https://doi.org/10.48047/AFJBS.6.15.2024.10863-10876

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Association Between Obesity with Pulmonary Function Parameters

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Volume 6, Issue 15, Sep 2024

Received: 15 July 2024

Accepted: 25 Aug 2024

Published: 25 Sep 2024

doi: 10.48047/AFJBS.6.15.2024.10863-10876

Abstract

Background: Obesity is a public health issue, contributing to cardiovascular diseases and increased healthcare costs. It can cause systemic complications and adversely affect respiratory function, leading to decreased pulmonary function. This study aims to explore the relationship between obesity and lung function parameters.

Methods: This analytical observational study with a cross-sectional approach was conducted at Wahidin Sudirohusodo General Hospital in 2024, involving 47 obese and 40 non-obese patients. Spirometry assessed pulmonary function, excluding those with asthma or COPD. Data were analyzed using descriptive statistics and Chi-Square tests, with significance set at $p < 0.05$.

Results: The study population was predominantly female (51.7%) and aged 30-39 years (50.8%). Among respondents, 16.1% were smokers and 54.0% were obese. A total of 70.1% had normal pulmonary function, and the remaining had mild obstruction, mild to moderate restrictions, or mixed disorders. No significant relationship was found between obesity and pulmonary function parameters, namely VC, FEV1, FVC, and FEV1/FVC with p value ratio exceeding 0.05 between obese and non-obese groups.

Conclusion: This study found no significant association between obesity and decreased lung function parameters.

Keywords: obesity, pulmonary function, VC, FEV1, FVC, FEV1/FVC

Introduction

Obesity is a public health problem in the world today because its prevalence tends to increase and becomes a risk factor for cardiovascular disease and increases health care costs. Based on the criteria of the World Health Organization (WHO), the definition of obesity is when BMI is equal to or greater than 30 kg/m2. An increased body mass index will increase the risk of obesity-related disease morbidity. Based on WHO estimates in 2015 there were around 2.3 billion adults who were overweight and more than 700 million adults who were obese. In Indonesia, within a period of 10 years, there has been a significant increase in obesity from 10.5% in 2007 to 21.8% in 2018. The national prevalence of obesity in 2023 in the population aged over 18 years increased from 21.8% in 2018 to 23.4% in 2023. Based on a survey of the health profile of South Sulawesi province, the prevalence of obesity in Makassar city is 25.05% higher than the national increase. Obesity has now been classified as a disease that requires comprehensive intervention.[1,2]

Several systemic complications are associated with obesity including damage to organs and tissues. Obesity can cause various adverse effects on respiratory function, namely changes in respiratory mechanics such as decreased strength and endurance of respiratory muscles, decreased pulmonary gas exchange, lower respiratory control and disturbances in pulmonary function tests and exercise capacity. These changes are caused by extra adipose tissue in the chest wall and abdominal cavity that presses on the diaphragm and lungs. This results in changes in respiratory physiology with consequences for decreased parameters of pulmonary function. The effects of obesity on the respiratory system have been increasingly studied.[3-5]

In addition to mechanical factors, inflammation also plays a role in impaired lung function in obesity. Adipose tissue, consisting of adipocytes, mesenchymal, and stromal cells, becomes filled with triacylglycerol in obesity, reducing free fatty acid release. Adipocytes act as ligands for Toll-like receptor 4, triggering systemic inflammation and releasing cytokines like TNF-α, IL-12, IL-6, and MIP-2. Adipose tissue also releases leptin, which affects the immune response, particularly in obesity, increasing systemic inflammation in the lungs. This is due to the expression of leptin receptors (LepRb and LepRa) by bronchial and alveolar epithelial cells in the lungs.[6,7] This study aims to determine the relationship between obesity and lung function parameters.

1. Methods

The study design was an analytical observational study with a cross-sectional approach. The research was conducted at Wahidin Sudirohusodo General Hospital, Makassar, with data collection carried out in 2024. The study population included all patients with obesity and non-obesity at Wahidin Sudirohusodo General Hospital. Spirometry examinations were conducted at the Pulmonology Clinic of the same hospital. The study sample consisted of subjects who met the inclusion criteria, including patients aged over 18 years and willing to participate in the study. Exclusion criteria included patients with conditions that could affect pulmonary function measurements, such as asthma, chronic obstructive pulmonary disease (COPD), or those undergoing treatment for pulmonary tuberculosis (TB). Based on sample size calculations, a minimum of 43 subjects was required for each group, resulting in a total minimum sample size of 86 subjects (43 obese and 43 non-obese).

