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Correlation of Body Mass Index (BMI) with Forced Vital Capacity (FVC) and Forced Expiratory Volume 1 Second (FEV1s) in Adolescents

(Korelasi Indeks Massa Tubuh (IMT) dengan Forced Vital Capacity (FVC) dan Forced Expiratory Volume 1 Second (FEV1s) pada Remaja)

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ABSTRACT

The Respiratory System plays an important role for humans. The main function of the respiratory system is to obtain oxygen (O_2) required by the body's cells and to expel carbon dioxide produced by the cells. Body Mass Index (BMI) influences lung volume. Forced Expiratory Volume in 1 second (FEV1) is the lung capacity that includes the volume of air that can be forcefully exhaled in one second during a pulmonary function test. FEV1 is often used as an important parameter in evaluating lung function. This study aims to investigated the relationship between Body Mass Index (BMI) and Forced Vital Capacity (FVC), as well as Forced Expiratory Volume in 1 Second (FEV1), in adolescents. This research is an analytical observational study using a cross-sectional research design. Sampling was performed using purposive sampling techniques. Data collection involved measuring body weight and height to calculate BMI and measuring Forced Vital Capacity (FVC) using a spirometer. Data analysis was conducted using normality tests and Spearman's correlation test. The study results revealed correlation between Forced Vital Capacity (FVC) and Body Mass Index in adolescents. Other results showed that there was no statistically significant relationship between Body Mass Index and FEV1s in adolescents.
Keywords: *BMI; FVC; FEV1; Adolescents*

ABSTRAK

Sistem pernapasan berperan penting bagi manusia. Fungsi utama sistem pernapasan untuk memperoleh oksigen (O_2) yang diperlukan oleh sel-sel tubuh dan mengeluarkan karbondioksida yang dihasilkan sel. Indeks Massa Tubuh (IMT) mempengaruhi volume paru. Force expiratory volume 1 second (FEV1s) adalah kapasitas paru-paru yang mencakup volume udara yang dapat dikeluarkan secara paksa dalam satu detik selama uji fungsi paru. FEV1s sering digunakan sebagai parameter penting dalam mengevaluasi fungsi paru. Penelitian ini bertujuan untuk mengetahui hubungan hubungan antara indeks massa tubuh (IMT) dengan Forced Vital Capacity (FVC) dan Forced Expiratory Volume 1 Second (FEV1s) pada usia remaja. Penelitian ini merupakan jenis penelitian observasional analitik dengan menggunakan rancangan penelitian studi cross sectional atau potong lintang. Pengambilan sampel menggunakan teknik Purposive Sampling. Pengambilan data mengukur berat badan dan tinggi badan untuk menghitung indeks massa tubuh, dan mengukur Forced Vital Capacity (FVC) menggunakan spirometer. Analisis data dengan uji normalitas dan uji korelasi Spearman. Hasil penelitian menunjukkan terdapat hubungan antara Forced Vital Capacity (FVC) dengan Indeks Massa Tubuh pada Remaja. Hasil lainnya menunjukkan tidak terdapat hubungan yang bermakna secara statistik antara Indeks Massa Tubuh dengan FEV1s pada Remaja
Kata kunci: *IMT; FVC; FEV1s; Remaja*

INTRODUCTION

Lung volume is one of the factors that affect ventilation function. Lung volume is a parameter that can be measured directly using a spirometer. Body weight affects lung volume. Obesity can cause a decrease in total lung capacity during lung volume examination (Delgado, 2023). As Body Mass Index (BMI) increases, fat content gradually increases, causing intra-peritoneal fat deposits and accumulation, which hinders diaphragm descent during inspiration, thereby affecting respiratory function. Additionally, increased abdominal fat volume can reduce expiratory

reserve volume by shifting the diaphragm upward and decreasing functional chest cavity volume (Saminan, 2019).

Factors affecting lung function vary, such as pneumonia, asthma, cystic fibrosis, bronchiolitis, obesity, exposure to pollution, and low socioeconomic status. Of all these factors, the relationship between obesity and decreased lung function has been extensively studied (Booth et al., 2016; Chaya et al., 2022). Body Mass Index (BMI) affects lung volume, and obesity is associated with variations in lung volume (Haznawati, 2019). In obese individuals, increased body fat can trigger fat accumulation in several parts of the body. Obesity can also cause a decrease in static and dynamic lung volume (Sha & Kaltsakas, 2023; Xue et al., 2021).

