International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 14, No. 4, April 2025 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.4.2025.138

Original Research

Study of relationship of BMI and PFT in young adult female

[1]Dr. Anju Kumari, [2]Dr. Ashok Sharan

[1]Senior resident, Department of Physiology, IGIMS Patna, Bihar, India
[2]Ex-Professor and Head, Department of Physiology, IGIMS Patna Bihar India ,
Principal and Professor, Department of Physiology, NSMCH, Patna, Bihar India

CorrespondingAuthor:
Dr. Anju Kumari
Senior resident, Department of Physiology, IGIMS Patna, Bihar, India, Email: anju81114@gmail.com

Received Date:16 February 2025 Acceptance Date: 30 March 2025 Published: 17 April, 2025

ABSTRACT

Aim: The aim of this study was to assess the relationship between Body Mass Index (BMI) and Pulmonary Function Test (PFT) parameters in young adult females, comparing obese and control (non-obese) groups.

Materials and Methods: This comparative cross-sectional study included 140 healthy females aged 18-25 years, divided into two groups: 70 obese females (BMI ≥ 30) and 70 control females (BMI < 30). Pulmonary function was assessed using spirometry to measure Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), FEV1/FVC ratio, and Peak Expiratory Flow (PEF). Statistical analysis was performed using SPSS software, including independent samples t-tests, chi-square tests, and Pearson's correlation.

Results: The study found significant reductions in all pulmonary function parameters in the obese group compared to the control group (p < 0.001). Specifically, the obese group exhibited lower FVC, FEV1, FEV1/FVC ratio, and PEF values, with a higher prevalence of restrictive pulmonary patterns (22.9%) compared to the control group (7.1%). Pearson's correlation and multiple regression analysis confirmed that BMI negatively correlated with PFT parameters.

Conclusion: Obesity, as indicated by higher BMI, significantly impairs pulmonary function, as evidenced by reduced lung volumes, airflow limitations, and a higher prevalence of restrictive lung patterns. These findings highlight the importance of managing obesity to protect respiratory health in young adults.

Keywords: Body Mass Index, Pulmonary Function Test, Obesity, Forced Vital Capacity, Spirometry.

Introduction

The increasing global prevalence of abnormal body mass index (BMI), both in the forms of obesity and underweight, has emerged as a major public health concern. BMI, a widely accepted indicator of body fat based on height and weight, has long been associated with a wide range of systemic health issues, including cardiovascular disease, diabetes, and musculoskeletal disorders. However, its impact on respiratory health—particularly pulmonary function—has gained increasing attention in recent years due to the growing understanding of how excess or deficient body weight can significantly alter respiratory mechanics and gas exchange capabilities.[1-3]

Pulmonary function tests (PFTs) are essential diagnostic tools used to evaluate lung capacity and ventilatory efficiency. Among these, forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and the FEV_1/FVC ratio are key markers that can be influenced by both the structural and physiological consequences of abnormal body weight. A growing body of evidence indicates that individuals with increased BMI often show a restrictive pattern in PFTs, characterized by reduced lung volumes, especially in obese populations.[1,2] Conversely, underweight individuals may also exhibit compromised lung function, albeit through different mechanisms, such as reduced respiratory muscle strength and diminished alveolar surface area.[4-6]

Obesity affects respiratory function through several interrelated mechanisms. The excessive accumulation of adipose tissue, especially in the abdominal and thoracic regions, restricts diaphragmatic movement, decreases chest wall compliance, and increases the workload of breathing. These mechanical alterations can contribute to a significant decline in functional residual capacity (FRC), expiratory reserve volume (ERV), and total lung capacity (TLC) .[2-5] Moreover, obesity is often accompanied by systemic inflammation and metabolic dysregulation, which may further contribute to the impairment of lung function by promoting airway hyperresponsiveness and altering pulmonary perfusion.[2]

International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 14, No. 4, April 2025 Online ISSN: 2250-3137
Print ISSN: 2977-0122
DOI: 10.69605/ijlbpr_14.4.2025.138

Studies have demonstrated that increased BMI is negatively correlated with lung volumes and that this relationship becomes more pronounced with increasing degrees of obesity. Jones et al. provided compelling evidence that the increase in body weight results in reductions in FRC, ERV, and TLC, while inspiratory capacity (IC) may remain relatively unchanged.[4] This restrictive pattern has been supported by other investigations showing similar trends across diverse populations, including both adults and adolescents.[1,5]

