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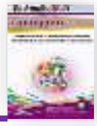

The Relationship Between Vital Lung Capacity and Physical Fitness

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Abstract

Physical fitness is an important determinant of health and functional capacity among medical students, who are exposed to substantial academic demands and often experience sedentary lifestyles. Although pulmonary function is physiologically relevant to cardiorespiratory performance, evidence regarding the association between vital lung capacity and physical fitness among medical students remains limited and inconsistent, particularly in the Indonesian medical education setting. Re-examining this relationship is important because identifying potentially modifiable pulmonary and fitness-related factors may provide an evidence base for targeted preventive programs within medical education institutions. This study aimed to determine the association between vital lung capacity and physical fitness among medical students of the Faculty of Medicine, Christian University of Indonesia, Class of 2023. An analytical observational study with a cross-sectional design was conducted among 57 FK UKI medical students who met the predetermined inclusion and exclusion criteria. Vital lung capacity was measured using a spirometer and categorized according to the applicable reference criteria. Physical fitness was assessed using the Harvard Step Test and classified into fitness categories based on the resulting Physical Fitness Index. The association between vital lung capacity and physical fitness was analyzed using the Chi-square test, with statistical significance set at p < 0.05. The magnitude of the association was assessed using an odds ratio (OR). Most respondents had low lung vital capacity and moderate physical fitness levels. The results of the bivariate analysis showed a statistically significant relationship between lung vital capacity and physical fitness level (p < 0.000), OR, 0.133; and 95% CI 0.054-0.332. Vital lung capacity was significantly associated with physical fitness among FK UKI medical students. Medical education institutions should incorporate structured cardiorespiratory fitness screening and regular aerobic exercise programs into student health initiatives, particularly for students identified with reduced pulmonary function or low fitness levels. Periodic monitoring of pulmonary function and physical fitness may provide an actionable preventive strategy to support student health and functional capacity throughout medical education.

Keywords: Cardiorespiratory Fitness, Function Tests, Health Promotion, Spirometry, Pulmonary.

INTRODUCTION

Physical fitness is an important determinant of health among young adults. It is particularly relevant in medical students, who often experience high academic workloads, prolonged study time, and limited opportunities for physical activity. Globally, insufficient physical activity and sedentary behavior remain major public health concerns and are associated with adverse cardiometabolic and functional outcomes (Babaeer et al., 2022; L. S. K. Li et al., 2023; Organization, 2020; Prabowo et al., 2021; Zakiuddin et al., 2016). Medical students may be particularly vulnerable to these behaviors because of the demanding structure of medical education, potentially affecting both their current health and the health behaviors they carry into professional practice (Taylor et al., 2022).

Cardiorespiratory fitness depends on the integrated function of the pulmonary, cardiovascular, and muscular systems. Vital capacity (VC), measured using spirometry, reflects ventilatory capacity and may be associated with exercise performance. Evidence from young adults suggests that higher cardiorespiratory fitness is associated with better preservation of lung function over time, supporting a potential relationship between pulmonary function and physical fitness (Barkous et al., 2024; Benck et al., 2017; Guthold et al., 2018; Hall & Hall, 2020; Okon et al., 2023). However, this relationship is multifactorial and should not be interpreted as a direct effect of lung capacity alone.

Several factors may influence both pulmonary function and physical fitness and therefore act as potential confounders. Body mass index (BMI) can affect lung volumes through mechanical effects of excess body mass while also influencing exercise capacity (McArdle et al., 2010; Winck et al., 2016). Physical activity and sedentary behavior independently affect cardiorespiratory fitness and may also be associated with pulmonary-function measures (Dugral & Balkanci, 2019; Vaara et al., 2019). Smoking exposure can impair pulmonary function and exercise capacity, while sex is associated with physiological differences in lung volumes and physical performance (Barkous et al., 2024; Krishna et al., 2025). These factors should therefore be considered when assessing the association between VC and physical fitness.

