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Effects of Low Impact Aerobic Exercise on Increasing Lung Function Capacity in Adolescent

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ABSTRACT

Lung function capacity is the ability of the lungs to hold air when breathing. Lung function capacity plays an important role in a person physical fitness. Therefore, respiratory fitness training is determined by lung function in supporting daily physical activities. The purpose of this study was to examine the effect of low-impact aerobic exercise, by calculating the VO2max value, on lung function capacity in adolescents (male and female aged 18 to 21 years), totaling 134 respondents. The research method used pre-experimental with one group pre-test and post-test design. This study used a spirometry measuring instrument to calculate the VO2max value. Data analysis showed an increase of 14.3%. The result found that the lung function capacity of adolescents before being given exercise was in the medium and low categories. Meanwhile, after being given low-impact aerobic exercise for 12 weeks (36 treatments), there was a significant increase of VO2max in adolescents. The results of this study prove that low-impact aerobic exercise can significantly increase lung function capacity showed by the increase of VO2max in adolescents. This study provides knowledge with relevant novelty on healthy lifestyle patterns in adolescents. It is recommended that adolescents should change their lifestyle by doing aerobic physical activities routinely and structured for better health.

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INTRODUCTION

Physical fitness plays an important role in lung capacity (Child et al., 2023). Lung capacity is the ability of the lungs to hold air through a combination of pulmonary circulation events (Martínez-Vizcaíno et al., 2023), (Cortes-Puentes et al., 2024). During the Covid-19 pandemic, lack of physical activity in adolescents had an impact on decreased lung functions due to unhealthy lifestyle patterns of adolescent, such as inactivity (Wang et al., 2024). In addition, technological developments may cause adolescents to often spend time playing games and scrolling through social media for a long time leading to reduced physical activity (Munawar et al., 2024). This condition will affect the level of cardiorespiratory fitness of adolescents, resulting in getting fatigue easily and reduced vital lung capacity, namely VO2max (Valkenborghs et al., 2024). This condition raises the assumption that adolescents nowadays are vulnerable to decreased lung function capacity (VO2max) caused by inactive behaviour due to unhealthy lifestyle patterns. Therefore, they will be susceptible to chronic diseases in the future due to low physical activity level. Recent studies had shown that low physical activity level could cause serious cardiorespiratory health problems in adolescents in the future, such as shortness of breath which could lead to respiratory failure (Kirkman et al., 2021), (Romero-Ruiz, Da Cuña-Carrera, Alonso-Calvete, & González-González, 2022), (Li et al., 2023). In this study, researchers aimed to analyse the lung function capacity, in the form of VO2max, of adolescents after Covid-19 pandemic. This study also measured the impact of low-impact aerobic exercise in increasing VO2max of adolescents because case studies discussing the method of aerobic exercise programs, specifically on the lung function capacity (VO2max) of adolescents after Covid-19, is limited.

Previous studies had found that lack of physical activity in adolescents combined with unhealthy lifestyle patterns, such as smoking for more than one year, resulted in a very low VO2max category (Turquetto et al., 2021). Other studies examining the relationship between exercise routines and lung function of students found that students who did not exercise regularly had a greater risk of having impaired lung function than those who exercised regularly (Pancera et al., 2021). Lack of physical activity is a major risk factor for decreased lung functions. Physical exercise itself can be categorized into two types, namely strength or anaerobic exercise and aerobic exercise (Stefani et al., 2021).

