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COMPARISON OF EXERCISE INTENSITY BASED ON ANAEROBIC THRESHOLD IN MEN WITH LOW ACTIVITY LEVELS ON PULMONARY FUNCTION

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ABSTRACT

Background: Low physical activity could decrease lung function. Aerobic exercise based on anaerobic threshold (AT) from cardiorespiratory exercise testing (CPET) is recommended by the American College of Sports Medicine (ACSM) whenever possible to prevent a decline in lung function. **Objective**: To compare the effect of exercise intensity above AT and below AT on lung function in men with low activity levels. **Methods:** This was a randomized controlled trial on 24 men with low physical activity, who were divided into above AT (n=12) and below AT group (n=12). The AT was determined based on CPET. Both groups performed aerobic treadmill training with the intensity range of 10-20% above AT (above AT group) and 20-10% below AT (below AT group). The intervention was given 3x/week for 4 weeks. The FVC and FEV1 were examined before and after intervention. **Results:** The mean of FVC of above AT group in baseline is 6639,17 ± 1419,01 while in post-intervention is 7320,83 ± 1370,35 (p=0.003). There is also an increase of mean FVC between baseline and post-intervention in below AT group (6041,67 ± 1358,65 vs 6377,50 ± 1573,82), p=0.012. An increase of mean FEV1 between baseline and post intervention is only shown in above AT group (6082,50 ± 1134,09 vs 6462,50 ± 1252,23), p=0.046. **Conclusion:** The above AT training provides a better increase in lung function than the below AT in men with low activity level.

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INTRODUCTION

Physical activity (PA) refers to any bodily movement produced by skeletal muscles that requires energy. Low physical activity is a term used for individuals who do not engage in physical activity as recommended by the WHO, which is 30-60 minutes of moderate to vigorous aerobic exercise 3 to 5 times a week.[1–3]

Low physical activity contributes to 35% of deaths caused by coronary heart disease and leads to decreased lung function, measured by Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1 second (FEV1). Therefore, individuals with low physical activity are at higher risk of developing chronic obstructive pulmonary disease (COPD) later in life.[4–6]

Regular physical exercise has been proven to prevent the decline of lung function in individuals with low physical activity and prevent cardiovascular complications.[7,8] The American College of Sports Medicine (ACSM) recommends aerobic exercise for 30-60 minutes at moderate intensity (≥ 150 minutes/week), or 20-60 minutes at vigorous intensity (≥ 75 minutes/week), or a combination of both, 3-5 times a week.[9]

The exercise intensity prescription often uses methods based on %HRreserve (HRR), %HRmax, %VO2max, or %VO2reserve (VO2R).[10] Several studies have shown that those methods cause heart rate (HR) variability, making prescriptions imprecise and leading to undertraining or overtraining.[11,12] Another prescription method based on the anaerobic threshold (AT) from cardiorespiratory exercise testing (CPET) is an accurate and recommended individualized prescription method whenever possible.[9] Thus, provide positive physiological

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effects, reducing injury risk, and increasing exercise adherence.[13] The AT cannot be determined based on symptoms/signs during exercise, so determining the exact AT point with CPET is crucial. The AT itself is utilized for exercise prescription, reflecting the transition of aerobic to anaerobic metabolism.[14,15]

The previous study found that the group trained at intensity near AT (at AT) had positive effects on ΔVO2AT. While the group trained above AT showed the greatest increase in ΔVO2AT, and the group trained below AT had the smallest increase.[16] In above AT training will yield a larger gain in ventilatory efficiency, thus a larger increase in pulmonary function.[17] However, studies that utilize AT as a determinant for exercise prescription to improve lung function in men with low activity levels have not been conducted. Thus, this study aims to compare the exercise intensity training based on CPET above and below the AT level on lung function in men with low activity levels.

METHODS

Subjects

This study was a randomized single blinded (sample-blinded) control trial that included 26 male subjects with low physical activity levels in Dr. Kariadi General Hospital during December 2023 until February 2024. Based on the calculation of sample size with a research power of 80%, a confidence interval of 95%, and a dropout probability of 20%, the minimum sample size was 11 per group. Subjects criteria were male around 25 - 35 years old that meet the inclusion criteria, i.e. having low level of PA based on International Physical Activity Questionnaire Short Form (IPAQ-SF), no history of metabolic disease, cardiorespiratory disorder and history of recent neuromusculoskeletal problem (less than 6 months), no other training other than from this study protocol, and sign the informed consent. In the end, 2 subjects dropped out, and 24 subjects were included in the statistical analysis. The CONSORT diagram of this study was shown in figure.

