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ORIGINAL ARTICLE

The relationship between the level of physical activity and lung function

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ABSTRACT

Physical activity is part of the basic needs of daily life, especially to improve the quality of health. Engaging in physical activity can increase blood flow through the lungs, causing oxygen to diffuse into the pulmonary capillaries with a larger or maximum volume. The purpose of the study was to determine the relationship between the level of physical activity and lung function. This study is a cross-sectional analytic study with a sampling technique of consecutive sampling, using a sample of 60 students of the Faculty of Medicine, Universitas Jenderal Achmad Yani who meet the inclusion and exclusion criteria. Research data were obtained using the International Physical Activity Questionnaire (IPAQ)-lf questionnaire instrument to assess physical activity levels and a vitalograph spirometer to assess FVC, FEV_1 and FEV_1/FVC. Data were analyzed using the Spearmann Rho Correlation Test. The results showed that there was a significant relationship between physical activity level and FVC% (p=0.008 and r=0.399) and FEV_1% (p=0.000 and r=0.501), while there was no significant relationship between physical activity level and FEV_1/FVC ratio (p=0.071 and r=0.235). Although there was no significant relationship between physical activity level and FEV_1/FVC ratio, there was a positive and unidirectional relationship between physical activity level and all lung function parameters in this study. Physical activity is one factor that has a positive influence on the respiratory system.When done regularly there will be adaptation to the body by increasing ventilation for maximum oxygen uptake and better diffusion capacity, resulting in respiratory efficiency. Therefore, students are expected to do physical activity according to recommendations to achieve health benefits, including increasing lung function parameters such as FVC, FEV_1 and FEV_1/ FVC ratio.

Keyword: FEV_1, FEV_1/FVC ratio, FVC, physical activity, respiratory system.

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INTRODUCTION

Physical activity is an essential component of daily life, particularly in enhancing health quality.[1] It is defined as any bodily movement produced by skeletal muscles that requires energy expenditure. Regular physical activity, as recommended, can maintain health and reduce the risk of premature death by 20-30%.[2-6] Conversely, a decrease in physical activity can diminish lung endurance and become the fourth leading risk factor for mortality worldwide. According to the World Health Organization (WHO), 1,4 billion adults, constituting more than a quarter of the global adult population, are insufficiently physically active.[2] Riskesdas data from 2018 indicates that 33.5% of the Indonesian population is not physically active, an increase from 26% in 2013.[7] Physical activity can be performed in variety of settings and situations, including leisure activities such as exercising, transportation from one place to another, or as part of one's occupation.[3,8] Three critical aspects of physical activity are intensity, duration, and frequency.[9] Physical activity levels, based on intensity and calorie expenditure, are categorized into low, moderate, and high, and can be measured subjectively using the International Physical Activity Questionnaire (IPAQ).[10]

In the general population, high physical activity is associated with better lung function, a slower decline in lung function, and reduced mortality. This is because physical activities, such as exercise, increase blood flow through the lungs, allowing oxygen to diffuse into the lung capillaries at a greater or maximal volume.[11-13] A person's lung quality can be assessed by evaluating lung function using a spirometer. Lung function is measured with a spirometry test to evaluate Vital Capacity (VC), Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1), and the FEV_1/FVC ratio.[14] Several studies have demonstrated that regular physical activity, such as exercise, impacts lung function. However, there is still a lack of research on physical activities in other domains, such as daily activities as part of one's occupation, activities performed during transportation, activities at home, and recreational and leisure-time physical activities classified by low, moderate, and high levels.[3,8,15,16] Therefore, this study aims to further investigate the relationship between various levels of physical activity and lung function using the IPAQ-lf questionnaire, which seeks to obtain more detailed information regarding the frequency, intensity, and location of activities.

Understanding the relationship between different levels of physical activity and their impact on lung function is essential, especially for individuals who do not have sufficient time to engage in regular physical activity as recommended for maintaining health. Medical students, due to their demanding schedules, tend to spend their time sitting and studying, thus rarely engaging in adequate physical activity, such as exercise.[17,18] As future healthcare professionals, medical students are expected to set a good example by being physically active, promoting a healthy lifestyle and encouraging increased physical activity in their patients, as physical activity has long-term health benefits.[5,19] Enhanced respiratory function will automatically improve physical fitness, boost students' morale, and support academic achievement.[5] Based on the above description, this study aims to further explore the relationship between the level of physical activity and lung function among the class of 2021 Faculty of Medicine, Universitas Jenderal Achmad Yani students.

