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The Effect of Harvard Step Test on Vital Lung Capacity Among Medical Students at Tadulako University

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ABSTRACT

Background: According to the World Health Organization (WHO), a lack of physical activity contributed to 830,000 deaths annually in 2022. University students are among the populations with low levels of physical activity. Vital capacity is the maximum amount of air that can be expelled from the lungs, influenced by various factors including age, gender, exercise habits, smoking activity, nutritional status, and medical history. This study aims to determine the effect of physical exercise using the Harvard Step Test on vital lung capacity in students at the Faculty of Medicine, Tadulako University. Specifically, this study aims to determine the value of vital lung capacity before and after physical exercise and analyze the effect of physical exercise on changes in vital lung capacity in students at the Faculty of Medicine, Tadulako University.. Methods: This study employed a pre-experimental method with a One Group Pre-Test Post- Test design without a control group, involving 23 participants, both male and female. Sampling was conducted using a non-probability method with purposive sampling technique. The physical exercise intervention consisted of the Harvard step test for four weeks, with a frequency of three times per week for approximately five minutes per session. The results were analyzed using the Paired Sample T-test in SPSS software. Results: The average pre-test vital capacity was 2.64 liters, while the average post-test vital capacity was 3.24 liters, indicating an increase in vital capacity following the intervention. The comparative analysis using the Paired Sample T-test yielded a p- value<0.000 (p<0.05), indicating a significant effect of the Harvard step test on vital capacity. Conclusion: There is an effect of physical exercise using the Harvard step test method on the vital capacity of the lungs in students of the Faculty of Medicine, Tadulako University.
Keywords: Physical exercise, Harvard step test, Vital capacity

INTRODUCTION

The World Health Organization (WHO) states that physical inactivity will cause 830,000 deaths annually by 2022. Globally, 81% of adolescents do not engage in the minimum recommended level of physical activity for health. Based on the 2018 Basic Health Research (Riskesdas), the low level of physical activity in Indonesia increased from 26.1% in 2013 to 33.5% in 2018. Technological advancements have made it possible to perform almost any activity using technology, which reduces physical activity. Instead of exercising occasionally, many people spend their time playing online games and using social media. Furthermore, people prefer to use vehicles rather than walking or cycling when commuting. This undoubtedly has a significant impact on reducing physical activity, which can lead to various health problems.[1]

Vital lung capacity is a crucial indicator in assessing respiratory system function and overall physical fitness. Optimal pulmonary function allows for efficient gas exchange, ensuring that oxygen demands during physical activity are adequately met. Adolescence is a critical developmental period characterized by significant physiological changes, including the rapid growth of lung volume, which is strongly influenced by physical activity and cardiovascular fitness Previous studies have demonstrated that physical activity plays a major role in maintaining and improving vital lung capacity among adolescents. [17]

Students are a group with low levels of physical activity. Research by Annamayra (2022) shows that students at the Faculty of Medicine, Pasundan University, do not engage in sufficient physical activity. A person can experience fatigue, difficulty concentrating, and decreased daily productivity if they lack physical activity. A person's physical fitness level is also related to their level of physical activity. According to research conducted by Elzandri and Dewi (2018) on the physical fitness profile of students at the Faculty of Medicine, Tarumanegara University, 26.8% of students had low average fitness, and 22% had poor physical fitness. [2,3]

Haditya (2017) revealed that in his research on factors that hinder medical students from exercising, the most frequently cited factors were insufficient time to exercise and a lack of friends to exercise with. Busy academic schedules prevent many medical students from having time to exercise. Furthermore, many spend their free time working on reports and preparing for upcoming exams. This hinders medical students from exercising, contributing to low levels of physical activity. [4]

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Physical exercise is crucial for overall health. Optimal exercise doesn't have to be expensive. Running, one of the best forms of physical exercise, increases blood and oxygen circulation in the body, promotes a feeling of well- being, and improves brain function. Its components will be damaged if they are not taught to move or function properly, much like a machine that is not used or is moving slowly [5]. using data from the *National Health and Nutrition Examination Survey (NHANES)*, found that adolescents who engaged in higher-intensity physical activity exhibited significantly higher *Forced Vital Capacity (FVC)* and *Forced Expiratory Volume in the first second (FEV_1)* compared to less active peers. Similarly, a systematic review and meta-analysis by Wu et al.[2] reported that regular exercise interventions in children and adolescents led to mean increases in FVC by 0.17 L and FEV_1 by 0.14 L, indicating measurable improvements in pulmonary function following consistent training.[18]