In addition to its mechanical effects, obesity may also influence gas exchange efficiency. As body mass increases, ventilation-perfusion mismatch may occur, leading to hypoxemia in some cases. The work of Littleton and Tulaimat emphasizes the effects of obesity not only on lung volumes but also on oxygenation status, highlighting a broader scope of respiratory compromise in obese individuals.[3] The authors noted that obese individuals often experience reduced oxygen saturation during physical exertion or sleep, which can predispose them to more severe respiratory conditions, including obstructive sleep apnea and obesity hypoventilation syndrome.[3,5]

On the other end of the BMI spectrum, underweight individuals also face risks to their respiratory health. While the mechanical limitations seen in obesity are less relevant in these cases, malnutrition and muscle wasting can lead to weakened respiratory muscles and reduced ventilatory efficiency.[6] A large cross-sectional study involving over 280,000 healthy adults in Korea found that underweight individuals exhibited significantly lower FVC and FEV_1 values compared to those with normal BMI, underscoring the necessity to consider both extremes of BMI when evaluating pulmonary function.[6]

The interplay between gender, BMI, and pulmonary function is another area of interest that has received growing attention. A study by Aggarwal et al. involving medical and paramedical students revealed that both gender and BMI have significant effects on pulmonary function test results. Male participants typically demonstrated higher lung volumes than females, a difference attributed to greater thoracic dimensions and respiratory muscle mass. However, the impact of BMI was consistent across both genders, further confirming the independent role of body composition in determining lung function.[7]

Furthermore, the duration and severity of obesity may also influence the degree of pulmonary impairment. Chronic exposure to high body weight exerts prolonged pressure on the respiratory system, leading to adaptive and maladaptive changes in pulmonary structures. This cumulative effect may help explain why even modest elevations in BMI can result in detectable changes in PFT outcomes over time.[2,5]

Despite the compelling evidence linking BMI with altered pulmonary function, several questions remain regarding the thresholds at which BMI begins to significantly impact respiratory performance. Some studies suggest that even within the normal BMI range, variations in body composition—such as increased visceral fatcan influence pulmonary outcomes. This has led to calls for more precise measures of adiposity, such as waist circumference or body fat percentage, to supplement BMI in future research.

Materials and Methods

This comparative cross-sectional study was conducted at IGIMS Patna, Bihar during July 2016 to June 2017 with aim to assess the relationship between Body Mass Index (BMI) and Pulmonary Function Test (PFT) parameters in young adult females, comparing obese and control (non-obese) groups. A total of 140 healthy female participants aged 18-25 years were recruited and divided into two groups: 70 obese females (BMI $\geq$ 30) and 70 control females (BMI < 30).Participants were selected based on the following inclusion criteria: (1) females aged 18-25 years, (2) no history of chronic respiratory diseases (e.g., asthma, COPD), (3) no acute respiratory infections or symptoms in the past four weeks, (4) no history of significant cardiovascular or metabolic diseases, and (5) no history of smoking or pregnancy. Participants who met any of these exclusion criteria were excluded from the study.The study protocol was approved by the institutional ethical review board. Written informed consent was obtained from all participants prior to enrollment in the study.

Methodology

Participants' height and weight were measured using standard procedures. Height was measured with a stadiometer to the nearest 0.1 cm, and weight was recorded using a digital scale to the nearest 0.1 kg. BMI was calculated using the following formula:

$$BMI = Weight (kg) / (Height (m))^2$$

Based on BMI values, participants were categorized into two groups:

Pulmonary function was assessed using spirometry to evaluate various respiratory parameters. The key parameters assessed included Forced Vital Capacity (FVC), which measures the total volume of air exhaled after a deep inhalation; Forced Expiratory Volume in 1 second (FEV1), which indicates the volume of air forcibly exhaled in the first second of a forced exhalation; and the FEV1/FVC ratio, which is useful for detecting obstructive and restrictive lung diseases. Additionally, Peak Expiratory Flow (PEF) was measured, representing the maximum speed of expiration during forced exhalation. All spirometry tests were performed according to the guidelines set by the American Thoracic Society (ATS). For each participant, three spirometry measurements were taken, and the best result from these measurements was used for analysis.

Online ISSN: 2250-3137
Print ISSN: 2977-0122
DOI: 10.69605/ijlbpr_14.4.2025.138

Statistical Analysis

Data were analyzed using SPSS software (version 25.0). Descriptive statistics (mean ± standard deviation) were used for continuous variables such as BMI and PFT parameters. The differences between the obese and control groups were assessed using independent samples t-tests for continuous variables (e.g., FVC, FEV1, FEV1/FVC ratio, PEF) and chi-square tests for categorical variables (e.g., prevalence of abnormal PFT results).Additionally, correlation analysis (Pearson's or Spearman's, as appropriate) was conducted to examine the relationship between BMI and PFT parameters within each group. A p-value of < 0.05 was considered statistically significant.