METHODS AND SUBJECT

This study was conducted after receiving approval from the Ethics Committee of the Faculty of Medicine, Universitas Jenderal Achmad Yani, as documented in approval letter number 054/UM1.10/2023, dated October 9, 2023. The research utilized an analytical observational methodology with a cross-sectional design. The target population consisted of students from the Faculty of

Medicine (FK) at Universitas Jenderal Achmad Yani (Unjani). The accessible population included FK Unjani students from the 2021 cohort; studied during the period of November-December 2023 and met the inclusion criteria. The inclusion criteria were: (1) active FK Unjani students from the 2021 cohort in good health, (2) aged 19-21 years at the time of the study; and (3) students who consented to participate by signing informed consent and completing the questionnaire. The exclusion criteria were: (1) students with a history of pulmonary diseases (such as asthma, pneumonia, tuberculosis, or abdominal and thoracic surgery) that have been diagnosed by a physician or indicated in the questionnaire; and (2) students who were absent during the study period.

The sample size was determined using the correlation coefficient formula (r), with a minimum required sample size of 55 students. Sampling was conducted using a non-probability sampling method, with consecutive sampling among FK Unjani 2021 students. A total of 60 students participated in the study, comprising 22 males and 38 females.

The instruments used in this study included the Indonesian version of the IPAQ-lf questionnaire to measure the level of physical activity, and a Vitalograph spirometer to assess lung function (FVC, FEV_1, and the FEV_1/FVC ratio).

Data analysis utilized both univariate and bivariate methods. A univariate analysis was employed to describe the characteristics of the study subjects. A bivariate analysis was conducted to determine the relationship between the level of physical activity and lung function (FVC%, FEV_1%, and the FEV_1/FVC ratio). The Spearman-Rho test was used for the analysis.

RESULTS AND DISCUSSION

Subject Characteristics Overview

The investigation's subjects were profiled according to gender distribution, age demographics, and nutritional status, as shown in Table 1.

Predominantly, the research cohort comprised female participants, constituting 63.3% of the total subjects, amounting to 38 individuals. Gender emerges as a pertinent determinant influencing pulmonary volume and capacity, with males exhibiting an approximate 20-25% larger capacity compared to their female counterparts.[20,21] The table delineates the distribution of research subjects across gender and nutritional categories:

Table 1. Characteristics of Research Subjects

Characteristics	N	%
Gender Categories		36,7%
- Males	22	63,3%
- Females	38	
Total	60	100%
Nutritional Status Categories		
• Underweight	1	1,7%
• Normal	25	41,7%
• Overweight	6	10%
• Obesity 1	17	28,3%
• Obesity 2	11	18,3%
Total	60	100%

Analysis of nutritional status reveals that the majority exhibit a normal Body Mass Index (BMI), with 41.7% of students falling within this category. This finding resonates with prior research by Nina (2021), which ascertained that the average BMI of students at the Faculty of Medicine, UISU, falls within the normal range.[22] However, despite the prevailing normal nutritional status, the 2021 cohort of FK Unjani students under scrutiny tends towards overweight, as indicated by the cumulative count of students classified under the overweight, obesity 1, and obesity 2 categories, surpassing those within the normal and underweight categories.

The age demographic of research subjects is elaborated in Table 2:

Table 2. Characteristics of Research Subjects Based on Age

Characteristics	Age				
	Mean	Median	SD	Min	Max
Males	20.27	20.00	0.398	19	21
Females	20.05	20.00	0.517	19	21

Findings from Table 2 reveal that the average age of male and female respondents stands at 20.27 and 20.05, respectively. This aligns with Haryati's observations, indicating that a significant proportion of second- and third-year medical students fall within the 20-year-old age bracket (ranging from 18 to 21). Consistent results are noted in Jason's study (2022), underscoring that the majority of medical students at Tarumanegara University also hover around the age of 20.[24]

Lung functionality exhibits an incremental trajectory with advancing age, reaching its zenith between the ages of 19 and 21.[25] Age-related changes impinge upon pulmonary function, precipitating a decline in the elasticity and flexibility of the airways and adjacent tissues. As a result, there is a concomitant reduction in lung diffusion capacity, ventilatory efficacy, oxygen uptake, vital lung capacity, and ancillary pulmonary parameters, postulating a decline following attainment of peak functionality during young adulthood.[25-28]

Physical Activity Overview among FK Unjani Class of 2021 Students

Figure 1 illustrates an examination of the delineation of physical activity levels relative to gender among the 2021 FK Unjani cohort.