Moreover, a longitudinal study by Benck et al.confirmed that cardiorespiratory fitness from childhood through adolescence is positively associated with better lung function in early adulthood, highlighting the long-term benefits of early physical activity on respiratory health[19]. Biological factors such as sex also influence lung function, with males typically showing higher FVC and FEV_1 values than females due to differences in lung size, cardiac output, and hemoglobin concentration.[20]

During physical exercise, blood vessels are compressed by striated muscles throughout the body, putting pressure on the heart and lungs, and increasing the heart rate. Physical exercise increases the endurance and strength of the respiratory muscles, which increases the lungs' ability to expand. Furthermore, exercise can help the respiratory muscles overcome resistance to airflow, which in turn increases air volume.[5]

The maximum amount of air the lungs can exhale is known as vital lung capacity. Its physiological volume is approximately 4600 ml. Age, gender, exercise habits, smoking activity, nutritional status, and medical history are factors that influence vital lung capacity. Therefore, physical exercise or exercise habits are crucial for increasing vital lung capacity, and spirometry is needed to measure vital lung capacity.[6]

Research by Nora Maulina and Cut Asmaul Husna (2017) from the Faculty of Medicine at Malikussaleh University used the Harvard Step Test to assess the physical fitness of medical students. The results showed that most students had poor to moderate levels of physical fitness. However, to date, there have been few studies in Indonesia that have used this method to assess lung vital capacity (LPV) in medical students, making this study crucial to address this gap.[16]

This is what sparked researchers' interest in examining the effect of physical exercise on lung capacity in students at the Faculty of Medicine, Tadulako University. Health plays a crucial role; without healthy lung function, fulfilling basic obligations will be difficult. Maintaining healthy lung capacity can be achieved through exercise or physical activity. Exercise and physical activity are preventative measures, meaning maintaining healthy lung function in adolescence is better than treating disease.

METHODS

This study was a pre-experimental study with a One Group Pretest-Posttest design, meaning the study was conducted on only one group without a comparison group. A pretest was administered before and a posttest after the treatment. The sample consisted of 23 male and female students from the Faculty of Medicine, Tadulako University. Using a purposive sampling method, the sample was selected by the researcher and met the inclusion and exclusion requirements. A non-probability sampling method was used in sample selection.

The study began with ethics approval, informed consent, and a pretest, which measured vital lung capacity using digital spirometry. The sample in this study were students of the Faculty of Medicine, Tadulako University, aged 18-25 years old, who met the inclusion and exclusion criteria. The sample was selected using a non-probability sampling method with a purposive sampling technique. In experimental research, a group of 8–10 subjects is considered sufficient to produce accurate results. At the beginning of the study, 26 subjects met the inclusion and exclusion criteria. However, as the study progressed, one subject did not complete the study due to illness, and two subjects were excluded due to engaging in strenuous exercise other than the training provided in this study. Therefore, the total sample size was 23.

The sample was selected using a non-probability sampling method with a purposive sampling technique, which involves selecting samples based on specific considerations or criteria established by the researcher to align with the study objectives. The inclusion criteria for this study included students of the Faculty of Medicine, Tadulako University, aged 18–25 years, both male and female, with a body mass index (BMI) within the normal range of 18.5–25 kg/m², willing to participate in the study, and signing an informed consent form.

Meanwhile, exclusion criteria included individuals who smoked, were currently ill, or had a history of obstructive or restrictive pulmonary disease, hypertension, or other systemic diseases. Furthermore, respondents who were participating in other research related to physical exercise or engaged in aerobic physical exercise activities outside of this study were also excluded from the sample.

