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COMPARISON OF EXERCISE INTENSITY BASED ON ANAEROBIC THRESHOLD ON FATIGUE IN MEN WITH LOW ACTIVITY

Mela Kurnia Widyarini [1,2], , Robby Tjandra [1,2] Tanti Ajoe Kesoema [1,3*]
[1]Department of Physical Medicine and Rehabilitation, Faculty of Medicine Diponegoro University
[2]Dr. Kariadi General Hospital, Semarang, Indonesia
[3]Diponegoro National Hospital, Semarang, Indonesia

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Corresponding Author:
E-mail: tantiajoe68@gmail.com

ABSTRACT
Background: A sedentary lifestyle can result in excessive fatigue. Aerobic exercise improves cardiorespiratory fitness, physical activity, and fatigue. Cardiorespiratory exercise testing (CPET) is the most appropriate and effective tool for prescribing exercise programs. **Objective:** To compare the effect of exercise at an intensity above and below the anaerobic threshold (AT) on fatigue men with low activity. **Methods:** This study was an experimental single-blinded control trial with a pre-post design. There were 24 participants divided into two groups: group A (n = 12) received intensity training above the AT, and group B (n = 12) received intensity training below the AT. Both groups received treadmill aerobic exercises three times a week for 4 weeks. Fatigue levels were measured with the *Fatigue Severity Scale questionnaire* at the beginning and end of fourth week of intervention. **Results:** After four weeks, there was a significant improvement in fatigue levels in both the A group ($p = 0.002$) and the B group ($p = 0.002$). There was no statistically significant difference between the A group (-6.58 ± 5.62) and the B group (-4.67 ± 5.87) ($p = 0.265$). **Conclusion:** Both exercise intensity above and below the AT within 4 weeks showed improvement on fatigue level in men with low activity. Exercise intensity above AT was not superior compared to exercise intensity below AT in improving fatigue levels.

INTRODUCTION

Technology has led to reduced activity, thereby encouraging a sedentary lifestyle. People who are less active in the long term can cause their bodies to become unfit and experience various health problems such as obesity, high blood pressure, diabetes mellitus, and coronary heart disease.[1,2]

In simple terms, physical fitness means a person's ability to carry out daily tasks without feel excessive fatigue, while health refers to a condition of being free from diseases.[3] Regular participation in aerobic exercise has been reported to improve cardiorespiratory fitness, increase physical activity, and reduce the severity of fatigue in patients with severe disease.[4]

Individual aerobic exercise is designed systematically and individually in terms of frequency, intensity, time, type, volume, and progressiveness. Prescribing exercise by looking at anaerobic threshold (AT) on cardiorespiratory exercise testing (CPET) has the potential to solve the problem of prescribing exercise at too low or too high intensity and volume while improving safety, health, and fitness for those with and without cardiovascular disease.[5-7] Using AT to prescribe exercise would be more feasible, avoid the limitations of maximal exercise testing, and more accurately demonstrate quantitative exercise response.[8]

The anaerobic threshold (AT) is the key physiological point at which muscle demand for oxygen exceeds what the cardiopulmonary system can provide. At this point, the muscles switch to anaerobic metabolism, producing adenosine triphosphate (ATP) and lactic acid. The lactic acid is then buffered by the circulation of bicarbonate, thereby increasing carbon dioxide (CO_2) levels. AT is usually identified by a

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disproportionate increase in CO2 production (VCO2) compared to oxygen consumption (VO2), which can be visualized using the 'V-slope method'. In addition, AT was indicated by an increase in the ventilatory equivalent for oxygen (VE/VO2), while the ventilatory equivalent for carbon dioxide (VE/VCO2) remains stable or slightly decreased. Accurately identifying AT is critical to designing effective exercise programs (see Figure. 1).[9]