Aerobic exercise is a structured sport that involves the use of large muscle groups of the body to perform rhythmic activities over a certain period of time. One of the benefits of aerobic exercise is its effect on lung functions. Based on the results of research related to aerobic exercise, it was found that mix impact aerobic exercise had a significant effect on lung vital capacity (Ma et al., 2025). Similar studies had also found that low impact aerobic exercise had a significant effect on increasing VO2max (Anne-Sophie et al., 2024). Previous studies had carried out comparisons between anaerobic and aerobic exercises, showing that both exercises could increase VO2max. However, a significant difference was apparent in aerobic exercise, indicating that aerobic exercise with a low-impact program could increase VO2max optimally. Based on a preliminary study conducted on adolescents aged 18 to 22 years at a university, almost 67% of respondents obtained low scores on lung function capacity test (Safa, Hemmatinafar, Nemati, Imanian, & Suzuki, 2024). By considering these problems, the purpose of this study was to analyse physical activity level and lung function capacity (VO2max) of adolescents, both male and female, after implementing low impact aerobic exercise program.

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METHODS

This research used a quantitative pre-experimental method with one group pre-test post-test design, assessing the samples before and after the treatment. This study employed purposive sampling technique in selecting the samples to ensure that selected samples would be suitable and meet the criteria and objectives of the study.

Participants

The samples of this study were 134 respondents selected based on inclusion and exclusion criteria. The inclusion criteria of this study were adolescents who were willing to be samples by signing a consent form, aged 18 to 21 years as evidenced by their ID cards, having physical capacity score below 1500 METs measured using the IPAQ-Short questionnaire, not active smokers, having a normal body mass index ranging from 18.5 to 24.9 kg/m², not consuming alcohol for 24 hours before the study, and not carrying out hard workout activity for 48 hours before the study. The basis for the sample determination was the results of test and evaluation. The participants acquired suboptimal lung function capacity (VO2max), which tended to be weak and decreasing, were selected as samples. Normally, healthy adolescents would show good Vo2max and have the potential to increase and be optimal. This study received approval from the Research Ethics Committee of Dhyana Pura University with an ethical eligibility number 000620/KEP Dhyana Pura University/2024. All respondents had received a comprehensive explanation of the study.

Sampling Procedures

The basis of the procedures used for collecting data of the samples in this study was the standard guidelines from the American College of Sports Medicine (ACSM), referring to the control of research subjects to be more measurable and evenly controlled. The procedure for selecting the sample in this research study included adolescents having a history of cardiovascular and pulmonary disease or musculoskeletal injury in the six months before the study, following a specific exercise program, and consuming supplements or drugs in the past year as determined by the researcher. Participants were instructed not to consume additional food or supplements the day before and during the study. They were required to consume food provided by the researcher in the exercise physiotherapy laboratory. The data collection started from April to June 2024.

Materials and Apparatus

The instrument used for measuring lung function capacity (VO2 max) in this study was a spirometry device, a simple device used to measure the volume of air in the lungs. The device assesses the amount of air that can be inhaled and exhaled by the lungs in milliliters and the lung air flow in milliliters per second. The spirometry is used by inhaling and exhaling through a mouthpiece (pursed lips). Spirometry examination consists of two instruments. The first instrument assesses the amount of air that can be inhaled and exhaled by the lungs. Through the mouthpiece, the person being examined is instructed to inhale as deeply as possible, then exhale completely. The second instrument assesses the lung air flow. The person should inhale deeply, then exhale as quickly and as hard as possible. The test using these two instruments should be repeated three times for each to get the best results.

Procedures

The data collection began with the preparation of the device which was periodically calibrated for at least once a week. The mouthpiece was only given for single use. The next stage was the preparation of respondents before carrying out measurements using a spirometry device. In this preparation stage, the respondents should understand the purpose and method of measurement using the device before being assessed. The data collector had to provide proper and correct guidance and examples of how to perform the spirometry

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examination (Ma et al., 2025). During the examination, respondents had to feel comfortable. Before conducting the spirometry examination, they had to be free from smoking for at least 2 hours before the measurement, not eating too much before the measurement, and not wearing tight clothes.