Obesity was measured using a meter and scales to calculate the Body Mass Index (BMI), determined by dividing body weight (kg) by height (m^2). The BMI values were interpreted based on the following objective criteria: a BMI of less than 18.5 kg/m^2 indicated underweight, 18.5–22.9 kg/m^2 represented ideal body weight, 23.0–24.9 kg/m^2 indicated overweight, 25–29.9 kg/m^2 corresponded to obesity level 1, and a BMI greater than 30 kg/m^2 was classified as obesity level 2. Decreased pulmonary function refers to a reduction in both the static and dynamic functional capacity of the lungs, which can be assessed using spirometry. Spirometric measurements include parameters such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and Total Lung Capacity (TLC), which help to identify different types of pulmonary function disorders, including restrictive, obstructive, and mixed disorders.

Data analysis was performed using SPSS version 25. The analysis method consists of descriptive methods and statistical tests. The descriptive method aims to obtain general information about the research sample. The statistical method used is the calculation of the mean value and standard deviation (SD) and frequency distribution. The statistical test used is Chi Square. The results of the statistical test are considered significant if the p-value of the test <0.05.

2. Results

Baseline Characteristics

Based on the results of the study with a sample of 87 respondents, **Table 1** pictured the distribution of participant characteristics which showed that most respondents were female (51.7%) and aged between 30-39 years (50.8%). As many as 16.1% of respondents were known to smoke, while most respondents (83.9%) did not smoke. The prevalence of obesity among respondents was 54.0%, with 46.0% of respondents categorized as non-obese. Regarding pulmonary function, majority of respondents had normal pulmonary function (70.1%), while a small portion showed disorders such as mild restriction (13.8%), moderate restriction (12.6%), mild obstruction (2.3%), and mixed (1.1%).

Table 1. Baseline characteristics

Variable	n (87)	%
Sex		
Male	42	48,3
Female	45	51,7
Age		
<30 years	29	33,3
30-39 years	44	50,6
≥40 years	14	16,1
Smoking		
Yes	14	16,1
No	73	83,9
Obesity		
Yes	47	54,0
No	40	46,0
Pulmonary function		
Normal	61	70,1
Mild obstruction	2	2,3
Mild restriction	12	13,8
Moderate restriction	11	12,6
Mixed	1	1,1

Based on the data normality test, the data distribution of all pulmonary function parameters studied was not normally distributed. In **Table 2**, these results indicate variability in pulmonary function parameters among respondents, with most values falling within the clinically acceptable range.

Table 2. Descriptive statistics of pulmonary function parameters

Parameter	Statistics (n=87)				
	Min	**Max**	**Median**	**Mean**	**SD**
VC	45,25	97,52	83,20	81,11	12,65
FEV1	2,80	110,43	88,85	80,23	24,28
FVC	50,19	109,00	87,00	82,74	12,69
FEV1/FVC	49,77	109,11	93,56	93,45	9,66

VC: vital capacity, FEV1: forced expiratory volume in 1 second, FVC: forced vital capacity

Relationship Between Obesity and Pulmonary Function

In this study, the relationship between obesity and pulmonary function was analyzed. Although differences in the median, mean, and standard deviation (SD) values for each pulmonary function parameter were observed between the obese and non-obese groups, these differences were not statistically significant, with all p-values greater than 0.05 (**Table 3**). Specifically, no significant differences were found in VC, FEV1, FVC, or the FEV1/FVC ratio between the obese and non-obese groups (p>0.05 for all parameters).

Table 3. Comparison of pulmonary function parameters between obese and non-obese

Parameter	Obesity	n	Median	Mean	SD	p
VC	Obese	47	82,00	80,01	12,04	0,311
	Non Obese	40	84,69	82,40	13,37	
FEV1	Obese	47	83,84	76,85	25,94	0,303
	Non Obese	40	89,81	84,21	21,82	
FVC	Obese	47	84,23	81,29	13,29	0,110
	Non Obese	40	88,79	84,44	11,89	
FEV1/FVC	Obese	47	93,63	92,46	12,13	0,956
	Non Obese	40	93,45	94,62	5,44	

VC: vital capacity, FEV1: forced expiratory volume in 1 second, FVC: forced vital capacity

The results in **Table 4** show that the proportion of obstruction and restriction of pulmonary function was found to be higher in obese (4.3% and 29.8%) compared to non-obese (0% and 22.5%). However, the results of the Chi-Square test with a p value = 0.459 ($p>0.05$), which means that there was no statistically significant relationship between obesity and the type of pulmonary function disorder. This indicates that the difference in pulmonary function distribution between obese and non-obese groups may occur by chance and is not strong enough to be concluded as a significant effect.

