shown continuous training (CT) VO_2max of post-test (4.42±0.72 ml/kg/min), and pre-test (3.35±0.92 ml/kg/min) was significantly difference ($p<0.05$).

6.4 The research result has shown that the anaerobic capacity in HIIT group was significant difference between post-test (8.69±0.94 W.kg-1) and pre-test (7.67±0.76 W.kg-1) ($p<0.05$). But there was no significantly difference between post-test and pre-test of MIIT (8.06±0.70 W.kg-1, and 7.58±0.63 W.kg-1), and CT groups (7.81±0.54 W.kg-1 and 7.69±0.64 W.kg-1) ($p>0.05$). In contrast, Aerobic capacity was found significant difference ($p<0.05$) between post-test and pre-test both in MIIT (3.95±0.39 ml/kg/min and 2.85±0.47 ml/kg/min), and CT groups (4.42±0.72 ml/kg/min and 3.35±0.92 ml/kg/min). But there were not find significant difference ($p>0.05$) in aerobic capacity of post-test and pretest of HIIT group (3.81±0.44 ml/kg/min and 3.3 ± 0.47 ml/kg/min) ($p>0.05$). After the comparisons of all three groups in anaerobic capacity, HIIT were different from CT significantly, but HIIT were indifferent from MIIT group. When compare in aerobic capacity HIIT were different from CT significantly, but HIIT were indifferent from MIIT group, because of the moderate-intensity interval training (MIIT) has exercise characteristic close to the HIIT, but the intensity of MIIT was the least of intensity of

training that could not affected on anaerobic capacity according to Coswig, S. V. et. Al, (2020) refer that intensity of exercise is an important factor of exercise training.

7. Suggestions

7.1 The suggestion from the policy

7.1.1 High-intensity interval training (HIIT) can be used by both athletes and the average person.

7.2 The suggestion for the practitioners

7.2.1 High-intensity interval training can adjust oxygen consumption.

7.2.2 Those who are interested in research can apply the results of this research to develop and apply in research.

7.3 The suggestion for the further research

7.3.1 Appropriate guidelines for exercise training to develop aerobic and anaerobic fitness.

7.3.2 Appropriate forms and guidelines for the study of exercise training patterns for the health and/or performance of athletes.

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