The next step was the implementation of low-intensity aerobic exercise, often called low-impact aerobic exercise. The procedure in implementing low impact aerobics should follow the requirements, including warming up (all warm-up movements were conducted for 8 seconds). The respondent daily activities were carried out in a controlled manner by companions or family members who were registered and connected with the data collector and researchers. Thus, they could monitor and evaluate physical activity and daily lifestyle patterns. The next stage was the core movement of low impact aerobic exercises which included several steps, namely single steps, double steps, V-steps, heel touch, mambo, gripe vine, and knee up. This low impact aerobics exercise followed the exercise dosage guidelines, including the frequency, intensity, time, and type (FITT) (L. Wang et al., 2024).

The stages of the low impact aerobic exercise program involved determination of the population and samples based on inclusion and exclusion criteria followed by the test using spirometry to determine VO2max. Furthermore, the low impact aerobic exercise was carried out 36 times based on the exercise dose. The FITT when performing low impact aerobic exercise referred to the standards, including 3 times a week for the frequency, low impact aerobics with moderate intensity for the exercise intensity, 30 minutes in one exercise for the time, and aerobic exercise involving many large muscle groups for the type. At the final stage, the samples were tested again by using spirometry to determine the increase in lung capacity (VO2max). After completing the low impact aerobic exercise (core movements), a cool-down movement was administered. The cool-down movement was carried out to reduce the pulse rate and optimize blood pressure (Flor-Rufino, Pérez-Ros, & Martínez-Arnau, 2024).

Data Analysis

The data obtained in this study were analyzed by using descriptive analysis, normality test (shapiro wilk test), and hypothesis testing using a parametric test namely paired-sample t-test. All tests were processed using the statistical package for social sciences (SPSS) for window application.

RESULTS

Characteristics of Samples

The samples of this study were adolescents aged 18 to 21 years, males and females, determined using the inclusion, exclusion, and drop out criteria. The following is the sample characteristic data which consist of gender, age, body mass index (BMI), and physical activity characteristics.

Table 1. Age of The Samples

Age (Years)	Frequency	Percentage (%)
18	17	12.69
19	28	20.90
20	46	34.33
21	43	32.08
Total	134	100

Table 1 presents that the 18-year-old age group consisted of 17 respondents with a percentage of 12.69%. The 19-year-old age group consisted of 28 respondents with a

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percentage of 20.90%. The 20-year-old age group consisted of 46 respondents with a percentage of 34.33%, while the 21-year-old age group consisted of 43 respondents with a percentage of 32.08%.

Table 2. Gender of The Samples

Gender	Frequency	Percentage (%)
Male	56	41.80
Female	78	58.20
Total	134	100

Table 2 shows that the male group consisted of 56 respondents with a percentage of 41.80% and the female group consisted of 78 respondents with a percentage of 58.20%.

Table 3. Physical Activity Level of The Samples

Physical Activity	Frequency	Percentage (%)
Moderate	86	64.17
Low	48	35.83
Total	20	100

Table 3 shows that 86 respondents had a moderate physical activity category with a percentage of 64.17%, while 48 respondents (35.83%) were in the low physical activity category.

This study involved male and female samples. This study showed that men had better lung function than women even though they both experienced a decrease in VO2max. The results also proved that the samples in this study, who were in adolescent period, had moderate and low physical activity categories. It might be due to the poor lifestyle patterns, such as lack of physical activity. The results of this study conclude that routine physical activity in adolescents, including aerobic physical exercise, has a correlation with vital lung capacity of adolescents.

Data Analysis

This study focused on quantitative data. The data were obtained from the pre-test and post-test using a spirometry to determine the lung function capacity of the research samples.

Table 4. Lung Function Capacity of The Samples

Variables	Mean	SD	Min	Max	Percentage (%)
Pre-test value of lung function capacity (VO_2max)	3.78	0.33	1.35	4.50	14,3
Post-test value of lung function capacity (VO_2max)	4.93	0.57	2.51	6.53	

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Table 4 shows the results of descriptive analysis data, including the pre-test and post-test lung function capacity values. The pre-test lung function capacity gained a minimum value of 1.35 and a maximum value of 4.50 with a mean value of 3.78. Meanwhile, the post-test lung function capacity obtained a minimum value of 2.51 and a maximum value of 6.53 with a mean value of 4.78. There was an increased percentage in lung function capacity of 9.8%.

