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The Relationship between Body Mass Index and Lung Vital Capacity

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Abstract

Vital Capacity (VC) serves as one of the main parameters in assessing lung function. Obesity, which can be measured using Body Mass Index (BMI) and waist circumference, has the potential to affect respiratory mechanics and decrease lung function. Medical students with limited physical activity are at risk of experiencing reduced VC due to increased BMI and central obesity. This study aims to determine the relationship between BMI and waist circumference with VC among 2023 cohort students of the Faculty of Medicine, Universitas Kristen Indonesia. This research is an observational study with a cross-sectional design. A total of 57 students participated as samples. Data were collected through measurements of BMI, waist circumference, and VC using spirometry. Chi-square test was used for analysis. Results showed that 54.4% of respondents had abnormal BMI, 40.4% had central obesity, and 57.9% exhibited abnormal vital capacity. A significant relationship was found between BMI and VC (p=0.001), as well as between waist circumference and VC (p=0.010). These findings indicate that increased BMI and waist circumference may contribute to reduced lung function.

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Introduction

The lungs play a vital role in the respiratory system. Lung health can be seen from their ability to function optimally, which can be measured through the Vital Lung Capacity (FVC), an indicator of lung function (Raharjo & Lontoh, 2024). The average vital lung capacity is 4,500 ml (Sherwood, 2020). The normal range for lung function varies depending on age, height, weight, and gender (Bai et al., 2023). A method that can be used to measure lung function objectively is spirometry. Spirometry is a lung function test that evaluates FVC. This test helps detect possible abnormalities in lung function (Prihantini & Batubara, 2019). There are several risk factors known to contribute to decreased lung function, such as genetic predisposition, lung disease, exposure to cigarette smoke, environmental or occupational exposure to pollutants, and lack of physical activity. Decreased FVC can also be caused by obesity; one study demonstrated that obesity can cause decreased FVC (Afgani, Yasin, & Zulqarnain, 2021; Engwa, Anye, & Nkeh-Chungag, 2022). Obesity is a global health problem, a major risk factor for non-communicable diseases and cardiovascular disorders, such as hypertension, diabetes mellitus, and dyslipidemia (Susumu, 2010). According to 2022 WHO data, approximately 2.5 billion adults (>18 years) are classified as overweight, including more than 890 million adults classified as obese ("Obesity and overweight," 2025) In Indonesia, based on the 2023 Indonesian Health Survey, the obesity rate among the population aged 18 and over was recorded at 14.4%, an increase from 13.6% in 2018 and 13.5% in 2013 ("Obesity and overweight," 2025). Obesity itself is defined as abnormal or excessive fat accumulation that negatively impacts health. The Ministry of Health defines a Body Mass Index (BMI) >27 kg/m2 as obesity (Mashuri, 2022).

The BMI method is quite simple and easy to assess obesity status, comparing body weight (kg) to height in square meters. However, BMI is unable to describe body composition, such as distinguishing between fat and fat-free mass, and is unable to identify central obesity which has the potential to affect lung function.(Dixon & Peters, 2018; Haznawati, Probosari, & Fitranti, 2019). Therefore, other methods are needed, such as waist circumference, which is more effective in assessing visceral adiposity, and is often used in clinical practice to measure central obesity (Mangasuli & Sherkhane, 2020). Adolescents of productive age can experience decreased lung function, influenced by various factors, such as genetics and growth hormones, exposure to air pollution, smoking habits, diet, and physical activity levels.1 According to a 2017 study by Huang et al (Huang et al., 2019), lung function was strongly associated with abdominal fat distribution in young adults.17 A 2021 study by Afgani et al (Afgani et al., 2021) found that higher BMI led to a lower FVC.7 A similar finding was noted in a 2024 study by Adjie et al. (Adjie et al., 2024). which found that BMI influences FVC.1 This study aimed to evaluate the quality of lung function in medical students and its relationship to BMI.

Method

The research method was observational with a cross-sectional approach. The study was conducted at the Faculty of Medicine, Christian University of Indonesia. Data collection, preparation, and implementation took place from September 2024 to February 2025. The population was 138 active students from the Faculty of Medicine, Universitas Kristen Indonesia (2023). The sample consisted of active students from the Faculty of Medicine, Universitas Kristen Indonesia (2023). The sample consisted of selected subjects and populations who met the inclusion and exclusion criteria. The sample size was determined using the Slovin formula.

The data in this study were obtained directly from respondents as the primary data source. Data collection was conducted using a KVP test using a spirometry device. Respondents were asked to complete an informed consent form as a sign of their willingness to participate in the study. Univariate analysis was performed to describe the characteristics of each variable separately, while bivariate analysis was used to determine the relationship between BMI and FVC using the Chi-square test. A P value <0.001 was considered highly significant, a P value <0.05 was considered significant, and a P value >0.05 was considered insignificant.

Result and Discussion/Use

1. Result

Table 1 presents data on the distribution of respondents based on Gender, Age, Body Mass Index, Waist Circumference Research Results and Lung Vital Capacity.