Afterward, the subjects received a physical exercise intervention using the Harvard step test for approximately 5 minutes. This intervention was conducted three times a week for four weeks. Following the intervention, the subjects underwent a posttest, which measured vital lung capacity using digital spirometry. The

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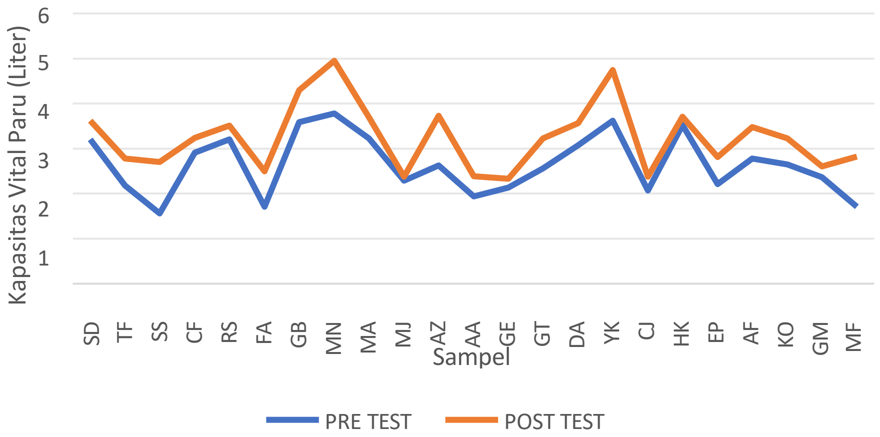
subjects' vital lung capacity was then calculated using SPSS and a Paired T-Test. Research ethics that have been approved by the Medical and Health Research Ethics Commission, Faculty of Medicine, Tadulako University, with ethics number 4995/UN 28.1.30/KL/2024

RESULTS

This study was conducted from April 29, 2025, to May 24, 2025, in the Physiology Laboratory, Faculty of Medicine, Tadulako University. The aim of this study was to determine the effect of the Harvard step test on lung vital capacity.

Univariate Analysis

In this study, the sample consisted of 23 students who met the inclusion and exclusion criteria. Primary data measured directly by the researcher were used in this study. Distribution tests were conducted in univariate analysis to see the distribution of lung vital capacity data before and after intervention with the Harvard step test. Measurements of lung vital capacity were carried out using a spirometer before the Harvard step test for four weeks, with a frequency of three times a week with a duration of ± 5 minutes, and after the Harvard step test for four weeks, with a frequency of three times a week with a duration of ± 5 minutes.



Grafic 1. Data on changes in vital lung capacity

Based on the graph of changes in vital lung capacity values above, all study samples experienced an increase in vital lung capacity. The sample with the highest post-test vital lung capacity value was 4.95 liters.

Table 1. Distribution of vital lung capacity values

Vital Capacity	N	Minimum	Maksimum	Mean	SD
Pretest	23	1,56	3,78	2,64	0,66
Posttest	23	2,33	4,95	3,24	0,74

Primary Data, 2025

Based on the table above, the pretest averaged 2.64 liters of vital lung capacity, and the posttest averaged 3.24 liters.

Normality Test

Since the research sample was less than fifty, the Shapiro-Wilk normality test was used to assess whether the data were normally distributed or not. The following table shows the Shapiro-Wilk normality test to determine the status of data distribution (normal or not normal), as well as the types of statistical tests that will be used in this study. The research sample is less than 50, so the test used is the Shapiro-Wilk normality test.

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Table 2. Normality Test

Lung Vital Capacity	Shapiro-Wilk
	Asymp.sig
Pretest	0,421
Posttest	0,067

Primary Data, 2025.

Normally distributed data on vital lung capacity after a four-week Harvard Step Test intervention (posttest) with a frequency of three times a week. Because p>0.05 was obtained with values of 0.451 and 0.067, respectively, the statistical test used is the Paired T-Test..

Bivariat Test

Based on the Paired T Test, the pretest and posttest lung vital capacity values obtained a sig value (two-sided p) <0.050, namely 0.000, which means there is a significant difference or increase between the pretest and posttest lung vital capacity.

Table 3. Paired T Test

Pair	N	Mean	SD	Significance (Two-Sided p)
Pretest-Posttest	23	0,59826	0,33880	0,000

Primary Data, 2025

Based on the Paired T Test, the pretest and posttest lung vital capacity values obtained a sig (two-sided p) value <0.050, namely 0.000, which means there is a significant difference or increase between the pretest and posttest lung vital capacity.

