Original Article

Association of Increasing Body Mass Index with Obstructive Ventilatory Defect Among Adult Patients in Perpetual Help Medical Center

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ABSTRACT

Background: Various studies show an association between obesity and obstructive ventilatory defects. The changing diet of the population plays an important role in public health thus it is important to assess the association of increased body mass index (BMI) with lung ventilatory defects to be able to formulate health programs that will reduce the risk of obesity.

Methodology: This cross-sectional study included adult patients subjected to pulmonary function testing at Perpetual Help Medical Center, Las Piñas. A review of records was performed to gather data on demographics, pulmonary function test, and BMI.

Results: A total of 459 patients were included. Seventy (15.3%) had normal spirometry values, 79 (17.2%) had restrictive ventilatory defect, 306 (66.7%) had obstructive ventilatory defect, and 4 (0.9%) had mixed defects. The mean age was highest among those with obstructive ventilatory defect (59.5 ±16.6 years; p <0.001). The proportion of obstructive ventilatory defect was significantly higher among males than females (76.0% vs 53.2%; p = 0.001). Height, weight, and BMI did not vary significantly between the groups. Majority of patients were either overweight (39.6%) or normal (37.2%). The prevalence of abnormal spirometry did not vary across BMI classifications (p = 0.068). Significant correlations with BMI were observed only with post-bronchodilator FEV_1 % predicted (r = 0.09; p = 0.044), post-bronchodilator FEV_1/FVC (r = 0.11; p = 0.015), and post-bronchodilator $FEF_{25-75\%}$ (r = 0.09; p = 0.047). After adjustment, obesity was not associated with obstructive ventilatory defect (OR 0.9, 95% CI 0.5 to 1.8; p = 0.601) and post-bronchodilator FEV_1 (OR 0.9, 95% CI 0.5 to 1.7; p = 0.940).

Conclusions: BMI is not correlated with spirometric parameters, and obesity is not associated with obstructive ventilatory defect or post-bronchodilator FEV_1. Although some correlations are observed with BMI and post-bronchodilator spirometric parameters, the observed correlations are weak. Further studies are needed to determine the effect of other measures of body mass on obstructive ventilatory defect.

Keywords: BMI, obstructive ventilatory defect, spirometry, pulmonary function test

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INTRODUCTION

Obstructive lung diseases include chronic obstructive pulmonary disease (COPD), emphysema, and asthma. In these conditions, less air flows in and out of the alveoli, leading to reduced gas exchange. This is debilitating to patients and requires proper medical attention.[1] COPD affects nearly 210 million people worldwide, with a local prevalence rate of 14% in Metro Manila and 20% in rural areas.[2] Asthma has affected an estimated 339.[4] million people worldwide, with a slightly higher prevalence rate in rural areas than in urban areas (15.3% vs 13.3%).[3-4] Spirometry is commonly used to assess lung function and it provides a more accurate diagnosis of bronchial asthma and COPD by measuring the volume of air an individual can expel from the lungs after maximal inspiration.[5] The method enables detection of airway obstruction, making a definitive diagnosis of an obstructive lung disease.[6]

Obesity, a chronic medical condition that is characterized by excessive fat accumulation on human body, is measured by the body mass index (BMI), which reflects weight in relation to height. The WHO classification is as follows: BMI of 18 to 24.9 kg/m^2 is normal weight, BMI of 25.0 to 29.9 kg/m^2 is overweight, and BMI of 30 kg/m^2 or higher is obese.[7]

Obesity has been a global problem because of its significant contribution to mortality and morbidity. Studies have reported an association between body mass index (BMI) and asthma, with asthma prevalence being shown to increase with obesity.[8] One study observed that a BMI of 28 and above increased the risk of asthma, but with the relationship being significant only among women.[9] Similar findings of increasing asthma prevalence with obesity have been reported in several other studies, with the association seen to be stronger in women and non-smokers.[10-16] However, there are also studies that show no association between obstructive lung disease and obesity.[17-18] One study explained that an elevated BMI might have a protective impact on lung function in chronic obstructive pulmonary disease with GOLD grades 3 to 4, while dietary status significantly influences lung function in later stages.[19,20]