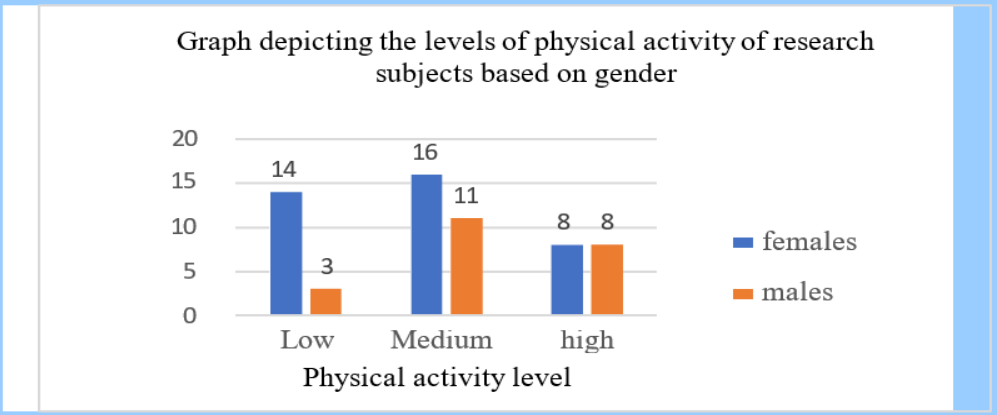

Figure 1. The levels of physical activity of research subjects based on gender.

Figure 1 presents a visual representation indicating that the predominant proportion of FK Unjani's 2021 student body, irrespective of gender, exhibits a moderate level of physical activity, followed by a prevalence of low physical activity among females and high physical activity among males. This observation concurs with Jessica's investigation, which identified that 53.5% of Doctoral Education students at Mataram University in 2020 maintained a moderate level of physical activity.[29] Conversely, Yhusi's research in 2018 revealed that 60% of medical students displayed low levels of physical activity.[30] Noteworthy is the acknowledgment that physical activity levels are subject to influences stemming from age and gender, with younger individuals and males typically demonstrating heightened physical activity levels.[31]

Students at Medical Faculty (FK) Unjani are known for their notably rigorous schedules, which encompass a gamut of academic pursuits including group discussions, tutorials, medical skill acquisition, laboratory sessions, lectures, and more. These scholarly engagements typically span from early morning to late afternoon or evening. Beyond scholastic commitments, students actively participate in extracurricular endeavors such as involvement in student organizations.

Table 3 provides a comprehensive breakdown of physical activity level characteristics based on nutritional status categories:

Table 3. Physical Activity Level Characteristics Based on Nutritional Status Categories

Characteristics	Nutritional Status					Total
	Under weight	Normal	Over weight	Obesitas 1	Obesitas 2	
Physical Activity Levels						
Normal Low	0 (0%)	9 (52.9%)	1 (5.9%)	1 (5.9%)	6 (35.3%)	17 (100%)
Moderate	1 (3.7%)	10 (37%)	3 (11.1%)	12 (44.4%)	1 (3.7%)	27 (100%)
High	0 (0%)	6 (37.5%)	2 (12.5%)	4 (25%)	4 (25%)	16 (100%)
Total	1 (1.7%)	25 (41.7%)	6 (10%)	17 (28.3%)	11 (18.3)	60 (100%)

Physical activity emerges as a contributing factor to Body Mass Index (BMI) values. Inadequate physical activity causes stored energy to be underutilized, promoting the accumulation of energy reserves in the form of adipose tissue. Conversely, excessive energy intake, devoid of commensurate and sustained physical activity, can precipitate the onset of obesity.[32] However, as delineated in Table 3, a predominant portion of students exhibiting low physical activity levels manifest normal BMI values, represented by 9 (52.9%) individuals, followed by students with Obesity 2 BMI values, totaling 6 (35.3%) students. This observation suggests that low physical activity levels are not invariably synonymous with individuals possessing elevated BMI values, thereby aligning with findings from Armanto's 2021 investigation at the University of Muslim Indonesia, wherein a majority of students exhibiting light physical activity levels, comprising 38 (65.5%) individuals, manifested optimal nutritional statuses.[33] Notably, students displaying moderate physical activity levels alongside Obesity 1 BMI values and normal BMI values demonstrated a congruent frequency distribution within this study, represented by 12 (44.4%) and 10 (37%) students, respectively. Likewise, students exhibiting high physical activity levels predominantly

showcased normal BMI values, totaling 12 (44.4%) students, followed by students with Obesity 1 and 2 BMI values, encompassing 4 (25%) individuals each. Thus, it is evident that besides physical activity, myriad other factors potentially exert influence upon students' nutritional statuses, including dietary patterns, sleep routines, and proclivities toward smoking, aspects which warrant further in-depth exploration beyond the scope of this study.[31]