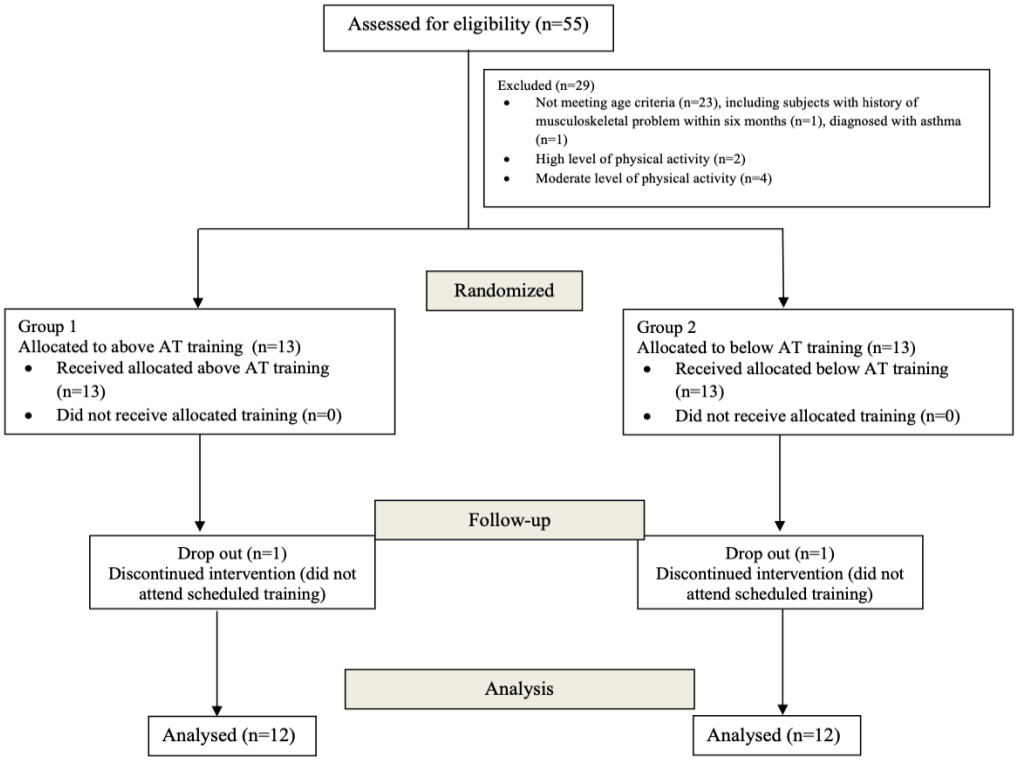


Figure 1. The CONSORT diagram of this study

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Intervention

All eligible subjects were familiarized with CPET instrumentation before the exercise testing procedure was done. All subject performed maximal exercise testing using the Bruce protocol in CPET treadmill *(Lode Valiant CPET®).* The AT point were determined using the V-slope method. The Heart Rate (HR) on the AT1 point was utilized to prescribe the training dose. Using simple randomization (enveloped randomization), all subjects were divided into above AT group and below AT group. The above AT performed training with the mean HR range from 10 to 20% above HR at AT. The below AT performed training with the mean HR range from 20 to 10% below HR at AT. The mean HR during training was measured every 3 minutes using *Mindray TM80.* Each group performed 50 minutes training, consisting of 20 minutes of conditioning, and 10 minutes for warming up and cooling down. Intervention were given 3x/weeks for 4 weeks.

Measurement

The assessment of FVC and FEV1 was obtained using a spirometer in the standing position before and after the 4-weeks intervention. All subjects were not allowed to consume alcohol within 4 hours, take heavy meals within 2 hours, smoke within 1 hour, or engage in vigorous activity within 30 minutes before the test. They were instructed to exhale forcefully after a maximal inspiration into the spirometer (*Multi-Functional Spirometer HI-801*®). The maneuver was done for minimum 3 times. The eligible result was recorded. The FVC and FEV1 were recorded in milliliters.

The PA level of participants was assessed using the short form of the International Physical Activity Questionnaire (IPAQ-SF). This form recorded their physical activities over the past seven days, including vigorous-intensity activities, moderate-intensity activities, and walking. An easy-to-use automated spreadsheet was used to classify the PA levels, which were categorized into low, moderate, and high.[18]

Statistical Methods

The data were analyzed in descriptive analysis and hypothesis testing. The normality of the distribution will be assessed using the Shapiro-Wilk test before conducting the hypothesis testing. The normally distributed data were continued to be analyzed using the independent t-test. If the data were not normally distributed, the Mann-Whitney test was done. The differences before and after treatment in both groups were tested using the paired t-test if the data distribution was normal or the Wilcoxon test if the data distribution was not normal. All data were processed using SPSS software. Significance in this study was determined if the p-value is <0.05 with a 95% confidence interval.