In the Philippines, there is a paucity of published literature regarding BMI and prevalence of obstructive ventilatory defects. Chua et al. described the body composition of Filipinos with chronic obstructive ventilatory defect and concluded in their study that underweight individuals with low fat-free mass indices were correlated with reduced lung function.[21] Variations in BMI are multifactorial and are influenced by environmental factors such as lifestyle, physical activity, and emotional factors. Las Piñas has become more populated over the last decade, with the changing diet of the population playing an important role in public health. As such, this study has a big contribution in this area as there are no local studies addressing the association between BMI and pulmonary defects. This study aimed to establish this association so corrective steps can be taken to address obesity risk factors in Las Piñas, such as diet and lifestyle, given obesity's effects on respiratory health.

METHODOLOGY

The study was a cross-sectional, analytic study that involved a review of records of adult patients subjected to pulmonary function test at Perpetual Help Medical Center, Las Piñas from January 2019 to December 2023. Excluded in the study were pregnant patients, those who did not complete the procedure, and spirometry results that did not meet the American Thoracic Society—European Respiratory Society 2019 guidelines. Records were obtained and reviewed, clinico-demographic data and spirometric values from pulmonary function tests were extracted, and data was tabulated and coded in an SPSS (Statistical Product and Service Solutions) spreadsheet.

Descriptive statistics were used to summarize the demographic and clinical characteristics of the patients. Frequency and proportion were used for categorical variables, median and inter quartile range for non-normally distributed continuous variables, and mean and standard deviation for normally distributed continuous variables. Independent samples t-test, Mann-Whitney U test, and Fisher's exact test/chi-square test were used to determine the difference in mean, rank, and frequency, respectively, between patients with and without obstructive ventilatory defects. Pearson's correlation was used to determine the correlation between BMI and spirometric parameters. Univariable and multivariable logistic regression analyses were employed to determine the association between BMI categories (specifically obese and non-obese) and obstructive ventilatory defects. Missing values were neither replaced nor estimated. Null hypotheses were rejected at 0.05 α-level of significance. STATA 13.1 was used for data analysis.

Operational definition of terms

Body mass index (BMI) refers to an individual's weight in kilograms divided by their height in meters squared. It is a measure of body size categorized into four groups, according to the conventional WHO classification: underweight (less than 18.5 kg/m^2), normal weight (18.5 to 24.9 kg/m^2), overweight (25 to 29.9 kg/m^2), and obese (30 kg/m^2 and above).[7]

Obstructive ventilatory defect refers to a disproportionate decrease in maximal airflow from the lungs (forced expiratory volume in 1 second; FEV_1) relative to the maximal volume that can be displaced from the lungs (forced vital capacity; FVC), and is characterized by an FEV_1/FVC of less than 70%.[22]

Restrictive ventilatory defect is characterized by a normal FEV_1/FVC (more than 0.70) and a reduction in total lung capacity (TLC) below the fifth percentile, or 80% of the predicted value.[22]

Mixed ventilatory defect is characterized by obstructive and restrictive defects, diagnosed when both FEV_1/FVC and TLC are below the fifth percentile of their predicted values; or when FEV_1/FVC is less than 0.70 and TLC is less than 80% of the predicted value.[22]

Forced expiratory volume 1 (FEV_1) refers to the volume of air that can be forced out in one second after full inspiration. FEV_1 is used to categorize the severity of any spirometric abnormality.

Forced vital capacity (FVC) refers to the total amount of air exhaled during the FEV test. The normal value is 80% and above.[23]

FEV/FVC ratio, also called the Tiffeneau-Pinelli index, is a spirometric parameter that represents the proportion of a patient's vital capacity that is expired in the first second of forced expiration. The normal value is 0.70 and above.[24]

$FEF_{25–75\%}$ refers to the average forced expiratory flow rate at 25% to 75% of the vital capacity and is expressed as a percentage of the predicted value (% predicted $FEF_{25-75\%}$). The normal value is 65% and above.[25]

Computation of sample size

The study examined all spirometries done from January 2019 to December 2023. A minimum of 190 patients were needed based on 95% confidence interval, 80% power, a 29% prevalence of obstructive ventilatory defects among non-obese individuals, and a reported odds ratio of 2.4 for the association between obstructive ventilatory defects and obesity.[4] This was computed using OpenEpi calculator.