Pulmonary Function Overview among 2021 FK Unjani

The examination depicted in Table 4 elucidates the mean values of Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), and the FEV_1/FVC ratio among the subjects. The mean FVC value stands at 93.82%, with a range spanning from 56% to 129%. Likewise, the mean FEV_1 value is recorded at 94.12%, ranging from 47% to 122%. Additionally, the mean FEV_1/FVC ratio is calculated to be 89.93%, with values varying between 69% and 100%.

Table 4. Description of lung function values (FVC, FEV_1, and FEV_1/FVC ratio) in research subjects

Variabel	Rerata	SD	Median	Minimum	Maksimum
FVC (%)	93.82	12.72	93.50	56	129
FEV_1 (%)	94.12	13.76	95	47	122
Rasio FEV_1/FVC (%)	89.93	6.63	90	69	100

Utilizing the classification and normative values for FVC provided by the Indonesian Pneumobile Team, it is observed that 54 subjects (90%) exhibit FVC values within the normal range (> 80%), while 6 subjects (10%) fall below this threshold. This distribution suggests a predominant presence of favorable FVC values among the subjects, corroborating findings from Sebastian's investigation at the Faculty of Medicine, Tarumanegara University, wherein 52% of students demonstrated commendable FVC values compared to 48% with suboptimal lung vital capacity.[34] Following the Indonesian Pneumobile Team's classification, where a normal FEV_1 is defined as greater than or equal to 80%, and a normal FEV_1/FVC ratio is considered to be greater than or equal to 75%, it is noted that 48 subjects (80%) in this study exhibit normal FEV_1 values, with 12 subjects (20%) displaying aberrant FEV_1 values. Moreover, 56 subjects (93.3%) demonstrate a normal FEV_1/FVC ratio, with only 4 subjects (6.7%) exhibiting deviations from this norm.

Table 5. Further elaboration on pulmonary function parameters based on the Pneumobile classification system.

Lung Function						
Variabel	**FVC%**		**FEV_1%**		**FEV_1/FVC%**	
	Normal □ 80%	Not Normal <80%	Normal □ 80%	Not Normal <80%	Normal □ 75%	Not Nnormal <75%
n	54	6	48	12	56	4
%	90%	10%	80%	20%	93,3%	6,7%

Despite the exclusion of subjects with respiratory illnesses, some individuals still exhibit values below the normal range. Contributory factors such as Body Mass Index (BMI), smoking habits, and exposure to environmental pollutants are posited as potential influencers in this study. Prior research suggests that obesity may precipitate a decline in lung capacity, as evidenced by reduced FVC.[35] Smoking habits, in contrast, compromise lung ventilation through irritation and excessive mucus production. Furthermore, the accumulation of toxins from prolonged cigarette use can impede gas exchange in the alveoli, resulting in diminished lung vital capacity and overall pulmonary function impairment.[36]

Table 6. Description of Lung Function Values (FVC%, FEV_1%, and FEV_1/FVC%) Based on Physical Activity Levels

Variabel	Physical Activity Levels		
	Low (Mean±SD)	Moderate (Mean±SD)	High (Mean±SD)
FVC (%)	89.76±9.4	91.74±12.96	101.63±12.64
FEV_1 (%)	86.35±12.3	93.44±14.12	103.5±8.67
FEV_1/FVC (%)	86.88±7.6	91.00±5.32	91.38±6.82

Table 6 provides a comprehensive synopsis of pulmonary function values (FVC%, FEV_1%, and FEV_1/FVC%) stratified by levels of physical activity. On average, subjects exhibiting low, moderate, and high levels of physical activity demonstrate commendable pulmonary function values. Notably, an upward trend in mean FVC%, FEV_1%, and FEV_1/FVC% values is discernible, indicating a positive association between heightened physical activity levels and enhanced pulmonary function parameter outcomes.