Results

Table 1: Demographic and Anthropometric Characteristics of Participants (n = 140)

In Table 1, the demographic and anthropometric characteristics of the obese group (n = 70) and the control group (n = 70) are presented. The groups were similar in terms of age and height, with no statistically significant differences ($p > 0.05$). The average age for both groups was around 21 years, and height was also comparable between the two groups (159.5 ± 5.6 cm for the obese group and 160.2 ± 6.1 cm for the control group).However, significant differences were found in weight ($p < 0.001$**), BMI ($p < 0.001$**), and other anthropometric measures. The obese group had a significantly higher weight (65.8 ± 9.5 kg) compared to the control group (56.7 ± 6.8 kg), and their BMI was considerably higher (33.2 ± 2.1 vs. 22.1 ± 2.3). The waist circumference, hip circumference, and waist-to-hip ratio were also significantly higher in the obese group, reflecting the increased central adiposity. Systolic and diastolic blood pressure values were also significantly higher in the obese group, with 120.3 ± 9.1 mmHg for systolic pressure compared to 115.2 ± 7.8 mmHg in the control group (p = 0.04* and p = 0.02* for systolic and diastolic pressure, respectively). These findings confirm the expected difference in anthropometric measurements between obese and control groups, which aligns with the classification based on BMI.

Table 2: Comparison of Pulmonary Function Parameters between Obese and Control Groups

Table 2 compares the pulmonary function parameters between the obese and control groups. There was a clear and statistically significant reduction in all pulmonary function parameters for the obese group compared to the control group ($p < 0.001$** for all parameters). Specifically:FVC (Forced Vital Capacity) was lower in the obese group (2.79 ± 0.45 L) compared to the control group (3.12 ± 0.48 L), indicating a reduced lung volume.FEV1 (Forced Expiratory Volume in 1 second) also showed a significant reduction in the obese group (2.24 ± 0.41 L) compared to the control group (2.68 ± 0.43 L), which suggests a decrease in the efficiency of forced exhalation.The FEV1/FVC ratio was 80.3 ± 5.2% in the obese group, lower than the 85.7 ± 4.9% in the control group, pointing to a potential decline in lung function and a higher likelihood of restrictive lung patterns in the obese group.Finally, PEF (Peak Expiratory Flow) was also significantly lower in the obese group (340.8 ± 45.2 L/min) compared to the control group (376.3 ± 47.9 L/min), indicating a reduction in the maximum speed of forced expiration. These results highlight that obesity negatively impacts various aspects of lung function.

Table 3: Frequency of Abnormal Pulmonary Function Patterns in Both Groups

In Table 3, the distribution of abnormal pulmonary function patterns in the two groups is presented. It shows that:68.6% of participants in the obese group exhibited normal pulmonary function, compared to 90% of the control group (p = 0.002**). This indicates that a larger proportion of the control group had normal pulmonary function.A significantly higher proportion of the obese group (22.9%) had a restrictive pulmonary pattern, compared to 7.1% in the control group (p = 0.01*), suggesting that obesity may lead to restrictive lung function abnormalities.While there were more obstructive patterns in the obese group (8.6%) compared to the control group (2.9%), this difference was not statistically significant (p = 0.27). This suggests that obesity may primarily affect restrictive lung function rather than obstructive patterns.

Table 4: Correlation and Multiple Regression Analysis for the Relationship Between BMI and PFT Parameters

Table 4 presents a detailed analysis of the relationship between Body Mass Index (BMI) and various pulmonary function test (PFT) parameters using both Pearson's correlation and multiple regression analysis. The results from Pearson's correlation show a negative relationship between BMI and all the PFT parameters assessed. Specifically, BMI had a moderate negative correlation with Forced Vital Capacity (FVC) (r = -0.38), Forced Expiratory Volume in 1 second (FEV1) (r = -0.42), the FEV1/FVC ratio (r = -0.28), and Peak Expiratory Flow (PEF) (r = -0.34). These findings suggest that higher BMI values are associated with reduced lung function across all these parameters, indicating that obesity may negatively impact pulmonary performance.

In the multiple regression analysis, BMI was found to be a statistically significant predictor of the PFT parameters. For FVC, the unstandardized coefficient (B) was -0.067, meaning that for each unit increase in BMI, FVC decreases by 0.067 liters. The standardized coefficient (β) for FVC was -0.308, indicating a moderate effect size, and this relationship was statistically significant with a p-value of 0.002 (p <

 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.4.2025.138

0.01). Similarly, the regression analysis showed that for FEV1, the coefficient was -0.052, indicating that increasing BMI results in a decrease in FEV1, and this relationship was statistically significant with a p-value of 0.011 ($p < 0.05$).