Ethical considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and the International Conference on Harmonization—Good Clinical Practice and upon the approval of the Technical and Institutional Ethics Review Board (IERB) of the Perpetual Help Medical Center—Las Piñas (UPHS-IERB 2023-020 RP). A waiver of informed consent was approved by the ethical review board and was given to the hospital where the study was conducted. The waiver assured the hospital that strict confidentiality was maintained, that the study employed pure records review, and that the patients will be anonymous. Patient identities were replaced by codes on data collection forms and data encoding sheets. There were no anticipated ethical issues on the conduct of this study. The study carried minimal risk, bringing no harm and discomfort to its subjects, as it was purely a chart review.

RESULTS

Table 1 shows the characteristics of the study population, classifying patients into those with and without obstructive ventilatory defect. A total of 459 patients were included in the study. Of these, 70 (15.3%) had normal spirometry values, 79 (17.2%) had restrictive ventilatory defects, 306 (66.7%) had obstructive ventilatory defects, and 4 (0.9%) had mixed ventilatory defects. The mean age was highest among those with obstructive ventilatory defect (59.5 ± 16.6; $p < 0.001$). The proportion of obstructive ventilatory defect was significantly higher among males than females (76.0% vs 53.2%; $p = 0.001$). Mean height (161.4 ± 10.5 cm), mean weight (67.8 ± 16.1 kg), and mean BMI (26.0 ± 3.7 kg/m^2) did not vary significantly between the groups. Majority of patients were either overweight (39.6%) or with normal BMI (37.2%). The prevalence of abnormal spirometry did not vary across BMI classifications ($p = 0.068$).

Table 2 shows significant correlations between BMI and post-bronchodilator FEV_1 % predicted, ($r = 0.09$; $p = 0.044$), post-bronchodilator FEV_1/FVC ($r = 0.11$, $p=0.015$), and post-bronchodilator $FEF_{25-75\%}$ ($r= 0.09$; $p = 0.047$). These observed correlations, however, were weak ($r <0.1$).

As seen in Table 3, obesity was not significantly associated with obstructive ventilatory defect in the univariable analysis (odds

Table 1. Characteristics of the study participants

	With obstructive ventilatory defect	Without obstructive ventilatory defect			Overall	p-value
		Normal	Restrictive	Mixed		
Total number of participants, n	306 (66.7)	70 (15.3)	79 (17.2)	4 (0.9)	459	
Age, years	59.5 ± 16.6	43.9 ± 16.9	42.7 ± 14.2	48.2 ± 15.1	54.1 ± 16.6	<0.001
Sex						
Male	206 (76.0)	28 (10.3)	36 (13.3)	1 (0.4)	271 (59.0)	0.001
Female	100 (53.2)	42 (22.3)	43 (22.9)	3 (1.6)	188 (41.0)	
Height, cm	162.1 ± 10.5	159.3 ± 10.3	160.5 ± 10.8	159 ± 10.2	161.4 ± 10.5	0.069
Weight, kg	67.3 ± 16.6	67.1 ± 12.7	68.2 ± 17.2	109.1 ± 21.2	67.8 ± 16.1	0.712
Smoking history						
Non-smoker	110 (50.5)	52 (23.8)	53 (24.3)	3 (1.4)	218 (47.5)	<0.001
Smoker	61 (78.2)	8 (10.3)	9 (11.5)	0 (0.0)	78 (17.0)	
Previous smoker	135 (82.8)	10 (6.1)	17 (10.4)	1 (0.6)	163 (35.5)	
BMI, kg/m^2	25.6 ± 5.9	26.3 ± 3.9	26.4 ± 4.9	43.2 ± 2.5	26.0 ± 3.7	0.642
BMI classification						
Underweight	19 (65.5)	2 (6.9)	8 (27.6)	0 (0.0)	29 (6.4)	0.068
Normal	121 (71.2)	19 (11.2)	30 (17.6)	0 (0.0)	170 (37.2)	
Overweight	115 (64.5)	39 (21.5)	27 (14.9)	0 (0.0)	181 (39.6)	
Obese	50 (64.9)	10 (13.0)	13 (16.9)	4 (5.2)	77 (16.8)	