Univariate Analysis

Table 1

Distribution of respondents based on Gender, Age, Body Mass Index, Waist Circumference Research Results and Lung Vital Capacity

Category	Frequency	Percentage
Age		
18 years	4	7.0
19 years	37	64.9
20 years	15	26.3
21 years	1	1.8
Gender		
Female	34	59.6
Male	23	40.4
Body Mass Index		
Normal	26	45.6
Abnormal		
Underweight	8	14.0
Overweight	7	12.3
Obesity	16	28.1
Waist Circumference Measurement Results		
Normal	34	59.6
Central Obesity	23	40.4
Vital Lung Capacity		
Normal	24	42.1
Abnormal	33	57.9

Bivariate Analysis

Tabel 2
Results of Bivariate Analysis of the Relationship between Body Mass Index and Vital Lung Capacity and the Relationship between Waist Circumference and Vital Lung Capacity

Category	Vital Lung Capacity				Total		*Fisher's Exact Test (2-sided)*
	Normal		Abnormal				
	N	%	N	%	N	%	
Body Mass Index							
Normal	17	29.8	9	15.8	24	45.6	*0.001*
Abnormal	7	12.3	24	42.1	33	54.4	
Waist size							
Normal	19	33.3	15	26.3	34	59.6	*0.010*
Central obesity	5	8.8	18	31.6	23	40.4	

2. Discussion

Discussion of the Relationship Between Body Mass Index and Vital Lung Capacity

Breathing is crucial for lung function. Proper breathing can impact quality of life, maintain homeostasis, and maintain the structure of the respiratory tract. A way to determine whether lung function is good is by identifying the Vital Lung Capacity (FLC). Many studies indicate that FLC is influenced by several factors, one of which is BMI (Li et al., 2024). Every individual has a unique BMI. The BMI method is a simple assessment method often used to identify a person's nutritional status based on the ratio of body weight to height (Pagayang, 2021). The Ministry of Health classifies BMI as underweight (BMI <18.5 kg/m2); normal (BMI 18.5-25 kg/m2); overweight (BMI 25-27 kg/m2); and obesity (BMI >27 kg/m2) (Mashuri, 2022).

Lung function can be reduced due to ventilation disorders, namely restrictive disorders and obstructive disorders. Restrictive disorders are disorders in the ability of the lungs to expand, the condition of the lungs becomes stiff so that they cannot expand optimally and there is a decrease in lung volume. Restriction can be caused by abnormalities in the lung parenchyma, namely: pulmonary fibrosis, lung abscess, lung tumor, pulmonary edema, atelectasis. Abnormalities in the pleura, namely: pleural edema, pleural effusion, pneumothorax. Abnormalities in the wall or sternum, namely: fracture, scoliosis, obesity (Bakhtiar & Amran, 2016). Idiopathic Pulmonary Fibrosis (IPF), Sarcoidosis, Pneumothorax are examples of lung diseases with a pattern of restrictive disorders (Martinez-Pitre, Sabbula, & Cascella, 2023). Obstructive disorders are conditions where there is increased airway resistance that occurs due to narrowing of the lower airway lumen, this condition causes airflow to be obstructed and requires a greater pressure gradient to maintain normal airflow velocity. Increased resistance can occur mucosal inflammation, mucus hypersecretion, bronchospasm, and damage to the alveolar walls. Asthma, chronic bronchitis, and emphysema are classified as obstructive lung diseases.

Tuberculosis (TB) sufferers are at risk of experiencing restrictive disorders due to necrosis, chronic inflammation, and fibrosis in lung tissue that reduces lung elasticity. Smoking habits are known to increase the risk of Chronic Obstructive Pulmonary Disease (COPD), emphysema, and various other lung diseases, which can significantly reduce lung function values. Various studies have shown the dangers of substances and cigarette smoke are toxic and to body cells, especially lung tissue (Churg, Cosio, & Wright, 2008; Mercer, Lemaître, Powell, & D'Armiento, 2006; Morse & Rosas, 2014).

Based on these considerations, subjects with a history of lung disease or smoking habits are considered potential confounding variables, so they are included in the exclusion criteria in this study. The results of the study showed a relationship between BMI and FVC, as evidenced by p <0.05. This study involved 57 participants as samples. The same results were found in the study of Sinha PH et al (Jones & Nzekwu, 2006; Sinha, Deep, & Panda, 2021). A total of 300 subjects were divided into two groups, namely group A (BMI> 25 kg / m2) and group B (BMI <25 kg / m2). Based on the results of the analysis of group A, there was a negative correlation between BMI and FVC, while in group B, a strong negative correlation was found between BMI and FVC. An increase in BMI was followed by a decrease in FVC. 27 In the study of Jones RL (Jones & Nzekwu, 2006). BMI correlated significantly with a decrease in FVC. There was a linear pattern of decreasing FVC along with increasing BMI and the most significant decrease occurred in the BMI range of 25-30 kg / m2.

