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EXTENSIVE INTENSITY EXERCISE MOST EFFECTIVELY INCREASES ANAEROBIC THRESHOLD

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ABSTRACT

One of the factors that determine performance in sports is the physical work capacity. To improve physical work capacity required training programs that meet the aerobic-anaerobic metabolic elements that proportion depends on the metabolic pathways of energy systems. Means to determine the metabolic pathways of energy systems is the intensity of exercise in accordance with the predominant energy system (ATP-PC, ATP-PC-LA, LA-O2). The intensity of exercise that most effectively improves the physical work capacity is still unknown. The purpose of this study was to prove the effects of various kinds of exercise intensity on the anaerobic threshold. This experimental study using the design randomized control group pretest-posttest design on 100 respondent students boarding school Al-Mukmin Ngruki, Solo. It is divided into four groups, namely the intensive intensity group (ATP-PC), extensive intensity group (ATP-PC-LA), moderate-intensity group (LA-O2) and the control group. Paired t-test found that the three types of exercise intensity can increase anaerobic threshold significantly ($p<0.01$). Increased anaerobic threshold is marked by a shift value of lactate 4mmol/L to a heavier workload, which means an increase in physical work capacity. Anacova test results, showed a highly significant difference between the intensive-intensity group with extensive- intensity group ($p< 0.01$), there are significant differences between groups of intensive-intensity with moderate-intensity groups ($p<0.05$), and there is no difference between extensive-intensity group with moderate-intensity group ($p>0.05$). Exercise load achieved by an extensive group of the most effective intensity increase anaerobic threshold, then follow the moderate intensity exercise group. Intensity exercise group intensive increase anaerobic threshold, but less effective.

Keywords: *intensity exercise, lactate, anaerobic threshold*

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INTRODUCTION

Based on the facts on the ground, it turns out athletes Indonesia is still very difficult to compete with athletes of the world in almost all sports. This is partly due to the method of training provided was based on the experiences of trainers as an athlete. Coach believes that more training (the frequency, duration and intensity), the results become better. Actually, that determines the success of an athlete is the accuracy of the intensity of exercise, because the intensity of exercise determines the metabolic pathways (Janssen 1987, Pate 1991). The frequency and duration of exercise refers only to the time dimension (how many times per week exercise or how long each exercise), without touching the metabolic processes of energy systems. A fundamental aspect of the exercise program at any branch of sport is to identify the metabolic pathways of the main energy system (the predominant energy system). Every sport requires a metabolic pathway through the mechanism of aerobic-anaerobic energy in the right proportions. ATP as an energy source ready to use (instant energy) allows the muscles to work through four different ways, namely ATP-PC system for intensive-intensity activity (short-term activity, with high-intensity exercise), the ATP-PC-LA for extensive intensity activity (medium-term activity, with high-intensity exercise), LA-O2 system for moderate intensity activity (medium-term activities, with the intensity of the workout is) and oxygen system for low-intensity activity (long-term activity with low intensity). The hallmark of the four energy systems is a basic exercise programming for various sports. Effective exercise program will look at how to exercise in accordance with its energy systems. Exercise program would improve physical work capacity, which in turn improves performance.

Physical work capacity is a combination of cardiorespiratory capacity and musculoskeletal capacity. The body's ability to retrieve and distribute oxygen is a reflection of cardiorespiratory capacity, while the working capacity of muscles that work without oxygen

(anaerobic components) as well as works by utilizing oxygen (aerobic component) is a reflection of musculoskeletal capacity. To improve physical work capacity required training programs that meet the elements of anaerobic metabolism and aerobic energy systems. Physical work capacity can be increased if the training program is based on the primary energy system (the predominant energy system). To determine the main energy systems in certain sports, reference is the intensity of exercise. Thus, determination of exercise intensity is an important issue that must be resolved in order to improve physical work capacity is a key component in improving the performance of athletes.

Training programs to improve the achievement made by the trainer in the field still focuses on the physical aspect through the concept of the cardiovascular system as reflected by monitoring heart rate (heart rate). Miller et al (1992) reveal that the reference heart rate monitoring is still using the maximum heart rate (Max Heart Rate = MHR). A MHR measurement accurately is not easy, because it used a very different prediction formula (Drake 1992, Nieman 1986, Whaley et al 1992, Miller et al 1992). The range of measurement errors MHR is still quite large (± 15 beats/min), so that the routine use of predictive formula MHR can cause maximum conditions for certain athletes and for other athlets submaximum (Whaley et al 1992). This can cause failure in determining the accuracy of intensity as a determinant of metabolic pathways. It is necessary for a shift in perspective in determining the accuracy of the intensity of exercise, by using the concept of metabolism that is reflected through the main energy system.