Medical students are a relevant population for investigating this relationship because the transition into medical education is often accompanied by changes in daily routines, physical activity, and sedentary behavior. The 2023 cohort of the Faculty of Medicine, Christian University of Indonesia (FK UKI) was selected because these students were in the early stage of medical training during the study period, when new academic demands and lifestyle patterns were being established. Studying this cohort may provide insight into potentially modifiable physiological factors associated with physical fitness at an early stage of medical education.

Although previous studies have demonstrated associations between pulmonary function and physical fitness in young populations, the magnitude and consistency of this relationship may vary according to sex, body composition, physical activity, and smoking exposure (Benck et al., 2017; Okon et al., 2023; Stanojevic et al., 2022). Thus, examining this association in medical students addresses a broader question of whether an easily measurable pulmonary parameter is associated with functional fitness in a population exposed to the distinctive demands of medical education. This study aimed to determine the association between vital capacity and physical fitness among medical students of FK UKI, Class of 2023.

METHODS

This analytical observational study used a cross-sectional design to assess the association between vital lung capacity and physical fitness among medical students of the Faculty of Medicine, Universitas Kristen Indonesia (FK UKI). The study was conducted from January 21 to 24, 2025, among students from the 2023 intake. The target population consisted of 147 students, and 57 eligible students participated in the study.

Participants were eligible if they were active medical students from the 2023 intake, provided written informed consent, and were able to complete the physical fitness assessment. Students with acute respiratory illness, chronic respiratory disease, medical conditions that prevented completion of the Harvard Step Test, or incomplete examination data were excluded. Eligible participants available during the study period were recruited consecutively.

Vital lung capacity was measured using a calibrated spirometer operated by trained personnel according to standardized measurement procedures. Participants performed repeated respiratory maneuvers, and the best technically acceptable measurement was recorded. Based on the predefined study criteria, vital lung capacity was categorized into normal and abnormal groups. Physical fitness was assessed using the standardized Harvard Step Test. The Physical Fitness Index was calculated based on heart-rate recovery following exercise and categorized into good and poor physical fitness according to the predefined classification criteria. Standardized procedures and trained assessors were used for all measurements to minimize measurement variability and observer bias.

Descriptive analysis was performed to summarize participant characteristics, including sex, age, vital lung capacity, and physical fitness level. Categorical variables were presented as frequencies and percentages. The association between vital lung capacity and physical fitness level was assessed using the Pearson Chi-square test. Fisher's exact test was also considered when the assumptions for the Chi-square test were not fulfilled. The strength of the association was assessed using the odds ratio (OR) with a 95% confidence interval (95% CI). Statistical significance was defined as a two-sided $p < 0.05$. The study received approval from the relevant ethics committee of Universitas Kristen Indonesia. approval No. 075/UKI.LPPM/PPM.00.00/ET.2023.

RESULTS

This study aims to determine the relationship between vital lung capacity and physical fitness levels in the 2023 intake of UKI Medical Faculty students. The study was conducted from January 21-24, 2025, and involved a sample of 57 students. The following are the results of this study.

Table 1. Respondent Characteristics Based on Gender, Age, Vital Lung Capacity, and Physical Fitness Level

Categories	Frequency (n)	Percentage (%)
Gender		
Male	22	38.6
Female	35	61.4
Age		
18 years	4	7.0
19 years	36	63.2
20 years	16	28.1
21 years	1	1.8
Vital Lung Capacity		
Abnormal	27	47.4
Normal	30	52.6
Physical Fitness Level		
Poor Fitness	26	45.6
Good Fitness	31	54.4

The data show that, among 57 research subjects, 22 were male students (38.6%) and 35 were female students (61.4%). By age, there were 4 participants aged 18 years (7%), 36 aged 19 years (63.2%), 16 aged 20 years (28.1%), and 1 aged 21 years (1.8%). Furthermore, based on the vital capacity of the lungs, which was divided into 2 categories, the results were that 30 subjects were Normal (52.6%), and 27 subjects were poor (47.4%). Then, based on the physical fitness index, which was divided into 2 categories, the results were: 26 subjects had poor fitness (45.6%), and 31 had good fitness (54.4%).