Data presented as mean (SD) and frequency (percentages); across-column percentages were computed
BMI: body mass index

Table 2. Correlation of different spirometric parameters with BMI

	Mean ± SD	Pearson's correlation	p-value
Pre-bronchodilator tests			
FVC, L	3.0 ± 4.1	0.03	0.492
% predicted	77.3 ± 17.4	0.03	0.531
FEV_1, L	2.1 ± 3.0	0.02	0.672
% predicted	71.9 ± 20.9	0.01	0.715
FEV_1/FVC, %	69.3 ± 18.5	0.04	0.361
% predicted	70.6 ± 15.5	0.08	0.110
$FEF_{25–75\%}$, L/s	1.6 ± 1.6	0.08	0.083
% predicted	52.6 ± 32.1	0.04	0.390
Post-bronchodilator tests			
FVC, L	2.8 ± 0.8	0.003	0.946
% predicted	79.7 ± 16.6	0.05	0.288
FEV_1, L	2.2 ± 4.0	0.04	0.358
% predicted	77.2 ± 9.9	0.09	0.044
FEV_1/FVC, %	71.8 ± 15.2	0.11	0.015
% predicted	73.3 ± 16.0	0.08	0.241
$FEF_{25–75\%}$, L/s	1.8 ± 1.2	0.09	0.047
% predicted	61.6 ± 35.5	0.08	0.051

BMI: body mass index; FVC: forced vital capacity; FEV_1: forced expiratory volume in the 1st second; FEV_1/FVC: ratio of FEV_1 to FVC; $FEF_{25-75\%}$: forced expiratory flow rate at 25% to 75% of the vital capacity

Table 3. Association of obesity with obstructive ventilatory defect, before and after adjusting for sex, age, and smoking status

	OR (unadjusted)	p-value	OR (adjusted)	p-value
Non-obese	1.2 (0.6 to 2.5)	0.534	1.1 (0.5 to 2.0)	0.601
Obese	0.8 (0.4 to 1.7)		0.9 (0.5 to 1.8)	

OR: odds ratio

Table 4. Association of obesity with post-bronchodilator FEV_1 before and after adjusting for sex, age, and smoking status

	OR (unadjusted)	p-value	OR (adjusted)	p-value
Non-obese	1.0 (0.5 to 1.8)	0.989	1.0 (0.6 to 2.0)	0.940
Obese	1.0 (0.6 to 1.7)		0.9 (0.5 to 1.7)	

OR: odds ratio

ratio [OR] 0.8, 95% confidence interval [CI] 0.4 to 1.7; p = 0.534) and multivariable analysis (OR 0.9, 95% CI 0.5 to 1.8; p = 0.601). Table 4 shows that obesity was not significantly associated with post-bronchodilator FEV1 in the univariable analysis (OR 1.0, 95%CI 0.6 to 1.7; p = 0.989) and multivariable analysis (OR 0.9, 95% CI 0.5 to 1.7; p = 0.940).

DISCUSSION

The relationship between obstructive ventilatory defects and obesity remains a topic of debate. Various studies have shown both positive and negative relationships between increased BMI and FEV_1/FVC.[26-29] Weight gain and increased BMI are associated with decreased lung volumes, as reflected by a more restrictive ventilatory pattern on spirometry.[30] However, obesity is also being recognized as being linked to obstructive lung diseases such as asthma.[31]

The result of this study revealed that obesity did not significantly affect the odds of having an obstructive ventilatory defect. This agrees with the study of Schachter et al which showed that even with reduced FEV_1 and FVC in obese subjects, they did not show any evidence of obstruction nor was there an increase in airway responsiveness.[32] This is in contrast with Liu et al which showed an increased prevalence of obesity on obstructive lung diseases.[33]