Improved performance of athletes can be provided by implementing a training program on the basis of primary energy system (ATP-PC system, LA and Oxygen). Every sport is supported by a specific energy system, because it has a different metabolic pathway. The basis for making appropriate training program is to determine the metabolic pathways of a given physical activity (Fox 1984, Fox et al 1988, Fox & Mathews 1981, Smith 1983). Metabolic pathway is determined by a variety of exercise intensity (intensity of intensive, extensive intensity and moderate intensity). Of various intensity exercises, the effect of increased physical work capacity probably derived from the optimal intensity exercise program extensively. This is because the intensity of the extensive system of enzymes involved in the metabolic process of energy system very much. Efforts to sharpen the intensity of monitoring and evaluation exercise training program accurately, it should be studied through a systems approach of energy metabolism known as anaerobic threshold concept. Anaerobic threshold is the intensity of aerobic exercise in which energy system is no longer able to serve the energy needs of the body and lead toward the improvement of the anaerobic process that increases the levels of blood lactic acid (Janssen 1987). Blood lactate concentration 4 mmol/L was determined as the anaerobic threshold (Heck et al 1985). Parameter to assess the anaerobic threshold in this study is to utilize the blood lactate profile changes due to physical stressors administered in a test run storey (Mattner 1988). The success of the training program can be seen from the increase in anaerobic threshold, namely a shift in the value of lactate 4 mmol/L to a heavier workload, and it is a parameter of increased physical work capacity. According to Rusko and Rahkila (1982), Sharkey & Graetzer (1993), Joyner (1993), Power (1993), anaerobic threshold is an indicator to determine the intensity of the exercise of various sports and also to assess the effect of training. All sports will increase the anaerobic threshold, but still unknown metabolic pathway of the most effective way to increase anaerobic threshold.

MATERIALS AND METHODS

This study is an experimental study design "randomized control group pretest-posttest design extended". Subject of research: Pupils Pondok Pesantren Al-Mukmin, Ngruki Solo, with selection criteria: Male, age 15-18 years, weight 45-60 kg, height 155-170 cm, 12-14 gr% hemoglobin levels, on Physical examination found no abnormalities, willing to Participate in training programs and are willing to take blood to check levels of lactic acid. The sample size of 100 people obtained from the formula developed by Higgins & Klinbaum (1985), divided into four groups by ordinal pairing (WHO Previously did "lactate test" to determine blood lactate levels in resting conditions). The experimental group-1 intensive exercise intensity (ATP-PC system) by way of physical activity in the form of interval training, a series of physical activity or interval work (work interval) repeated interspersed with intervals of recovery (relief interval). Interval work is done by running 50 meters at the "running pace", which gradually increased from 12 seconds to 9 seconds. Recovery interval in the form of passive rest (rest relief) was for 36 seconds to 27 seconds. The ratio of work-recovery intervals (work-relief ratio) is 1: 3. Group-2 experiments extensive exercise intensity (ATP-PC system-LA) with interval training, WHERE the intervals of work performed by running 400 meters in the "running pace", the which gradually Increased from 1 minute 40 seconds to 1 minute 12 seconds. Recovery interval in the form of active rest (relief work) for 2 minutes 80 seconds to 2 minutes 24 seconds. The ratio of work-recovery intervals (work-relief ratio) is 1:2. The

experimental group-3 perform moderate intensity exercise (energy systems LA-O2) with interval training, WHERE the intervals of work performed by running 800 meters in the "running pace", the which gradually Increased from 3 minutes 20 seconds to 2 minutes 24 seconds . Recovery interval in the form of passive rest (rest relief) for 3 minutes and 20 seconds to 2 minutes 24 seconds. The ratio of work-recovery intervals (work-relief ratio) is 1: 1.

The instrument Used to measure running speed and recovery activities is a stop watch and running track for interval training. Group C is the WHO's control group did not do interval training. Treatment was conducted over 12 weeks. Anaerobic threshold is determined by blood lactate levels (mmol/L). During the test they run on a treadmill to test anaerobic threshold. To know the difference in anaerobic threshold before and after treatment performed Paired t-test. To examine differences in treatment groups after exercise, Anacova test. Statistical calculation used the cystate program.