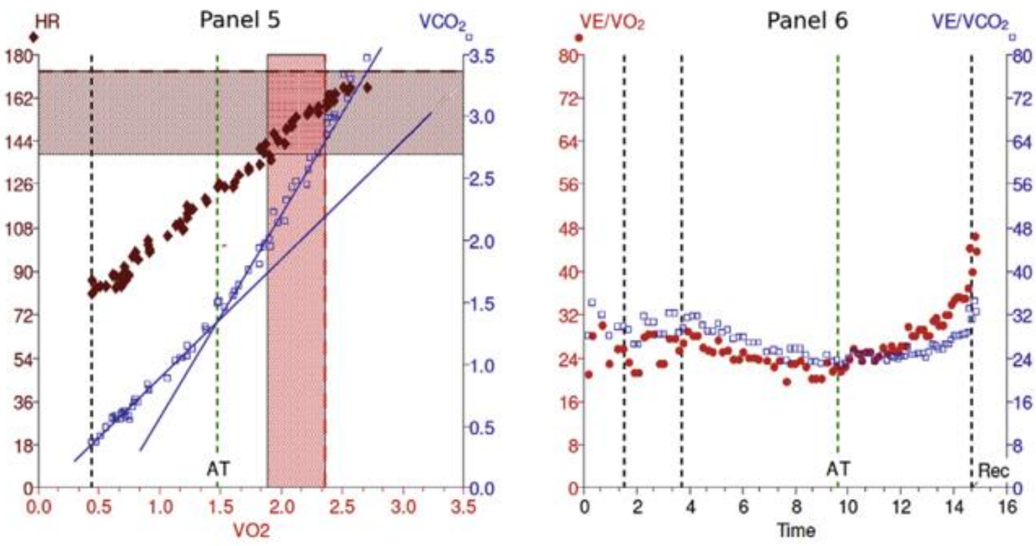

Figure 1. Panels 5 and 6 show the anaerobic threshold (AT)
The blue box in panel 5 represents the V slope method for determining AT with VCO2 (y-axis) plotted against VO2 (x-axis). A sudden change to a steeper gradient indicates the start of anaerobic metabolism, namely AT. In panel 6 AT can also be determined as the point where VE/VO2 (red dot) begins to increase while VE/VCO2 (blue box) remains relatively constant.

Fatigue is defined as a temporary inability, decreased ability, and/or strong reluctance to respond situations due to physical, mental, and emotional exhaustion.[10] The Fatigue Severity Scale (FSS) questionnaire is used to measure the severity of fatigue felt by a person in various health facilities. Measurements were carried out in various conditions, ranging from normal populations to populations with severe neurological disorders (systemic lupus erythematosus, multiple sclerosis, amyotrophic lateral sclerosis, fibromyalgia, cancer, etc.).[11]

This study compared the effect of providing exercise with an intensity above the AT and exercise with an intensity below the AT on fatigue in sedentary males.

METHODS

Subjects

This study was conducted within the academic community of Dr. Kariadi Semarang from December 2023 to February 2024. Twenty-six participants met the inclusion and exclusion criteria and signed the informed consent, then twenty-six participants were taken using simple random sampling, and divided into 2 groups: those who received intensity exercise above the AT (n = 13) as the A group and those who received training intensity below the AT (n = 13) as the B group. There was 1 participant who dropped out in each group, leaving 24 participants at the end of the study. (Figure. 2)

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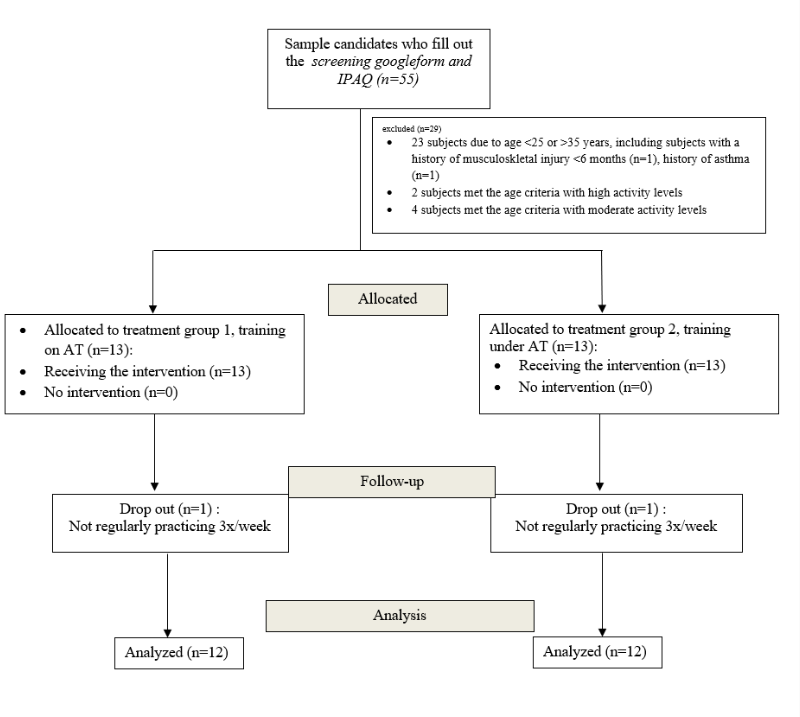

Figure 2. Flow Diagram of The Study

This study used a single-blind experimental method, pre-post design in a randomized controlled trial to compare the effect of providing exercise at intensities above and below the anaerobic threshold (AT) on fatigue in low-activity men.

Inclusion criteria were young adult males (25-35 years), normal upper and lower extremity muscle strength (MMT = 5), Low activity level (classified from the results of the IPAQ questionnaire).