Table 4. The relationship between obesity and pulmonary function

Obesity		**Pulmonary Function**					**Total**
		Normal	**Mild obstruction**	**Mild restriction**	**Moderate restriction**	**Mix**	
Obese	n	30	2	7	7	1	47
	%	63,8%	4,3%	14,9%	14,9%	2,1%	100,0%
Non Obese	n	31	0	5	4	0	40
	%	77,5%	0,0%	12,5%	10,0%	0,0%	100,0%
Total	**n**	**61**	**2**	**12**	**11**	**1**	**87**
	%	**70,1%**	**2,3%**	**13,8%**	**12,6%**	**1,1%**	**100,0%**

Relationship Between IMT and Pulmonary Function Parameters

The results, as shown in **Table 5**, indicate no significant correlation between BMI and any of the pulmonary function parameters. The correlation coefficients for all parameters were weak, and none reached statistical significance ($p>0.05$). These findings suggest that BMI does not have a significant impact on pulmonary function in this subject population.

Table 5. Relationship of BMI to pulmonary function parameters

Pulmonary Function Parameter	BMI		
	n	R	p
VC	87	-0,158	0,143
FEV1	87	-0,003	0,977
FVC	87	-0,043	0,694
FEV1/FVC	87	-0,027	0,805

VC: vital capacity, FEV1: forced expiratory volume in 1 second, FVC: forced vital capacity

The Role of Confounding Factors on Pulmonary Function Parameters

In this study, confounding factor analysis was conducted on pulmonary function parameters. There was no significant relationship between sex while there was a significant relationship between age and smoking on pulmonary function. Based on **Table 6**, it shows that the VC, FEV1 and FVC values were found to be not significantly different between women and men (all with $p>0.05$). The FEV1/FVC values (median and mean) were found to be significantly lower in women (92.47 and 91.09) compared to men (97.02 and 95.99) ($p<0.05$).

Table 6. Comparison of pulmonary function parameters by sex

Parameter	Sex	n	Median	Mean	SD	p
VC	Female	45	82,58	81,18	13,47	0,374
	Male	42	83,29	81,03	11,87	
FEV1	Female	45	90,23	82,14	24,01	0,150
	Male	42	87,69	78,19	24,70	
FVC	Female	45	87,23	84,78	11,35	0,304
	Male	42	86,52	80,56	13,79	
FEV1/FVC	Female	45	92,47	91,09	10,65	**0,015**
	Male	42	97,02	95,99	7,82	

VC: vital capacity, FEV1: forced expiratory volume in 1 second, FVC: forced vital capacity

Based on the results in **Table 7**, significant differences in pulmonary function were observed between age groups, particularly in terms of VC and FVC. These findings suggest that age has a significant impact on certain aspects of pulmonary function, particularly those related to vital capacity, with older age being associated with reduced pulmonary function.

Table 7. Comparison of pulmonary function parameters by age

Parameter	Age	n	Median	Mean	SD	p
VC	<30 years	29	91,67	84,82	11,08	**0,002**
	30-39 years	44	83,29	82,37	10,57	
	≥40 years	14	71,03	69,45	15,56	
FEV1	<30 years	29	89,65	78,79	28,67	0,075
	30-39 years	44	90,23	85,56	16,47	
	≥40 years	14	71,31	66,48	30,48	
FVC	<30 years	29	88,02	84,15	9,81	**0,037**
	30-39 years	44	87,57	84,85	10,81	
	≥40 years	14	78,00	73,18	18,78	
FEV1/FVC	<30 years	29	92,34	92,91	6,80	0,389
	30-39 years	44	95,72	93,37	11,30	
	≥40 years	14	93,79	94,83	9,60	

VC: vital capacity, FEV1: forced expiratory volume in 1 second, FVC: forced vital capacity

Based on the results in **Table 8**, smoking status has a significant impact on lung function, particularly in reducing FEV1 and FVC, which are key indicators of impaired respiratory function among smokers. These findings indicate that smoking is associated with decreased lung function, despite higher VC, and contributes to greater respiratory impairment in smokers.

Table 8. Comparison of pulmonary function parameters by smoking status

Parameter	Smoking	n	Median	Mean	SD	p
VC	Yes	14	72,34	70,69	11,40	**0,001**
	No	73	84,00	83,11	11,93	
FEV1	Yes	14	64,04	56,20	30,30	**0,000**
	No	73	90,23	84,84	20,12	
FVC	Yes	14	60,67	66,09	14,90	**0,000**
	No	73	88,13	85,93	9,38	
FEV1/FVC	Yes	14	100,68	98,12	8,66	**0,015**
	No	73	92,78	92,56	9,63	

VC: vital capacity, FEV1: forced expiratory volume in 1 second, FVC: forced vital capacity

3. Discussion

Relationship Between Obesity and Pulmonary Function

The results presented in Table 3 indicate no significant differences between the obese and non-obese groups in terms of pulmonary function parameters such as Vital Capacity (VC), Forced Expiratory Volume in 1 second (FEV1), Forced Vital Capacity (FVC), and the FEV1/FVC ratio. Although variations in median, mean, and standard deviation were observed, these differences did not reach statistical significance ($p>0.05$). Previous studies have suggested that obesity can influence lung function through mechanisms like reduced lung compliance and decreased ventilatory capacity due to mechanical compression of the chest wall and diaphragm caused by abdominal fat accumulation.