However, other researchers have different results. A study conducted by Liu P in 2017, 19 found no significant relationship between BMI and FVC in Zhuang university students in China. This is indicated by a p-value exceeding the statistical significance limit (p>0.05), both in the analysis of the difference in mean FVC between BMI categories and in the multivariate regression analysis after adjustment for various body composition factors. This is most likely due to the very small proportion of obese subjects (BMI>27.9), thus limiting the statistical power to detect differences in FVC between BMI categories. Lung vital capacity is the maximum volume of air that can be expelled from the lungs after maximal inspiration, which is the sum of tidal volume, inspiratory reserve volume, and expiratory reserve volume. The lungs act as the main organ in the process of gas exchange, namely oxygen and carbon dioxide. A high FVC value reflects better lung quality in distributing oxygen throughout the body's tissues, even during high-intensity physical activity (Pagayang, 2021)

Discussion of Waist Circumference and Vital Lung Capacity

Obesity assessment relies not only on BMI but can also utilize other anthropometric parameters such as waist circumference and waist-to-hip ratio as indicators of central obesity (Kaparang, Padaunan, & Kaparang, 2022). There are two main patterns of body fat distribution: central and peripheral. Central obesity is characterized by increased fat accumulation in the thorax, abdomen, and visceral organs. Peripheral obesity, on the other hand, is characterized by fat accumulation in the hips, thighs, and legs, as well as in the subcutaneous tissue. This distinction is important because central obesity has a more direct impact on lung mechanics and has a more significant impact on metabolic inflammation (Dixon & Peters, 2018).

The analysis results showed that there was a relationship between waist circumference and FVC, as evidenced by the chi-square test results with a p value = 0.010 (p <0.05). This result is in line with the research of Goto et al. (Goto et al., 2015) which showed a significant relationship between increasing waist circumference and decreasing FVC, as evidenced by a p value >0.001 in men with a waist circumference ≥85 cm and p <0.05 in women with a waist circumference ≥95 cm. This finding indicates that limited chest wall movement and respiratory muscle weakness in individuals with central obesity have the potential to cause a decrease in FVC.30 This is different from the findings reported by Ferbiliani SK, et al In that study, the result obtained was p = 0.091 (>0.05) which indicated no relationship between waist circumference and FVC.

This is likely influenced by the characteristics of the majority of subjects who had waist circumferences within normal limits and the presence of uncontrolled variables such as physical activity before measurement, which can affect the accuracy of FVC data. In central obesity, body fat accumulates in the abdominal area, particularly around the waist and peritoneal cavity. This fat consists of visceral fat surrounding the internal organs and subcutaneous fat located beneath the abdominal skin. This condition can inhibit the downward movement of the diaphragm during inspiration and decrease expiratory reserve volume by pushing the diaphragm upward, thereby reducing the functional volume of the thoracic cavity. Furthermore, fat accumulation around the ribs reduces chest wall compliance. All of these factors contribute to suboptimal lung expansion, ultimately affecting respiratory function.

This study found subjects with abnormal BMI or abdominal circumference but normal FVC. This finding contradicts the researchers' hypothesis that predicted a negative correlation between increased BMI or abdominal circumference and decreased FVC. This phenomenon likely occurs because other compensatory factors play a role in maintaining lung function in these individuals, namely physical activity. Regular physical activity such as aerobic exercise and weight training can increase the strength and endurance of the respiratory muscles, improve the efficiency of alveolar ventilation, and maintain the elasticity of the lungs and chest wall, so that lung function can remain optimal even though there is an accumulation of excess body fat (Hackett, 2020; Umang Vats & Prosenjit Patra, 2015).

Subjects with normal BMI or waist circumference but abnormal FVC were also found. This is caused by exposure to air pollution, dust, and environmental irritants, which can affect lung function by reducing FVC and forced expiratory volume in one second (FEV_1) through mechanisms of chronic inflammation in the airways, impaired lung tissue elasticity, and impaired gas exchange (Adam et al., 2014; Li et al., 2024; Mathew, Maier, & Kaba, 2023). The possibility of undiagnosed respiratory disease in the subjects is also a contributing factor. The implications of the relationship between BMI and FVC for the community are quite broad, as the prevalence of obesity in the community is increasing, which can contribute to the increasing burden of undiagnosed or difficult-to-diagnose chronic lung disease. Therefore, BMI measurement can be used as an initial screening tool to identify individuals at risk of developing impaired lung function, while also providing a basis for promotional education regarding the importance of weight control as part of respiratory disease prevention efforts.

Conclusion

The following are the researchers' findings regarding the relationship between body mass index and vital lung capacity in students from the Faculty of Medicine, Universitas Kristen Indonesia (2023): 1) There is a relationship between BMI and FVC, as evidenced by a p-value of 0.001 ($p<0.05$); 2) There is a relationship between waist circumference and FVC, as evidenced by a p-value of 0.010 ($p<0.05$).

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