Exclusion criteria included history of metabolic disease (history of DM, HT, dyslipidemia), history of cardiorespiratory disease (PJK, CHF, PJB, cardiomyopathy, arrhythmias, respiratory infections, restrictive and obstructive pulmonary disease), history of neuromusculoskeletal disease, abnormalities of the lower extremities (tendon, ligament, meniscus, joint capsule, peripheral nerve injury), history of neurological disorders (central nervous system disorders and peripheral nervous system disorders), history of psychiatric disorders (schizophrenia, depression, anxiety, bipolar disorder). The drop out criteria were not attending the training session more than 2 times after the scheduled training session, not following the CPET procedure, and experiencing complications.

The research has received approval for ethical clearance (No 1658/EC/KPEK-RSDK/2023) from the Health and Medical Research Ethics Committee of RSUP Dr. Kariadi Semarang

Intervention

All subjects who met the inclusion and exclusion criteria were familiarized with the CPET device before being divided into two treatment groups. Both groups performed a maximal exercise test using the Bruce protocol to obtain HR on the AT. Group A received training with a target heart rate (HR) above the anaerobic threshold (AT), with an upper limit range of 20% above the mean HR in AT and a lower limit of 10% above the mean HR in AT, both measured every 3 minutes. Group B received training with a target HR below AT, with an upper limit of 10% below the mean HR in AT and a lower limit of 20% below the mean HR in AT, also measured every 3 minutes. Each group accepted core training for 20 minutes, 10 minutes for warm-up and cool-down. Exercise was given for 4 weeks with a frequency of 3x/week.

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Measurements

Measurement of fatigue levels using *Fatigue Severity Scale questionnaire*. This questionnaire consists of nine statements that represent the respondent's level of fatigue. Assessment were carried out to seen the effect of fatigue on motivation, activity, physical function, task performance, and interference with work, family, or social life. A Likert scale was used to measure the scale from 1 (strongly disagree) to 7 (strongly agree). Interpretation of the results showed that the higher the score, the greater the perceived severity of fatigue.[12] FSS scores were examined before intervention and 4 weeks post-intervention in both groups.

This study used a physical activity questionnaire, namely the International Physical Activity Questionnaire Long-Form Version (IPAQ-LF), because this questionnaire assesses a person's physical activity in the last 1 week. This questionnaire consists of 27 questions grouped into 4 domains, namely work, active transportation, doing house and yard work, and free time. The questionnaire results obtained would be processed using the IPAQ assessment protocol guide. Subjects were considered sedentary if they did not engage in moderate/vigorous activity in the IPAQ questionnaire.

Statistical Methods

Data analysis includes descriptive analysis and hypothesis testing. The distribution normality test was carried out using the Shapiro-Wilk test. Levene's test was used to test the homogeneity of data in this study. The Independent t-test was used to test the normality of the data for the pre- and posttest FSS scores in each intervention group. The Mann-Whitney test was used to compare FSS score in pretest and posttest data in each group. The Wilcoxon test was used to test the difference in FSS scores between training groups above AT and below AT. All data were processed using SPSS. Significance was obtained when p-value<0.05, with a 95% confidence interval indicates the study's significance criteria was met.

RESULTS

Until the end of the study, the data analyzed was 24 subjects. There were 2 subjects, each from treatment groups A and B who dropped out because they did not follow the intervention exercises as agreed. No side effects were reported during the intervention in either the group A or group B.

The study flow diagram was available in Figure 2. Participant characteristics were described in Table 1. The two groups did not differ statistically significantly (p-value > 0.05). It can be seen that the study subjects in both groups have almost the same characteristics. There were also no significant differences in baseline measurements before intervention between them.

Table 1. Baseline Characteristic

Variable	Group		p
	Above AT	Below AT	
IPAQ Score	520.25 ± 72.68	447.50 ± 122.28	0.192‡
Age	31.17 ± 2.44	31.33 ± 2.06	0.858§
Weight	70.06 ± 5.21	74.00 ± 6.76	0.245§
Height	170.75 ± 3.08	170.08 ± 4.06	0.655§
IMT	24.37 ± 1.67	25.59 ± 2.27	0.150§

Note: * No Significant (p > 0.05) ‡ Mann-Whitney; § Independent-t

The results of the paired t-test for the Fatigue Severity Scale (FSS) showed the differences in group above AT resulting in a p-value of 0.002, which indicates statistical significance with p-value less than 0.05. These findings also showed a significant difference in the group below AT, with a p-value of 0.002. (Table 2)

A comparison of the average improvement in fatigue severity scale (FSS) scores between the two groups using the Mann-Whitney test showed no significant difference. (Table 2)