RESULT

All of the 26 subjects were active residents from various medical specialties, namely: Physical Medicine and Rehabilitation (38.5%), Surgery (3.85%), Neurosurgery (7.7%), Internal Medicine (11.5%), Neurology (11.5%), Microbiology (3.85%), Cardiology (7.7%), Ophthalmology (3.85%), Anatomical Pathology (3.85%), and Clinical Nutrition (7.7%). They were randomly divided into 2 groups, above AT and below AT. Assessment of FVC and FEV1 was conducted one day before and one day after the intervention period. There is no musculoskeletal or cardiorespiratory complication amongst subjects during the study. At the end of study, 2 subjects dropped out due to unable to follow the intervention protocol. The rest subjects were analysed. The demographic and clinical characteristics of those subjects are shown in Table 1.

Table 1. Characteristic distribution of all subjects

Variable	Groups		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§
Body weight (BW)	70.06 ± 5.21	74.00 ± 6.76	0.245§
Body Height (BH)	170.75 ± 3.08	170.08 ± 4.06	0.655§
BMI	24.37 ± 1.67	25.59 ± 2.27	0.150§
Brinkmann index	3,75±	7,58 ±	0,616‡

‡ Mann-Whitney; § Independent-t test

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The comparisons of FVC and FEV1 at baseline and post-intervention between the above AT and below AT groups are shown in Table 2. In the above-AT group, mean FVC increased from 6639.17 ± 1419.01 to 7320.83 ± 1370.35 (p = 0.003); in the below-AT group, mean FVC increased from 6041.67 ± 1358.65 to 6377.50 ± 1573.32 (p = 0.012). The between-group difference in FVC change was statistically significant (p = 0.043). For FEV_1, the above-AT group increased from 6082.50 ± 1134.09 to 6462.50 ± 1252.23 (p = 0.046), while the increase in the below-AT group was not statistically significant (p = 0.215).

Table 2. Comparisons of FVC and FEV1 on baseline and post-intervention

Variable	Groups		p
	Above AT	Below AT	
FVC			
Baseline	6639,17 ± 1419,01	6041,67 ± 1358,65	0,304§
post-intervention	7320,83 ± 1370,35	6377,50 ± 1573,82	0,132§
p	0,003†*	0,012†*	
Delta	681,67 ± 576,24	335,83 ± 528,85	0,043‡*
FEV1			
Baseline	6082,50 ± 1134,09	5610,83 ± 1143,65	0,321§
post-intervention	6462,50 ± 1252,23	5725,00 ± 1295,04	0,170§
p	0,046¶*	0,215¶	
Delta	380,00 ±	114,17 ±	0,175§

* Significant (p < 0,05); § Independent-t test; ‡ Mann-Whitney; † Wilcoxon; ¶ Paired t test

DISCUSSION

Out of all potential participants (n = 55), 49% showed low physical activity levels, irrespective of our inclusion or exclusion criteria. This result is similar to a study in Malaysia, which used the same measurement tool and found that 41.4% of students aged 18-25 had low physical activity levels.[19] Another cohort study in the UK indicated that individuals aged 25-34 had the highest rate of low physical activity levels, recorded at 45%.[20] The low activity levels among health professionals in this age group are often due to limited free time, extended working hours, and neglect. Additionally, another study points out that young doctors are frequently very busy with financial achievement and social commitments, leaving little time for exercise.[20,21]

This study involved subjects with a Body Mass Index (BMI) ranging from normal to overweight according to WHO criteria. The distribution of BMI in both groups was homogeneous and not statistically different, as shown by the anthropometric data on weight and height. The relationship between BMI or other anthropometric measures (weight or height) and lung function was not statistically analysed in this study. Some studies indicate that being underweight and slightly obese is associated with decreased lung function.[22] This study involved males with BMI ranging from normal to overweight with homogeneous distribution between groups, indicating that the effects of the intervention were not influenced by anthropometric factors.