RESULTS

Characteristics of research subjects include age, weight, height and hemoglobin (Table 1). Descriptive data of blood lactate levels pre and post tests obtained from blood sampling through an ear lobe taken at each end of the test load in the form of horizontal run on a treadmill with the speed gradually increased from 0 m/sec (resting lactate levels), 2.6 meters/second, 3.0 meters/second to 3.4 meters/second (Table 2). Expenses during lactate concentration was 4 mmol/l (Anaerobic Threshold). Load on the levels of lactate 4 mmol/l referred to as load exercise (running in the speed meter/second) while blood lactate concentration reached 4 mmol/L and is called the Anaerobic Threshold (Table 3).

Table 1. Descriptive data of research subjects

Variables	Group 1 Intensive Intensity ATP-PC n (25)	Group 2 Extensive Intensity ATP-PC-LA n (25)	Group 3 Moderate Intensity LA-O2 n (25)	Control Group n (25)
Age (Year)	16.00 ± 0.87	16.28 ± 0.89	16.56 ± 0.87	16.32 ± 0.75
Bodyweight (Kg)	50.36 ± 3.07	50.44 ± 4.50	52.24 ± 4.34	50.28 ± 4.37
Bodyheight (Cm)	160.48 ± 3.77	162.28 ± 4.41	161.08 ± 4.58	159.36 ± 3.71
Hemoglobin (Mg%)	12.95 ± 0.77	12.73 ± 0.63	12.72 ± 0.34	12.77 ± 0.57

Table 2. Blood lactate levels pre and post-tests

Treatment groups	Load							
	Pre-test				Pos-test			
	0	2.6	3.0	3.4	0	2.6	3.0	3.4
Intensive (ATP-PC)								
Mean	0.906	5.154	07.540	9.786	0.922	3.896	5.380	7.318
SD	0.364	1.398	2.120	2.127	0.285	0.658	1.049	1.106
Extensive (ATP-PC-LA)								
Mean	0.782	5.235	7.684	9.978	0.814	3.567	5.066	7.083
SD	0.309	0.988	1.738	2.126	0.231	0.554	1.072	1.456
Moderate ($LA-O_2$)								
Mean	0.692	5.653	7.601	9.540	0.803	3.681	5.316	7.614
SD	0.262	1.322	1.755	2.061	0.215	0.670	1.240	1.567
Control								
Mean	0.760	5.205	7.659	9.604	0.829	5.470	7.954	10.240
SD	0.339	1.217	1.696	1.654	0.212	0.958	1.384	1.413

* Assessment (Mean ± SD)

Table 3. Anaerobic Threshold Intensity Group Intensive (ATP-PC), Intensity Extensive (ATP-PC-LA), Medium Intensity (L-O2) and Control Group

	ATP-PC		ATP-PC-LA		LA-O2		Control	
Notes	Pre-test	Pos-test	Pre-test	Pos-test	Pre-test	Pos-test	Pre-test	Pos-test
N of cases	25.000	* 24.000	25.000	25.000	25.000	*23.000	25.000	*24.000
Mean	1.671	2.403	1.648	2.708	1.625	2.630	1.674	1.681
SD	0.526	0.493	0.309	0.571	0.454	0.534	0.350	0.295

* Total dropped out of four people (one in the ATP-PC, two people in the group of LA-O2 and a grouped control)

From the results of anaerobic threshold pre and post tests in each treatment group (except in the control group), it turns out there was a shift to higher anaerobic threshold value (shift right), meaning that anaerobic threshold is achieved at higher workloads. Anaerobic threshold shift to higher grades, in sports medical terminology is called the anaerobic threshold increased. To test whether there are differences in anaerobic threshold before and after the exercise program (for 12 weeks) performed paired t-test.

From the results of paired t-test found that the three types of exercise intensity (intensive, extensive and is) to increase the anaerobic threshold significantly ($p < 0.01$). To test the difference between the treatment group (exercise intensity intensive, extensive and is being) done anacova test. From the test results anacova, there are very significant differences between intensity groups intensively with extensive intensity group ($p < 0.01$) in which extensive intensity group (ATP-PC-LA) is better in increasing the anaerobic threshold intensity group compared intensive (ATP-PC).