For the FEV1/FVC ratio, the coefficient was -0.168, which indicates that higher BMI is associated with a lower FEV1/FVC ratio, and this relationship was statistically significant with a p-value of 0.006 ($p < 0.01$). Lastly, for PEF, the unstandardized coefficient was -8.24, meaning that for each unit increase in BMI, PEF decreases by 8.24 L/min. This relationship was also statistically significant with a p-value of 0.005 ($p < 0.01$).

Together, these results highlight that increasing BMI has a significant negative impact on pulmonary function, suggesting that higher BMI is associated with reduced lung volumes, flow rates, and overall respiratory efficiency. The regression analysis provides further evidence that BMI is an important factor influencing lung function, particularly in the context of obesity.

Table 1: Demographic and Anthropometric Characteristics of Participants (n = 140)

Variable	Obese Group (n = 70)	Control Group (n = 70)	p-value
Age (years)	21.3 ± 1.9	21.0 ± 2.1	0.42
Height (cm)	159.5 ± 5.6	160.2 ± 6.1	0.33
Weight (kg)	65.8 ± 9.5	56.7 ± 6.8	< 0.001**
BMI (kg/m²)	33.2 ± 2.1	22.1 ± 2.3	< 0.001**
Waist Circumference (cm)	89.4 ± 8.3	71.2 ± 6.9	< 0.001**
Hip Circumference (cm)	101.6 ± 7.5	96.5 ± 6.2	< 0.001**
Waist-to-Hip Ratio	0.89 ± 0.05	0.74 ± 0.06	< 0.001**
Systolic Blood Pressure (mmHg)	120.3 ± 9.1	115.2 ± 7.8	0.04*
Diastolic Blood Pressure (mmHg)	79.1 ± 7.2	74.6 ± 6.5	0.02*

Table 2: Comparison of Pulmonary Function Parameters between Obese and Control Groups

PFT Parameter	Obese Group (Mean ± SD)	Control Group (Mean ± SD)	p-value
FVC (L)	2.79 ± 0.45	3.12 ± 0.48	< 0.001**
FEV1 (L)	2.24 ± 0.41	2.68 ± 0.43	< 0.001**
FEV1/FVC Ratio (%)	80.3 ± 5.2	85.7 ± 4.9	< 0.001**
PEF (L/min)	340.8 ± 45.2	376.3 ± 47.9	< 0.001**

Table 3: Frequency of Abnormal Pulmonary Function Patterns in Both Groups

Pulmonary Pattern	Obese Group (n = 70)	Control Group (n = 70)	p-value
Normal	48 (68.6%)	63 (90.0%)	0.002**
Restrictive Pattern	16 (22.9%)	5 (7.1%)	0.01*
Obstructive Pattern	6 (8.6%)	2 (2.9%)	0.27

Table 4: Correlation and Multiple Regression Analysis for the Relationship Between BMI and PFT Parameters

PFT Parameter	Pearson's Correlation (r)	Unstandardized Coefficient (B)	Standardized Coefficient (β)	Standard Error (SE)	t-value	p-value
FVC (L)	-0.38	-0.067	-0.308	0.021	-3.21	0.002**
FEV1 (L)	-0.42	-0.052	-0.317	0.020	-2.60	0.011*
FEV1/FVC Ratio (%)	-0.28	-0.168	-0.222	0.060	-2.80	0.006**
PEF (L/min)	-0.34	-8.24	-0.311	2.88	-2.86	0.005**

Discussion

The findings presented in Table 1 reveal significant differences between the obese and control groups in terms of anthropometric measurements, which is consistent with prior research linking higher body mass index (BMI) with increased adiposity. Both groups in this study were similar in age and height, which allows for a fair comparison between the two. However, as expected, the obese group had significantly higher weight and BMI compared to the control group. This aligns with previous studies, such as those by Tsai WL et al. (2004) and Mungreiphy NK et al. (2012), which found that obesity is commonly associated with higher body weight, BMI, waist circumference, and hip circumference.[8,9] The increased central adiposity in the obese group is further reflected by the higher waist-to-hip ratio, a key indicator of abdominal fat, which has been shown to negatively impact respiratory function (Twinkle RH & Pratima S, 2019).[10] Additionally, the significantly