DISCUSSION

One method that can be used to measure fitness levels is the Harvard step test, which can be done regularly or repeatedly to increase oxygen consumption. This test can assess the body's ability to adapt to workload and the feeling of fatigue received by the body. The Harvard step test uses a Harvard bench with a bench height of 48 cm for men and a bench height of 43 cm for women. The measurement results will then be calculated using a formula and classified based on the Physical Fitness Index with categories of very good: ≥ 90, good: 80-89, sufficient: 65-79, less: 55-64, very less: ≤ 54 [7]. In this study, the physical fitness value before physical exercise using the Harvard step test method for four weeks, three times per week (pretest) was in the very poor category for 23 people or the entire research sample. This is in accordance with a study conducted by Elzandri and Dewi (2018) at the Faculty of Medicine, Tarumanegara University without intervention in their research that the physical fitness index in medical students was classified as low to very poor. Meanwhile, physical fitness scores after physical exercise using the Harvard Step Test (posttest) were measured as: 3 individuals were in the adequate category, 14 in the very poor category, 2 in the good category, 3 in the poor category, and 1 in the very good category. All participants in the very poor category experienced an increase in fitness, but this was not visible because the interval value for this category was very wide compared to the other categories, namely ≤ 54. This increase in physical fitness is due to adaptations in the cardiorespiratory system, such as heart muscle hypertrophy and ventricular wall thickening, which result in greater blood ejection and stronger heart contractions.[8,9]

This study aligns with a study by Yunus (2023), which found that resting heart rate decreased in the group that performed aerobic exercise three times a week for four weeks. This is likely due to cardiovascular adaptations in the form of inhibition of sympathetic nervous system activation and increased parasympathetic activation. In addition to a decrease in heart rate, participants who exercised also experienced a decrease in blood pressure. This may be due to increased blood flow to the muscles during exercise and vasodilation within the muscles due to increased muscle metabolism. Increased blood flow during exercise forces more blood into the blood vessels, stretching the arteriole walls and reducing vascular resistance.[10]

Vital capacity is the sum of inspiratory reserve volume, tidal volume, and expiratory reserve volume. Vital capacity is influenced by many factors, including age, gender, exercise habits, smoking, nutritional status, and medical history. In this study, a Contec SP70B digital spirometer was used to assess the sample's vital capacity, using the forced vital capacity (FVC) as the measured value. The sample's vital capacity before the Harvard Step Test exercise (pretest) was 1.56 liters, the highest was 3.78 liters, and the mean was 2.64 liters. Meanwhile, after four weeks of three weekly exercises using the Harvard Step Test (posttest), the entire sample experienced an increase in vital capacity, with the lowest value being 2.33 liters, the highest being 4.95 liters, and

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the mean being 3.24 liters. Physical exercise using the Harvard Step Test method significantly increased the vital lung capacity of students at the Faculty of Medicine, Tadulako University. Data analysis using a bivariate paired t-test yielded a P value of <0.050, or 0.000. This study aligns with research conducted by Chendra and Lotoh (2019) on 50 students at the Faculty of Medicine, Tarumanagara University, from the 2013-2016 intake. The results showed an increase in vital lung capacity both before and after physical exercise, respectively, with a P value of <0.050, or 0.000.[11]

Suryadi (2021) stated that regular exercise, 3-5 times per week, with a duration of less than 60 minutes and involving large body weight, improves physical fitness components by enhancing heart, lung, muscle, and bone function. This study demonstrated an increase in vital lung capacity after four weeks of Harvard Step Test exercise, performed three times per week for approximately 5 minutes.[12]

During physical exercise, the heart rate increases, but the heart adapts to become more stable as the heart muscle becomes stronger to deliver oxygen throughout the body. A sufficient oxygen supply to all cellular organelles improves heart function. The respiratory system also works in conjunction with the cardiovascular system; when cardiac output increases, the alveolar surface area increases to meet oxygen demands (Patel, 2022).[13]

This study shows an increase in vital lung capacity, consistent with previous research conducted by Buriticá-Marín (2023) entitled "Effects of a Physical Exercise Program on the Physical Capacities of Older Adults: A Quasi-Experimental Study," which found that physical exercise can improve elements of physical fitness such as coordination, balance, flexibility, and aerobic capacity. In this study, vital lung capacity was increased as the aerobic component.[14]