Table 2. The Comparison of FSS Score Pre and Post in each group

Score FSS	Group		p
	Above AT	Below AT	
Pre	30.92 ± 9.69	30.08 ± 9.96	0.837§
Post	24.33 ± 7.94	25.42 ± 8.03	0.743§
p	0.002†*	0.002†*	
Difference	-6.58 ± 5.62	-4.67 ± 5.87	0.265‡

Note : * Signifikan (p < 0.05); § Independent t; ‡ Mann-Whitney; † Wilcoxon

DISCUSSION

Participants' demographic data did not show significant differences (Table 1). Participant characteristics were said to be homogeneous based on data on age, BMI, physical activity, education, and

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occupation. Sample recruitment information was disseminated via the WhatsApp group of active residents of each batch. The number of subjects who filled out the Google and IPAQ screening in this study were 55 male subjects. A total of 23 subjects did not meet the age inclusion criteria and had exclusion criteria (history of musculoskeletal injury for last six months and history of asthma). Six subjects were excluded from the remaining 32 subjects. They had high activity levels (n = 2) and moderate activity levels (n = 4). Thus, a total of 26 subjects were involved in this study. The twenty six subjects consisted of residents with different study programs such as Physical Medicine and Rehabilitation (38.5%), Surgery (3.85%), Neurosurgery (7.7%), Internal Medicine (11.5%), Neurology (11.5%), Microbiology (3.85%), Cardiovascular (7.7%), Ophthalmology (3.85%), Anatomical Pathology (3.85%), and Clinical Nutritionist (7.7%).

There was a significant improvement in FSS score results after training at intensity above and below AT seen in this study consistent with the changes shown by Timothy et al.[12] However, there was no significant difference between group A and group B in the post-result perhaps because the baseline data on participant fatigue in this study was good, the intervention was only carried out within 4 weeks. In previous studies, aerobic exercise was provided for 6 weeks[12] and 8 weeks[13] resulted in a significant difference in fatigue scores.

Chronic exercise promises improved fatigue in sedentary people.[14-16] The effect of exercise training on feelings of fatigue was moderated by exercise intensity. After adjusting for baseline scores, there was a trend for improved fatigue with low-intensity exercise training. Moderate-intensity exercise often provides better health outcomes compared to low-intensity exercise[17] . The reason for the different pattern of results for feelings of energy compared with feelings of fatigue remains unclear. Factor-analytic studies of mood questionnaires have yielded distinct energy and fatigue factors.[12]

Anaerobic threshold (AT) exercise has a significant impact on fatigue levels, as proven by various studies. Mah et al. found that individuals who practiced AT demonstrated improved metabolic efficiency, which contributed to reduced perceived fatigue during high-intensity activities.[18] Similarly, Bøgseth's study highlighted that AT training leads to adaptations in muscle metabolism, allowing better energy utilization and lowering fatigue levels during sustained efforts.[19] However, Škof and Strojnik noted that although AT training was beneficial, individual responses could vary, and overtraining might lead to increased fatigue if not managed properly.[20]

CONCLUSION

In conclusion, our study showed that 4 weeks of exercise at an intensity above AT and exercise at an intensity below AT performed by sedentary adults without medical illness and not met the criteria for unexplained fatigue syndrome resulted in similar benefits on feelings of energy. Changes in feelings of energy and fatigue after exercise training were not associated with changes in aerobic fitness. Whereas aerobic fitness increases with high-intensity training, this study found no significant differences in the effects of training above and below AT. The exercise intensity above AT was not superior in improving fatigue level compared to exercise intensity below AT. It may be necessary to conduct research over a longer period so that it can produce differences in fatigue scores at different intensities.

ETHICAL APPROVAL

The Research Ethics Committee at the Health and Medical Research Ethics Commission of RSUP Dr. Kariadi Semarang, Indonesia granted ethical approval with the ethical clearance number No. 1658/EC/KPEK-RSDK/2023

CONFLICTS OF INTEREST

The authors declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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AUTHOR CONTRIBUTIONS

The authors confirm contribution to the article areas as follows: Conceptualization, Tanti Ajoe Kesoema, Robby Tjandra, and Mela Kurnia Widyarini; methodology, Mela Kurnia Widyarini; software, Mela Kurnia Widyarini; validation, Mela

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Kurnia Widyarini; formal analysis, Mela Kurnia Widyarini; investigation, Mela Kurnia Widyarini; resources, Mela Kurnia Widyarini; data curation, Mela Kurnia Widyarini; writing—original draft preparation, Mela Kurnia Widyarini; writing—review and editing, Mela Kurnia Widyarini; visualization, Mela Kurnia Widyarini; supervision, Tanti Ajoe Kesoema and Robby Tjandra; project administration, Mela Kurnia Widyarini; funding acquisition, Mela Kurnia Widyarini.

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