Association between Physical Activity Level and Pulmonary Function (FVC%, FEV_1%, FEV_1/FVC%)

The Spearman Correlation Test was employed to analyze the relationship between physical activity level and pulmonary function parameters, namely Forced Vital Capacity (FVC%), Forced Expiratory Volume in one second (FEV_1%), and the FEV_1/FVC ratio. The results revealed statistically significant correlations between physical activity level and FVC% (p=0.008, r=0.399) as well as FEV_1% (p=0.000, r=0.501). However, no significant correlation was observed between physical activity level and the FEV_1/FVC ratio (p=0.071, r=0.235).

Table 7. Relationship Between Physical Activity Levels and Lung Function (FVC%, FEV_1%, and FEV_1/FVC%)

Variabel	Physical Activity Level	
	r	P-value
FVC	0.399**	0.008
FEV_1	0.501**	0.000
FEV_1/FVC	0.235	0.071

**Correlation is significant at the 0.001 level (2-tailed)

These findings resonate with prior investigations by Nor Azura (2021) among students at the National University of Malaysia, which similarly highlighted a notable correlation between physical activity level and FVC values (p=0.001, r=0.452).[37] Correspondingly, Theresia's study on the correlation between physical activity level and vital capacity in adolescents (2019) uncovered a significant moderate correlation (r=0.506, p=0.001).[38] Furthermore, Ahmed's research on Saudi university students (2015) identified significant differences in FVC values (p<0.001) across varying levels of physical activity.[39]

During physical exertion, such as exercise, the body's muscles, particularly skeletal and cardiac muscles, signal the brain via afferent neurons, indicating heightened oxygen demand for metabolic processes.[40] Subsequently, the brain stimulates respiratory muscles, leading to increased blood flow through the lungs, facilitating optimal oxygen diffusion into the pulmonary capillaries. [6,20,28,40]

The observed correlation between physical activity level and FEV_1 values aligns with Nor Azura's investigation (2021) among National University of Malaysia students, which reported a significant moderate correlation (r=0.423, p=0.002).[37] Likewise, Ahmed's study on dental and pharmacy students at a Saudi university (2015) unveiled significant differences in FEV_1 values across different physical activity levels (p<0.001).[39]

Regular physical activity and enhanced physical fitness are associated with improved lung function, with intense physical activity potentially mitigating the rate of FEV_1 decline.[39] This increase in respiratory muscle strength during regular physical activity promotes adequate inspiratory pressure for maximal ventilation, thereby boosting respiratory function.[5] This phenomenon is attributed to increased oxygen demand during physical exertion, prompting the body to augment respiratory frequency, consequently elevating ventilation and enhancing pulmonary vital capacity.[41]

The absence of a significant correlation between physical activity levels and FEV_1/FVC, as evidenced in the present study, mirrors the findings delineated by Nor Azura (2021) in their investigation conducted among university students at Universiti Kebangsaan Malaysia. Nor Azura (2021) elucidated a lack of statistically significant association between physical activity levels and FEV_1/FVC, denoted by a modest correlation coefficient (r=0.180, p=0.198). These findings corroborate the current study's outcomes, suggesting that while a positive relationship is implied, indicating that heightened levels of physical activity might potentially elevate FEV_1/FVC values, no substantive correlation exists between the two variables.[37]

The lack of a significant correlation between physical activity and the FEV_1/FVC ratio observed in this study may be attributed to the fact that the FEV_1/FVC ratio is influenced by changes in both FEV_1 and FVC values. If the decrease in FEV_1 is proportionally smaller compared to that in FVC, the FEV_1/FVC ratio will consequently increase, and vice versa.[42] Additionally, there are confounding factors, such as gender, height, weight, BMI, and smoking status, which can impact lung function. This study did not specifically focus on a particular gender and did not match characteristics such as height, weight, and BMI to homogenize the characteristics of the research subjects. Furthermore, smoking status was not an exclusion criterion in this study. Additionally, exposure to dust or pollutants, which could not be controlled in this study, might have influenced the results, leading to nonsignificant findings.

CONCLUSION

An important correlation has been observed between the degree of physical activity and the parameters of pulmonary function, specifically FVC and FEV_1. Consequently, it is anticipated that students will endeavor to augment their physical activity levels in accordance with established health recommendations.

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DECLARATION OF INTEREST

No conflicts of interest were identified within the scope of this scholarly work.

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