Table 2. The Relationship Between Vital Lung Capacity and Physical Fitness Level

VitalLungCapacity * PhysicalFitnessLevel Crosstabulation

Count

		Physical Fitness Level		Total
		Good Fitness	Poor Fitness	
Vital Lung Capacity	Normal	26	4	30
	Abnormal	0	27	27
Total		26	31	57

Table 3. Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	43.026[a]	1	.000		
Continuity Correction[b]	39.603	1	.000		

Likelihood Ratio	55.019	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	42.271	1	.000		
N of Valid Cases	57				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 12.32.
b. Computed only for a 2x2 table

Risk Estimate

	Value	95% Confidence Interval	
		Lower	Upper
For cohort PhysicalFitnessLevel = Poor Fitness	.133	.054	.332
N of Valid Cases	57		

The Chi-square analysis demonstrated a statistically significant association between vital capacity and physical fitness level ($p < 0.001$). The magnitude of the association was further assessed using an odds ratio, with OR = 0.133, 95% CI 0.054-0.332.

DISCUSSION

Characteristics of Research Results

The present study included 57 medical students from the Faculty of Medicine, Universitas Kristen Indonesia (FK UKI), Class of 2023. Most participants were female (61.4%) and 19 years old (63.2%). Regarding pulmonary function, 30 participants (52.6%) were classified as having normal vital capacity, whereas 27 (47.4%) had reduced vital capacity. Physical fitness was classified as poor in 26 participants (45.6%) and good in 31 (54.4%).

The relatively high proportion of students with reduced vital capacity and poor physical fitness is noteworthy because the participants were young adults without reported acute respiratory illness. This finding suggests that suboptimal cardiorespiratory fitness may be present even before the substantially greater clinical and academic demands encountered during later stages of medical education. However, the present study did not assess habitual physical activity, smoking exposure, BMI, or environmental exposure, and therefore the observed distribution cannot be attributed to pulmonary function alone. The sex distribution in this study was unequal, with females comprising 61.4% of participants. Although biological differences in pulmonary structure and respiratory physiology between males and females are well established, sex was not analyzed as a determinant or effect modifier in the present study. Therefore, these anatomical differences should not be used to explain the observed association between vital capacity and physical fitness in this sample. Future studies with larger samples should perform sex-stratified or interaction analyses to determine whether the association differs between male and female medical students (Barroso et al., 2018; Kim et al., 2022).

Association between Lung Vital Capacity and Physical Fitness Level

The principal finding of this study was a statistically significant association between vital capacity and physical fitness ($p < 0.001$). The observed OR was 0.133 (95% CI, 0.054–0.332), indicating that the odds of poor physical fitness differed substantially according to vital-capacity status. Because the OR was below 1, its interpretation depends on which category was defined as the reference and which outcome was coded as the event. Therefore, the direction of the association should be stated explicitly according to the coding used in the statistical model rather than interpreted simply as a protective effect.

The finding is consistent with evidence linking pulmonary function with cardiorespiratory fitness. Benck et al. reported that higher cardiorespiratory fitness in young adulthood was associated with better preservation of lung function over time, supporting an important relationship between respiratory function and exercise capacity.(Benck et al., 2017) Similarly, previous research has demonstrated associations between FEV_1, FVC, and measures of physical fitness, suggesting that pulmonary-function parameters may contribute to differences in exercise performance (B. Li et al., 2022; Prabowo et al., 2021). These findings provide biological plausibility for the association observed in the present study.