There are significant differences between groups of intensive intensity with moderate intensity group ($p < 0.05$) in which the moderate intensity group (LA-O2) is better in increasing the anaerobic threshold intensity group compared intensive (ATP-PC), and there is no difference between the groups extensive intensity (ATP-PC-LA) and the moderate intensity group (LA-O2) in increasing the anaerobic threshold ($p > 0.05$). Exercise load achieved by an extensive group of the most effective intensity increase anaerobic threshold, then follow the moderate intensity exercise group. Intensity exercise group intensive increase anaerobic threshold, but less effective.

DISCUSSION

This study was designed to prove the effects of various kinds of exercise intensity on the anaerobic threshold. This type of training every sport has a characteristic metabolic energy system respectively. Training for marathon runners differ from training for a sprinter. Marathon runners train primarily aerobic capacity, while the sprinter trains primarily to increase anaerobic capacity. Exercise program used in this research is the interval training program, because exercise with various intensities (especially high intensity) is not possible to implement a program of continuous training (continuous training). Selection of an interval training program based on the energy system events that occurred during the period of work and rest periods. During the work period, the metabolic pathways are determined by exercise intensity that is reflected through a wide range of energy systems (ATP-PC, ATP-PC and LA-LA-O2). During periods of rest, the metabolic pathways used are aerobic system.

By knowing the relationship between the main energy systems with duration of action, it can be arranged interval training program with various intensities. Taking into account the work interval duration and intensity of the main energy system will be developed which can be determined. Increased levels of high-energy phosphate (ATP-PC system) are possible through intensive intensity interval training (10-20 seconds in duration). To train the lactate system (ATP-PC System-LA), performed with intensity interval training extensively (with a duration of exercise was extended to 60-80 seconds). To train the energy system located between the anaerobic and aerobic systems (LA-O2 System) used moderate-intensity interval training, with the duration of training plus up to 180 seconds (Janssen, 1987, Fox et al, 1988, MacDougall et al, 1982, Pate 1991, Dirix et al 1988).

Interval training programs provided in this study were divided into three main groups of energy system, namely: (1) The ATP-PC: to run a distance of 50 meters of the running speed improved (from 13 seconds a gradual rate of speed plus 1 seconds until finally reaching 10 seconds). The number of replications (Repetition) interval training work to determine the distance (from a distance of 1600 meters to 3200 meters distance). Thus the number of reps at the beginning of the exercise 32 times replicates (32 x 50 meters = 1600 meters), reps added gradually to 64 repetitions (64 x 50 meters = 3200 meters). Distance traveled 50 meters in length within 10 to 13 seconds meant to stimulate the primary energy system ATP-PC. Then the activities

carried out at intervals of relief or rest break is a break passive, mild form of movement such as walking or flexing the arm or leg movement. The purpose of rest intervals relief is to design build the main energy system ATP-PC (Fox & Mathews 1981, Fox et al 1988), (2) The ATP-PC-LA: make 400-meter sprints the running speed improved (from 80 seconds gradual rate of speed plus 2 seconds until finally reached 74 seconds). The number of replications (Repetition) interval training work to determine the distance (from a distance of 1600 meters to 3200 meters distance).

Thus the number of repetitions at the beginning of exercise 4 times repeated (4 x 400 meters = 1600 meters), reps added gradually to 8 repetitions (8 x 400 meters = 3200 meters). Distance of 400 meters in length of time taken by 74 to 80 seconds was intended to stimulate the primary energy system ATP-PC-LA. Then the activities carried out at an interval of rest are workt relief or rest on, in the form of brisk walking or jogging. Mean interval of relief work is to design build the main energy system ATP-PC-LA. Because of activity during active rest will hinder the rebuilding of ATP-PC system. Consequences of active resting activity LA system is more focused on the following working interval in which way this will improve also fixes the LA system (Fox & Mathews 1981, Fox et al 1988), (3) The LA-O2: do 800 meter sprints the speed of flight further increased (from 180 seconds gradually speed plus 10 seconds to finally reach 150 seconds). The number of replications (Repetition) interval training work to determine the distance (from a distance of 1600 meters to 3200 meters distance).

Thus the number of repetitions at the beginning of the exercise 2 times replicates (2 x 800 meters = 1600 meters), reps added gradually to 4 replicates (4 x 800 meters = 3200 meters). Distance of 800 meters in length of time taken by 150 till 180 seconds was intended to stimulate the primary energy system LA-O2. Then the activities carried out at intervals of relief or rest break is a break passive, mild form of movement such as walking or flexing the arm and leg movements. The purpose of rest intervals relief is to design the main energy system wake-O2 LA. Therefore, light activities during the rest interval would prevent the system rebuild LA (Fox & Mathews 1981, Fox et al 1988).