Table 5. Paired Sample T-Test

Paired Sample T-Test			
Lung Function Capacity (VO_2max)	Mean	Std. Deviation	Sig-tailed
Pre-test	3.78	0.20	0.000
Post-test	4.93	0.23	

The results of the normality test using the Shapiro Wilk Test on lung function capacity showed a value of p = 0.933 (p> 0.05) for the pre-test and a value of p = 0.635 (p> 0.05) for the post-test. The results indicated that the pre-test and post-test lung function capacity data were normally distributed because the significance value was more than 0.05. Table 5 depicts the mean value of the pre-test and post-test lung function capacity from 134 respondents. The significance value of the lung function capacity data was p = 0.000 (p <0.05), indicating that there was a significant increase in the mean value from the pre-test to the post-test. It concludes that the low impact aerobic exercise could increase the lung function capacity of adolescents aged 18 to 21 years.

DISCUSSION

The result of this study, based on gender characteristics, showed that men had better lung function than women. This study found that men had better lung function than women even though they both experienced a decrease in VO2max in adolescent period. Gender differences could affect lung capacity and respiratory performance (Hayama et al., 2020). The results of a review of a study published by the National Institutes of Health in 2023 argues that most lung capacity depends on body size. Therefore, women tend to have smaller lung capacity than men due to their smaller size. In addition, lung capacity and respiratory performance also refer to gender (Aly et al., 2020). There are reproductive hormones (estrogen and progesterone) in women that have been shown to reduce lung functions (Tran et al., 2020). Women have a smaller diffusion area than men which can cause respiratory performance and lung function capacity to be less optimal (Herrmann & Selamet Tierney, 2022), (Curran et al., 2022). Regarding physical function and movement activities, it is believed that women have to work harder and maintain breathing rates more than men (Munawar et al., 2024).

The age range of respondents of this study was between 18 to 21 years. The latest study explains that physiologically, with increasing age, the ability of the body organs will naturally decrease, including the lung and heart function capacity (Kirkman et al., 2021). On average, at the age of 30-40 years, a person will experience a decrease in lung functions (Turquetto et al., 2021). The results of this study found that, at the age of less than 25 years, the samples had decreased lung function capacity (obtaining less and moderate categories) that might be influenced by other factors such as poor lifestyle (such as smoking and lack of physical activity) and unhealthy environmental impacts (such as the use of gadgets) (Romero-Ruiz et al., 2022).

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This study also supports the statement that, related to physical activity category, the current teenager generation tends to have less than optimal lung function capacity compared to the previous generation who tended to be more active in carrying out physical movements (Child et al., 2023), (Martínez-Vizcaíno et al., 2023). Similar studies also prove that the human body, especially the muscles, requires a smooth and stable supply of energy and fuel when performing physical activity. Thus, oxygen, as the fuel for the formation of the necessary energy, is needed (Li et al., 2023), (Voorn et al., 2023). To meet all components of the body need for oxygen, the body will respond with a compensatory mechanism by increasing the frequency of respiratory function (Avancini et al., 2023). The increase in the frequency of respiratory function will increase the ventilation efficiency, causing the vital capacity of the lungs to increase. For this reason, physical exercise has a direct relationship with the vital capacity of the lungs (Okon, Okorocha, Beshel, Abali, & Owu, 2023), (Malandish & Gulati, 2023), (Cortes-Puentes et al., 2024).