However, the relationship between pulmonary function and physical fitness is unlikely to be explained by a simple linear mechanism in which greater oxygen delivery automatically produces better lung function. During exercise, performance depends on the integrated interaction of pulmonary ventilation, gas exchange, cardiac output, peripheral oxygen extraction, skeletal-muscle metabolism, and neuromuscular function. In healthy young adults, the lungs generally possess substantial functional reserve, meaning that pulmonary function alone does not necessarily determine maximal exercise capacity (Benck et al., 2017; Chu et al., 2019; L. S. K. Li et al., 2023; Prabowo et al., 2021). Therefore, the significant association identified in this study should be interpreted as an association between two interconnected physiological domains rather than evidence that reduced vital capacity directly causes poor physical fitness.

An alternative explanation is reverse causality. Students with low habitual physical activity may have lower cardiorespiratory conditioning and respiratory-muscle performance, while prolonged sedentary behavior may coexist with unfavorable body composition and other lifestyle factors that influence pulmonary measurements. Conversely, individuals with impaired pulmonary function may reduce their participation in physical activity because exercise is more difficult or causes respiratory symptoms, potentially leading to lower physical fitness. Because this study used a cross-sectional design, the temporal direction of the relationship cannot be established. Longitudinal studies are therefore required to determine whether reduced pulmonary function precedes declining fitness, whether low physical activity contributes to both outcomes, or whether these processes occur bidirectionally.

The magnitude of the observed association should also be interpreted in the context of potential confounding. BMI, habitual physical activity, smoking, and environmental exposures can influence both pulmonary function and physical fitness. For example, excess adiposity may mechanically reduce lung volumes while simultaneously increasing the physiological demands of physical activity. Smoking can impair pulmonary function and may also be associated with lower exercise participation (Dugral & Balkanci, 2019; Huriah & Rahman, 2021; Taylor et al., 2022; Winck et al., 2016). Because these variables were not comprehensively measured or adjusted for in the present analysis, residual confounding cannot be excluded. Consequently, the findings demonstrate a statistically significant association but should not be interpreted as evidence of an independent causal effect of vital capacity on physical fitness.

The present findings should also be considered alongside differences between study populations. Previous investigations have been conducted in populations with different ages, habitual activity patterns, environmental exposures, and educational structures. Medical students may differ from the general young-adult population because their academic schedules often involve prolonged sedentary learning and high cognitive workloads. Thus, the association identified in the FK UKI cohort may reflect a combination of physiological characteristics and the lifestyle environment associated with medical education. Differences between medical curricula, academic workload, and institutional opportunities for exercise may also explain variation between studies conducted in different countries or educational settings.

Limitation

Several limitations should be considered. First, the cross-sectional design prevents determination of temporal or causal relationships between vital capacity and physical fitness. Second, the sample was derived from a single medical-student cohort and was relatively small, limiting statistical precision and generalizability to other cohorts or medical schools. Third, the unequal sex distribution was not evaluated through sex-stratified or interaction analysis. Fourth, important potential confounders, particularly BMI, habitual physical activity, smoking exposure, and environmental factors, were not comprehensively measured or adjusted for. These factors may influence both pulmonary function and physical fitness and therefore may have contributed to the observed association. Finally, the study assessed the relationship at a single time point; longitudinal studies incorporating repeated spirometry, objective physical-activity measurements, BMI, smoking exposure, and cardiopulmonary fitness testing are needed to establish temporal relationships and clarify potential causal pathways.

CONCLUSION

This study identified a significant association between vital capacity and physical fitness among FK UKI medical students. However, the cross-sectional design and absence of comprehensive adjustment for lifestyle and anthropometric confounders preclude causal interpretation. The findings support the potential value of integrated student-health strategies combining periodic cardiorespiratory fitness assessment, targeted exercise programs, and lifestyle counseling within medical education. Future longitudinal multicenter studies should determine whether improving physical activity and cardiorespiratory fitness can produce sustained improvements in pulmonary function and whether these effects differ according to sex, BMI, and other relevant risk factors.

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