As physical activity increased with increasing intensity, blood lactate levels rise in response to increased reliance on anaerobic metabolism. Sudden increase in lactate levels (which given the term "anaerobic threshold") raises important implications for forecasting the performance and training prescription. Anaerobic threshold proved to be a good marker for the transition of moderate intensity exercise program to severe intensity, so useful in the preparation of the prescription practice (Power 1993). Steed et al (1994) and Tanaka et al (1984) tells us that the response of blood lactate levels to exercise a measure of metabolic stress that is more sensitive than the up-take of oxygen or heart rate (HR). Even Sharkey & Graetzer (1993) and Joyner (1993) revealed that the anaerobic threshold plays a major role as determinants of performance of physical training as well as assess the effect of training. The success of the training program can be seen from the increase in anaerobic threshold, ie the shift value of lactate 4 mmol/L to a heavier workload. Lactate curve shift to the right in the chart lactate/performance showed increased metabolic processes of adaptation to exercise. Thus, the slower increase in blood lactate during physical activity, the greater use of aerobic glycolysis. One important effect of exercise given is to increase the number and size of mitochondria and elevated levels of myoglobin and mitochondrial enzyme activity of cytochrome oxidase and succinate dehydrogenase (Lash & Sherman 1993, Nieman 1986). According to Nieman (1986) the number of mitochondria increased by over 120% and the amount of more than 14-40%. Levels and activity of enzymes involved in the Krebs cycle (succinate dehydrogenase) and electron transport system (cytochrome oxidase and cytochrome c) was also increased (Lash & Sherman, 1993, Nieman 1986). Glycogen stored in muscle increased 2.5 x fold (Nieman 1986). More muscle triglycerides (1.5 x), and more free fatty acids released from adipose tissue (Nieman 1986). The capacity to oxidize fat is greater because of more number of enzymes and mitochondria. Thus, the practice led to oxidize fat more but fewer carbohydrates, which means less depletion of glycogen, less accumulation of lactic acid and therefore less muscle fatigue and more endurance duration (Nieman 1986, Lash & Sherman 1993).

From the research results can be explained that the intensive group exercise intensity (ATP-PC), the activity of enzyme systems involved during the interval of only a few, the enzyme myosin ATP-ase and creatine phosphokinase, while extensive intensity exercise group (ATP-PC-LA), activity of enzyme systems involved during the work intervals more than 10 enzymes because ADP rephosphorilation (the ATP) using metabolic energy from the breakdown of glycogen (from pyruvate to lactate) with the help of the sarcoplasmic glycolytic enzymes. Thus, to explain why there are very significant differences between groups of intensive exercise intensity (ATP-PC) with extensive intensity group (ATP-PC-LA). Meanwhile, why there is no difference between extensive intensity exercise group (ATP-PC-LA) with moderate intensity exercise group (LA-O2), can be explained that the percentage of energy systems that are involved between the two

groups are not much different (for the anaerobic system alaktasidnya). The percentage of the metabolic pathways of energy system exercise intensity groups showed extensive metabolism of ATP-PC energy system-LA: 80%, LA-O2: 15% and O2: 5%). For the LA group, the percentage of lane-O2 metabolic energy systems involved is ATP-PC-LA: 30%, LA-O2: 65% and O2: 5%. Other findings from this study is the large blood lactate levels (resting condition) among those contained in the literature with research subjects is not much different. Resting blood lactate levels in this study between 0.51-1.84 mmol/L (for respondent Indonesian men aged 15-18 years, weight 45-55 kg and height 155-170 cm). While resting blood lactate levels indicated in the literature are: 0.7-1.8 mmol/L (Dirix et al 1988), 1.0-1.78 mmol/L (Mattner 1988), 1.0-1.8 mmol/L (Fox et al, 1988), 1 -2 mmol/L (Janssen 1987).

CONCLUSION

Effects of different exercise intensities (intensity of intensive, extensive intensity and moderate intensity) shown to increase anaerobic threshold. Exercise load achieved by an extensive group of the most effective intensity increase anaerobic threshold, then follow the moderate intensity exercise group. Intensity exercise group intensive increase anaerobic threshold, but less effective.

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