The latest research results state that low impact aerobic exercise is a sport that involves more lower extremities and several other supporting muscles (m. quadriceps femoris, m. hamstring, m. gluteus maximus, m. iliopsoas, m. gastrocnemius, m. soleus, m. biceps brachii, m. diaphragm, and m. abdomen) (Priego-Jiménez et al., 2024), (Safa et al., 2024). These muscles work continuously without stopping during low impact aerobic exercise. The work of these muscles is due to the metabolic process (Poon et al., 2024), (Valkenborghs et al., 2024). The metabolic process is the breakdown of ATP into ADP. The energy from the breakdown of ATP will be used as energy for muscle contraction (Dibben et al., 2024). One of the sources of ATP itself is the oxygen system from the carbohydrate oxidation process and beta oxidation of fatty acids and proteins. In the mechanism system, oxygen will undergo an oxidation reaction through the Krebs cycle (Toohey et al., 2024). If the muscle contraction is higher, the ATP work is also higher to produce energy. If more energy is needed, the oxidation process occurs and the need for oxygen supply will increase (Z. Wang et al., 2024). When the need for oxygen supply increases, the work system of the heart and lungs will also increase because they have to pump blood throughout the body. Along with the increase in the work system of the heart and lungs, there will be an increase in the lung function capacity optimally when low impact aerobic exercise is performed (Flor-Rufino et al., 2024), (Anne-Sophie et al., 2024).

This study is in line with the research conducted by Permadi et al. in 2021 stating that a combination of aerobic exercise, such as treadmill, static bicycle, and Tai-Chi gymnastics, can optimize the heart and lung function capacity (VO2max, blood pressure, and pulse rate) and cardiac outputs (Permadi et al., 2021). It therefore will increase the pressure on the left ventricle which causes an increase in pulmonary artery pressure simultaneously, resulting in increased perfusion in the pulmonary ventricle which further reduce the mechanical needs of the lungs in the ventilation process. However, some studies showed that aerobic exercise in patients with chronic obstructive pulmonary disease, after 12 weeks of exercise with a duration of 30 minutes, found no significant differences in lung function capacity such as VO2max (Hayama et al., 2020).

The low-impact aerobic exercise has an optimal impact on VO2max as the result of performance in increasing lung function capacity, especially in adolescents aged 18 to 21 years. Thus, this exercise is suggested to be carried out as early as possible for adolescents aged 18 to 21 years (Aly et al., 2020). This study is supported by the results of similar studies proving that low-impact aerobic exercise with gymnastics training in adolescents showed rapid results in VO2max increase after 16 weeks of training (Tran et al., 2020), (Permadi et al., 2021). This also explains that structured and gradual trainings can have a positive impact on all components of heart and lung functions, especially for those at age ranging from 17 years

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(Causer et al., 2020). However, the results of other studies showed that aerobic exercise that activated one or two types of exercise had not obtained significant results on overall and long-term lung vital capacity. Therefore, a more detail research on this topic is needed. A larger number of samples is also required so that other components, such as the levels of blood sugar, uric acid, cholesterol, and inflammation of body organs can be measured and identified more comprehensively and thoroughly (Herrmann & Selamet Tierney, 2022). This study has limitations, which include the limited control of the sample activities, such as their daily activities, and unhealthy lifestyles, such as consuming junk food and alcoholic beverages, smoking, and other activities affecting the lung function capacity (Curran et al., 2022), (Munawar et al., 2024), (Ma et al., 2025).

CONCLUSION

The finding of this study showed that the average value of lung function capacity (VO2max) before low impact aerobic exercise program was 3.78, while the average value of lung function capacity (VO2max) after the low impact aerobic exercise program was 4.93. It concludes that the 12 weeks of low impact aerobic exercise treatments (totaling 36 treatments), given to adolescents aged 18 to 21 years, gave a significant impact on the increase of lung function capacity (VO2max) by 14.3%. It proves that low impact aerobic exercise can increase lung function capacity (VO2max). It is recommended that further research, sport coaches, and health policy makers add other factors to analyze the capacity of heart and lung functions, such as blood pressure (BP), pulse rate (PR), and respiratory rate (RR).

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AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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