This study is based on the research gap of several previous studies. Lamtiar (2019) in a study on the correlation between body mass index and forced vital capacity in 63 male students aged 18-23 years who did not smoke, selected as samples using purposive sampling, found a significant positive relationship between body mass index and forced vital capacity based on Pearson's correlation test. This study differs from previous studies in terms of age. This study was conducted on subjects aged 15-17 years using Spearman's correlation test. Another difference between this study and previous studies is the sample size, which in in this study exceeds that of previous studies. Fattah et al. (2022) in a study on the Effect of Body Mass Index (BMI) on Forced Vital Capacity in Patients with Chronic Obstructive Pulmonary Disease (COPD). The difference in this study is in the research subjects, which were adolescents.

Forced expiratory volume in 1 second (FEV1s) is the lung capacity that includes the volume of air that can be forcibly exhaled in one second during a lung function test. FEV1 is often used as an important parameter in evaluating lung function and is often an indicator in diagnosing obstructive lung disease. A decrease in FEV1s may indicate a disorder of the airways or lungs (Sharon, 2022).

This study was motivated by a research gap in previous studies. Firmansyah et al. (2021) focused their study on stable asthma patients. The results of this study indicate that there is a relationship between Body Mass Index (BMI) and FEV1s / FVC in stable asthma patients. Excess body fat can cause mechanical and chemical changes in the respiratory system (Firmansyah et al., 2019). This study aims to determine the correlation between Body Mass Index (BMI) and *Forced Vital Capacity (FVC)* in adolescents and to determine the correlation between Body Mass Index (BMI) and *Forced Expiration Volume 1 Second (FEV1s)* in adolescents.

METHODS

This study is a cross-sectional study conducted at Amurang 1 Public High School, located in Amurang District, South Minahasa. This study was conducted during June 2024 and involved teenage students in grades X and XI at SMA Negeri 1 Amurang as respondents. The sampling technique used in this study was purposive sampling. The inclusion criteria for this study were teenagers aged between 15 - 17 years. Exclusion criteria in this study included refusal to participate in the study, lack of adequate physical or mental capacity, history of pneumonia within the last 3 months, suffering from lung diseases such as tuberculosis or Chronic Obstructive Pulmonary Disease (COPD), and a history of exposure to cigarette smoke, either passive or active. The initial stage of the study includes preparing a research proposal, obtaining research ethics approval from the relevant

institutions, obtaining permission from the parties responsible for the research facilities, providing information about the study to the respondents, and coordinating between the medical teams. The tools and materials used in this study were research questionnaires, weighing scales, microtoise, and spirometry kits. The independent variable in this study was Body Mass Index. The dependent variables or the focus of this study were *Forced Vital Capacity (FVC)* and *Forced Expiratory Volume 1 Second (FEV1s)*. The statistical analysis in this study consists of two parts, namely descriptive analysis and analytical analysis. Descriptive analysis is used to present the distribution of data for quantitative variables and proportions (%) for qualitative variables. The test used is the Pearson Correlation Test.

RESULTS AND DISCUSSION

The researchers conducted a study by sampling male and female students in grades X and XI at SMA Negeri 1 Amurang as respondents. The sample size was 88 students aged between 15 - 17 years old, with the youngest sample aged 15 years old consisting of 55 people (62.50%), the oldest sample aged 17 years old consisting of 4 people (4.54%), and the largest sample aged 15 years old (**Table 1**).

Table 1. Age of research respondents

Age Group	n	%
15 years	55	62,50
16 years	29	32,96
17 years	4	4,54
Total	88	100

Researchers are interested in taking samples at this young age because at this age, Forced Vital Capacity (FVC) is not yet significantly affected by other factors such as advanced age, degenerative diseases, and other accompanying factors. When collecting data, researchers also measured body weight and height to calculate the body mass index of the sample. The average height was 163 cm and the average weight was 54.62 kg (**Table 2**).

Table 2. Height and Weight

Height and Weight	**n**	**Average**
Height (cm)	88	163.0
Weight (kg)	88	54.62

Table 3. Body Mass Index (BMI)

Body Mass Index	**n**	**%**
Underweight	25	28.41
Normal	44	50.00
Overweight	15	17.05
Obesity 1	4	4.54
Obesity 2	-	-
Total	88	100

The sample group with an underweight body mass index consisted of 25 people (28.41%), 44 people (50%) were normal weight, 15 people (17.05%) were overweight, and 4 people (4.54%) were obesity 1 (**Table 3**).