This study involved three subjects with light smoking habits (score <199), with an average Brinkmann score of 5.67 ± 19.38. The Brinkmann scores were homogeneously distributed across both groups and showed no significant differences before and after the intervention. This indicates that smoking habits did not affect the intervention outcomes on lung function.[23] Previous studies also showed that light smoking habits did not have a significant relationship with lung function. Another study on outpatients with COPD in Banda Aceh found that 46.7% had a moderate Brinkmann index, and there was no relationship between the Brinkmann index and spirometry results.[24]

Impact of Exercise Above Anaerobic Threshold on Lung Function

Aerobic exercise can enhance lung function in both healthy adults and those with pulmonary conditions. This study involved subjects performing aerobic exercise prescribed based on their anaerobic threshold (AT), with the same duration and frequency but varying intensities. The subjects exercising above their AT showed significant improvements in lung function, specifically in Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1). Aerobic exercise, particularly at moderate to high intensity above the anaerobic threshold, significantly improves lung function by enhancing respiratory muscle strength, endurance, and overall lung capacity.[25,26]

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Exercise Below Anaerobic Threshold on Lung Function

There is still limited study of low to moderate intensity aerobic training to subjects with low activity.[27] Studies with sedentary subjects more often provide moderate to high intensity with various types of interventions.[28–30] Few of them correlated the low-intensity aerobic training to lung function in men with low activity levels. To the best of our knowledge, this is the first study in Indonesia that investigates this correlation, particularly using individual prescriptions based on CPET. Low-intensity training in this study showed a significant increase in FVC before and after the intervention in both groups, but a significant increase in FEV1 was only shown in the group above AT. The increase in FEV1 in the group below AT was not significant because, basically, the effect of aerobic exercise produces a linear dose-response relationship.[25] The higher the exercise dose, the better the exercise effect. The low-intensity training dose was not better in increasing FEV1 compared to moderate intensity, possibly due to the lack of physiological effects produced by the training itself, such as increased sympathetic response, oxidative muscle capacity, which results in changes in respiratory muscle strength and endurance affecting lung function parameters.[25]

Differences impact of Exercise Above and Below the Anaerobic Threshold

Essentially, the difference between the two intervention groups is the intensity of the exercise. The exercise intensity in the above AT group is similar to moderate to high intensity, while the below AT group corresponds to low to moderate intensity. Thus, the findings of this study support the dose-response effect of exercise on lung function (FVC). Various studies have mentioned that regular aerobic exercise can improve lung function regardless of the duration and intensity of the exercise.[28–31] A study in the Aerobics Center Longitudinal Study on 30,594 men from 1970-2005 categorized subjects into 4 activity levels based on MET-minutes/week of physical activity. The study found that a linear dose-response effect was observed in several variables, including lung function.[32]

In the exercise above AT, aerobic metabolism begins to be supported by anaerobic metabolism, resulting in an increase in VCO2 that is not exponential with the available VO2. Continuous exercise above this threshold will cause hyperpnea or increased depth of breathing to meet the depleted O2 needs. Besides, CO2 levels trigger the respiratory center to increase breathing frequency, resulting in hyperventilation to exhale CO2. These effects are not prominently shown in the exercise below AT, which has lower intensity due to less O2 usage.[33,34]

Our study has some limitations, such as no control subject without intervention due to the small sample size. The non-significant between-group difference in FEV1 might be due to the limited sample size and statistical power. Lastly, since all subject participants in this study is medical professionals who previously might have prior knowledge about exercise training, blinding could not be implemented to all subjects.

CONCLUSION

This study conclude that the 4 weeks of exercise with dose trice a week using intensity above the anaerobic threshold (AT) can increase the average score of FVC and FEV1 in male with low activity levels. While exercise below the AT increases the average score of FVC but not FEV1 in male with low activity levels. The delta of FVC and FEV1 score is higher in the above AT group compared to the below AT group in males with low activity levels. Further study is needed with a larger sample size and adding control subjects without intervention. Besides, a further study using the CPET prescription method for samples other than sedentary males and evaluating the intervention periodically to determine the long-term effects on pulmonary function is mandatory.

ETHICAL APPROVAL

The Research Ethics Committee at the Health and Medical Research Ethics Commission of Dr. Kariadi General Hospital Semarang, Indonesia granted ethical approval with the ethical clearance number No 1601/EC/KPEK-RSDK/2023.

CONFLICT OF INTEREST

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

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AUTHOR CONTRIBUTIONS

The authors confirm contribution to the article areas as follows:
Conceptualization: Nura Eky Vikawati, Erna Setiawati, I Made Widagda;
Methodology, software analysis, validation, investigation, resources, data curation, writing original draft preparation, visualization, project administration, funding acquisition : Nura Eky Vikawati;
Writing— review and editing : Nura Eky Vikawati, Erna Setiawati, I Made Widagda;
Supervision: Erna Setiawati, I Made Widagda.

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