Research by Poulain et al. found that central obesity could reduce VC and FVC, but in some populations, these effects were not statistically significant. This is consistent with our findings, which showed no significant differences in VC and FVC between obese and non-obese groups. Similar results were reported by Melo et al., who noted that while obesity can affect lung capacity, the degree of impact varies depending on the level of obesity and fat distribution.[8,9]

The FEV1/FVC ratio is commonly used to detect airway obstruction, as seen in obstructive lung diseases. Our results show no significant differences in FEV1 or the FEV1/FVC ratio between the obese and non-obese groups, suggesting that obesity is not directly associated with obstructive disorders in this study population. This aligns with findings from Lazarus et al., who reported that obesity tends to affect lung function more restrictively than obstructively, implying that while obesity may reduce lung volumes, it does not significantly impair expiratory airflow, as reflected in the normal FEV1/FVC ratios observed.[10]

Studies by Peters et al. also suggest that higher Body Mass Index (BMI) is often associated with restrictive lung disorders, where fat accumulation around the chest and abdomen restricts diaphragm movement and lung expansion. This observation aligns with our finding that restrictive lung disorders were more common in the obese group, although the differences did not reach statistical significance. Guerra et al. also noted that while obesity is associated with reduced lung function in some populations, these associations are not always significant when factors like age, sex, and smoking status are considered. Thus, the relationship between obesity and lung function requires further evaluation, considering additional contributing factors.[12,13]

Relationship Between BMI and Pulmonary Function Parameters

This study showed that the correlation between BMI and VC was negative (-0.158) but not significant ($p = 0.143$). Several previous studies have linked obesity to decreased lung capacity such as VC, due to fat accumulation in the chest wall and abdomen that inhibits diaphragm movement. However, this study did not find a significant relationship. According to research by Santana et al., the impact of obesity on lung capacity is more pronounced in morbid obesity, while lower BMI did not show a significant effect. In addition, Jafri et al. found that other factors such as physical activity and body fat distribution can affect lung function more than BMI itself. [14-16]

The Role of Confounding Factors on Pulmonary Function Parameters

A study by Harik-Khan et al. showed that men generally have higher vital capacity (VC) than women due to anatomical differences like larger lung and chest cavity sizes, though in this study, the difference was not statistically significant ($p=0.072$), possibly influenced by age or physical condition. No significant differences were found in FEV1 and FVC values between men and women, aligning with studies that suggest body size, height, muscle mass, and composition may play a larger role in FEV1 and FVC than sex. However, a significant finding was the lower FEV1/FVC ratio in women compared to men (p=0.015), which could indicate a higher risk of airway obstruction in women, corroborated by Johannessen et al. and Chapman et al., who suggest hormonal factors and lung elasticity changes, particularly after menopause, might contribute to this risk. These findings highlight the clinical importance of routine lung function monitoring, especially in women who may be more prone to conditions like asthma and COPD. [19-23]

The decline in lung function with age, particularly in vital capacity (VC) and forced vital capacity (FVC), has been well-established, with a significant drop observed in individuals aged ≥40 years. This decrease is largely due to reduced lung elasticity and respiratory muscle weakening, which increases the risk of lung diseases such as COPD and restrictive lung conditions. However, this study found no significant difference in FEV1 values or FEV1/FVC ratio between age groups, indicating that these parameters decline more gradually compared to VC and FVC. Interventions like pulmonary rehabilitation and regular exercise can help mitigate the impact of lung function decline in older adults. The study underscores the need for routine lung function screening in individuals over 40, especially to detect early signs of decline and prevent more serious respiratory complications. This aligns with clinical practices in internal medicine, where spirometry is used to monitor lung health in older or at-risk patients, highlighting the importance of proactive management in this population.[24-29]

The statistical analysis from **Table 7** reveals significant differences in lung function parameters between smokers and non-smokers, specifically in VC, FEV1, FVC, and the FEV1/FVC ratio. Smokers exhibited higher VC values, likely due to lung hyperinflation caused by increased retained air volume, as described by Costa et al. This compensatory mechanism may occur in the early stages of COPD, though it eventually leads to reduced lung elasticity. Lower FEV1 in smokers reflects airway obstruction, marking the onset of chronic obstructive pulmonary disease (COPD), as noted by López-Campos et al. This highlights the role of internal medicine specialists in identifying early signs of lung dysfunction and implementing smoking cessation programs to prevent disease progression. Medical specialist residency studies should emphasize both early recognition of lung impairment in smokers and a comprehensive management approach to mitigate the impact of smoking on lung health.[30]

4. Conclusions

There was no association between obesity and decreased lung function parameters.

5. Acknowledgments

This research was supported by the Department of Internal Medicine, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia

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