Table 4. Descriptive data results

	N	Min	Max	Mean		SD
	Statistic	Statistic	Statistic	Statistic	SE	Statistic
Age	88	15.00	17.00	15.7273	.05988	.56176
Height	88	148.00	180.00	163.0000	.94327	8.84866
Weight	88	40.00	87.00	54.6250	1.11725	10.48076
Body Mass Index (BMI)	88	15.10	27.80	20.4545	.29456	2.76322
FVC	88	54.00	106.00	83.1477	1.38269	12.97082
FEV1	88	56.00	117.00	89.1705	1.59645	14.97601

The results of the data normality test using the Kolmogorov-Smirnov test (sample >50) showed that the data were normally distributed. Based on the results of the normality test showing that the data were normally distributed, the researcher used Pearson's correlation test to determine whether there was a relationship between Forced Vital Capacity (FVC) and Body Mass Index using SPSS Statistics, and to determine whether there was a relationship between *Forced Expiratory Volume 1 Second (FEV1s)* and Body Mass Index.

Table 5. Relationship between Body Mass Index (BMI) and FVC

		FVC	Body Mass Index
FVC	Pearson Correlation	1	0.373**
	Sig. (2-tailed)		0.000
	N	88	88
Body Mass Index	Pearson Correlation	0.373**	1
	Sig. (2-tailed)	0.000	
	N	88	88

An increase in abdominal fat volume can reduce expiratory reserve volume by shifting the diaphragm upward and reducing functional chest cavity volume (Haznawati & Probosari, 2019; Saminan, 2019). The results of the Pearson correlation test analysis (**Table 5**) show that Forced Vital Capacity against Body Mass Index obtained a correlation coefficient value of 0.373 with a p-value = 0.000 (p = <0.05), which means H_0 is rejected and H_1 is accepted, namely that there is a relationship between Forced Vital Capacity (FVC) and Body Mass Index, with a correlation coefficient value of 0.373, which means there is a significant positive relationship between Forced Vital Capacity (FVC) and Body Mass Index. This means that the higher the Forced Vital Capacity (FVC), the higher the Body Mass Index.

Research conducted by Xue et al. (2021) on the Effect of Body Mass Index on Spirometry Tests in Adults in Xi'an, China found significant results where FVC% (p = 0.0004) was significantly higher in subjects with normal weight than in subjects who were underweight. Research conducted by Tang X et al. (2022) on the Relationship between Body Mass Index and Lung Function in populations with different characteristics found that the higher the Body Mass Index, the higher the Forced Vital Capacity (FVC). This indicates that FVC is lower in subjects with lower body weight compared to subjects with normal body weight. Subjects with obesity have higher FVC compared to subjects with normal body weight.

Table 6. Relationship between Body Mass Index (BMI) and FEV1s

		FEV1s	Body Mass Index
Body Mass Index	Pearson Correlation	0.153	1
	Sig. (2-tailed)	0.156	
	N	88	88
FEV1s	Pearson Correlation	1	0.153
	Sig. (2-tailed)		0.156
	N	88	88

Forced Expiratory Volume in One Second (FEV1) is a measure of the volume of air that can be exhaled forcefully and rapidly in one second during lung function testing. This refers to the forced expiratory capacity in one second (Ranu et al., 2019). The results of Pearson's correlation test (**Table 6**) it was found that FEV1s (Pred%) against Body Mass Index obtained a correlation coefficient value of 0.153 with a p-value = 0.156 (p = > 0.05), which means that H_0 is accepted, and H1 is rejected, namely that there is no relationship between Force Expiration Volume 1 Second (FEV1s) and body mass index.

The results of this study are inconsistent with previous research by Setiyawan (2015), which showed that subjects with excess body mass index had a lower chance of experiencing a decrease in first-second forced expiratory volume (FEV1) Setyawan, 2019). Overall, the results of this study do not support the concept that there is a relationship between respiratory parameters such as FEV1s and Body Mass Index. These observations provide further insight into the complexity of interactions between physiological components of the body and the importance of monitoring and managing various aspects of respiratory health, especially in populations with respiratory disorders such as asthma and obstructive pulmonary disease.

CONCLUSION

The results showed that BMI significantly affected Forced Vital Capacity (FVC) in adolescents. Conversely, BMI did not affect Forced Expiration Volume 1 Second (FEV1s) in adolescents. The factors that influence Forced Vital Capacity (FVC) and Forced Expiratory Volume 1 Second (FEV1s) are multifactorial. Further research is needed to assess other factors that influence lung Forced Vital Capacity (FVC) and Forced Expiratory Volume 1 Second (FEV1s).

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