Gender differences affect vital lung capacity in men and women. This is consistent with research conducted by Santisteban (2022) entitled "Sex Differences in VO2max and the Impact on Endurance-Exercise Performance." Exercise increases oxygen demand. Oxygen distribution throughout the body is influenced by central hemodynamic components such as pulmonary ventilation, diffusion across the pulmonary capillary membrane, cardiac output, and hemoglobin mass. These factors are associated with lower vital capacity in women than in men. Women have lower heart, lung, and hemoglobin mass than men, meaning they have a lower vital lung capacity. Furthermore, women's hormonal fluctuations related to their menstrual cycle also affect how the body distributes oxygen during exercise.[15]

The assessment of cardiorespiratory fitness and pulmonary function is essential in understanding overall health status, particularly among adolescents and young adults. Vital lung capacity (VLC), expressed as *forced vital capacity (FVC)*, is one of the key indicators of respiratory efficiency and endurance performance. Adequate pulmonary function supports optimal oxygen uptake and delivery during physical activity, which directly influences aerobic performance and recovery.[21]

One of the widely used field tests to evaluate cardiovascular endurance is the *Harvard Step Test (HST)*, a simple, cost-effective, and valid method to estimate physical fitness and indirectly assess maximal oxygen consumption (VO_2max) [22]. The test involves stepping onto and off a platform of standardized height at a defined rhythm, providing an index of physical fitness through heart rate recovery and endurance response. Validation studies have demonstrated a significant correlation between HST-derived fitness indices and laboratory-measured VO_2max, confirming its utility in both athletic and academic populations.[23]

Regular aerobic exercise, including structured step tests, has been shown to improve pulmonary function parameters such as FVC and *forced expiratory volume in one second (FEV_1)*, especially among adolescents who are in their peak phase of physiological lung development [24]. Meta-analyses and interventional studies further indicate that consistent exercise enhances lung compliance, respiratory muscle strength, and alveolar ventilation, all of which contribute to improved vital lung capacity.[25]

Among medical students, sedentary behavior and academic workload often contribute to reduced cardiorespiratory fitness and lower lung capacity [26]. Therefore, evaluating the *effect of the Harvard Step Test on vital lung capacity among medical students* is important not only to understand the physiological impact of aerobic exercise but also to promote awareness of the importance of maintaining respiratory health in this population.

Despite its established use in assessing fitness, limited research has explored the direct impact of the Harvard Step Test on spirometric measures such as FVC and FEV_1 among medical students, creating a research gap that the present study aims to address.

CONCLUSIONS AND SUGGESTIONS

The average vital lung capacity value of students of the Faculty of Medicine, Tadulako University before physical exercise using the Harvard step test method for 4 weeks with a frequency of 3 times a week was 2.64 liters. The average vital lung capacity value of students of the Faculty of Medicine, Tadulako University after physical exercise using the Harvard step test method for 4 weeks with a frequency of 3 times a week was 3.24 liters. This value has increased compared to the average vital lung capacity value before physical exercise using the Harvard step test method. The average vital lung capacity value of students of the Faculty of Medicine, Tadulako University after physical exercise using the Harvard step test experienced a significant increase with

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a significance value of p<0.000. Therefore, it can be concluded that there is an effect of physical exercise using the Harvard step test method on students' vital lung capacity. Students of the Faculty of Medicine, Tadulako University, are encouraged to increase their vital lung capacity by regularly exercising or doing physical training. Researchers are encouraged to conduct similar studies by adding previously unexplored variables to obtain better results, such as blood pressure, VO2 Max levels, fatigue markers, and to compare the control and test groups.

AUTHOR CONTRIBUTIONS

Rahma Badaruddin: Conceptualization, Project administration, Methodology, Supervision. **Ria Sulistiana**: Methodology, Formal analysis, Data curation. **Fitriah Handayani**: Investigation, Data collection, Validation. **Yuli Fitriana**: Literature review, Writing – original draft (Introduction and Background). **Mohammad Zainul Ramadhan**: Statistical analysis, Writing – review & editing (Results and Discussion). **Muhammad Ihsan Akib**: Writing – original draft (main author), Visualization, Integration of revisions from co-authors. **Junjun Fitriani**: Writing – review & editing, Figure and Table preparation, Formatting compliance. **Muhammad Nasir**: Validation, Conceptual review, Critical revision of the manuscript. **Geovani Ginting**: Final review, Language editing, Ethical and publication compliance verification.

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