In the study of Tang et al, individuals with obstructive lung disease and moderate to very severe COPD were shown to have significantly greater FEV_1/FVC in the overweight/obese group compared to the normal BMI group.[29] According to Jing Zhu et al, elevated BMI had a protective impact on lung function in COPD GOLD grades 3 to 4.[19] The protective effect of BMI was more compelling in patients with severe COPD, as dietary status significantly influences lung function in later-stage patients.[20] Such protective impact was not seen in the current study. The protection afforded by obesity may be explained by several factors. For example, individuals with obstructive lung disease or COPD may benefit from increased respiratory muscle mass to manage elevated airway resistance and airflow blockage.[34] Obese COPD patients are also shown to benefit from an increased fat-free mass, a proxy for skeletal muscle mass, accounting for the protective effect.[35] Additionally, the expiratory reserve capacity and end-expiratory lung volume are less in obese COPD patients.[36] There is also a decrease in hyperinflation as a result of weight-related restrictions that counterbalance obstructive lung defects.[37] Ultimately, the processes underpinning the "obesity paradox" need to be further investigated and clarified.

By increasing the position of the diaphragm in the thoracic cavity as a person gains weight, obesity impairs lung function and increases the effort required to breathe. It also prevents the thoracic cage from moving freely because of direct resistance and/or abnormal functioning of the intercostal muscles brought on by fat accumulation in the chest wall. Therefore, obesity is typically associated with lung volume abnormalities, and not airway obstruction.[38] The findings of Wang et al support this wherein FVC was found to be decreased in obese people, but not the FEV_1, FEV_1/FVC, peak expiratory flow, and $FEF_{25–75}$.[38] Similarly, Al Ghobain et al did not find a significant correlation between BMI and post-bronchodilator FEV_1, FEV_1/FVC, and $FEF_{25\text{-}75\%}$[17] However, in the present study, a weak correlation was seen.

The difference in the results of this study with previous studies may be attributed to the difference in the population used. Based on research, body fat distribution and BMI vary among populations. Asians have a greater body fat percentage and a lower average BMI than Americans and Europeans.[39] The different cut-off scores used to classify obesity (e.g., WHO 30 kg/m^2, Asian 25 kg/m^2, and Chinese 28 kg/m^2) may have also affected the finding[40]

In terms of the association between BMI and spirometric parameters, the study did not find a significant correlation with most parameters. For those parameters with significant correlation, these were found to be weak. The results are in contrast with the study of Salahuddin et al which showed a decreasing trend of bronchodilator response with increasing BMI.[41]

The study has a number of limitations. As a cross-sectional study, it cannot establish causation. Despite an adequate sample size, the estimated accuracy may be limited by the comparatively lower sample sizes in a number of subgroups. Because of the observational, records-based design of the study, the outcomes could have been biased by unmeasured or unknown confounders. There may not be enough standardization of the procedure performed in terms of the technician's role in performing the pulmonary function test in which the attitude of a well-motivated and enthusiastic technician is vital for its successful performance.[42] The study also did not account for the type of test performed (e.g., simple or complete spirometry, with or without DLCO [diffusing capacity for carbon monoxide]) and severity of obstruction. Further, this study did not mention the comorbid conditions of the subjects, and adjustment for the presence of asthma and COPD was not done. It is recommended that prospective studies with equal sample sizes of subgroups be done in the future, with inclusion of other demographic data such as comorbid conditions (e.g., asthma, COPD) which may affect the actual relationship between BMI and airway obstruction. Likewise, as fat accumulation greatly affects lung functions, future studies may also take into account other body measurements such as chest circumference, abdomen circumference, and hip circumference, or their ratios.

CONCLUSION

This study observed that BMI is not correlated with spirometric parameters, and obesity is not associated with obstructive ventilatory defect or post-bronchodilator FEV_1. Although some correlations are observed with BMI and post-bronchodilator spirometric parameters, the observed correlations are weak. Further studies are needed to determine the effect of other measures of body mass on obstructive ventilatory defect.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Authors' Disclosure

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