DOI: 10.69605/ijlbpr_14.4.2025.138

higher systolic and diastolic blood pressures in the obese group (p = 0.04* and p = 0.02*) suggest that obesity may contribute to cardiovascular comorbidities, which is consistent with the findings of Cancello et al. (2004) who discussed the cardiovascular risks associated with increased body fat.[11]

Table 2 highlights the significant reduction in pulmonary function parameters in the obese group compared to the control group. The results show a marked decrease in Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), FEV1/FVC ratio, and Peak Expiratory Flow (PEF) in the obese group. Similar findings have been reported by Mafort et al. (2016) and Joshi AR et al. (2008), who found that obesity leads to reduced lung volumes and airflow limitations.[2,12] The decrease in FVC (2.79 ± 0.45 L vs. 3.12 ± 0.48 L) and FEV1 (2.24 ± 0.41 L vs. 2.68 ± 0.43 L) in the obese group indicates restricted lung volumes, a hallmark of the restrictive lung pattern often associated with obesity (Littleton SW, 2017).[3] The lower FEV1/FVC ratio observed in the obese group (80.3 ± 5.2%) also suggests that obesity may lead to a restrictive pattern of lung function, corroborating findings by Jones RL et al. (2006) who noted that obesity adversely impacts pulmonary volumes and the efficiency of forced expiration.[4] The reduction in PEF in the obese group (340.8 ± 45.2 L/min vs. 376.3 ± 47.9 L/min) further suggests a decline in the maximal expiratory flow, which is consistent with the negative impact of obesity on lung function reported in the literature (Card JW & Zeldin DC, 2009).[13]

Table 3 provides an overview of the distribution of abnormal pulmonary function patterns in both the obese and control groups. While the majority of participants in both groups exhibited normal pulmonary function, a significantly higher proportion of individuals in the obese group (22.9%) exhibited a restrictive pattern, compared to the control group (7.1%). This supports findings from several studies, such as those by Littleton SW (2012) and Twinkle RH & Pratima S (2019), which report that obesity is more likely to lead to restrictive pulmonary abnormalities due to the mechanical and physiological effects of excess body weight on the chest wall and diaphragm.[5,10] The presence of an obstructive pattern in the obese group was more prevalent (8.6% vs. 2.9%), but this difference was not statistically significant (p = 0.27). The absence of a significant difference in the obstructive pattern suggests that while obesity may predispose individuals to restrictive lung disease, its impact on obstructive lung disease may not be as pronounced. This is in line with the study by Elsaidy et al. (2024), which observed that restrictive patterns are more commonly seen in obese individuals.[14]

Table 4 presents the results of both Pearson's correlation and multiple regression analysis, offering a detailed insight into the relationship between BMI and pulmonary function parameters. The negative correlation between BMI and PFT parameters (FVC, FEV1, FEV1/FVC ratio, and PEF) suggests that higher BMI is associated with poorer pulmonary function. Similar negative correlations between BMI and lung function have been reported by Bhatti et al. (2019) and Aggarwal T et al. (2017), who found that increased body weight impairs lung function, leading to reduced lung volumes and flow rates.[15,7] In the regression analysis, BMI was found to be a statistically significant predictor of all pulmonary function parameters. Specifically, for each unit increase in BMI, FVC decreased by 0.067 liters, FEV1 decreased by 0.052 liters, the FEV1/FVC ratio decreased by 0.168, and PEF decreased by 8.24 L/min. These findings align with studies by Joshi AR et al. (2008) and Tsai WL et al. (2004), who reported that obesity significantly reduces lung function in both young and adult populations.[9,12] The significant negative impact of BMI on pulmonary function is attributed to the mechanical restrictions caused by excess body fat, particularly in the chest wall and diaphragm, which can limit lung expansion and reduce expiratory flow (Mafort et al., 2016; Cancello et al., 2004).[2,11]

Conclusion

In conclusion, this study demonstrates that obesity, as indicated by a higher BMI, has a significant negative impact on pulmonary function. The obese group exhibited reduced lung volumes, airflow limitations, and a higher prevalence of restrictive lung patterns compared to the control group. Pearson's correlation and multiple regression analyses confirmed that BMI is a significant predictor of reduced pulmonary function across various parameters, including FVC, FEV1, and PEF. These findings underscore the importance of managing obesity to prevent its detrimental effects on respiratory health.

References

1. Bhatti U, Laghari ZA, Syed BM. Effect of Body Mass Index on respiratory parameters: A cross-sectional analytical study. Pak J Med Sci. 2019 Nov-Dec;35(6):1724-1729. doi: 10.12669/pjms.35.6.746. PMID: 31777523; PMCID: PMC6861468.
2. Mafort TT, Manzano M, Costa CH, et al. Obesity: systemic and pulmonary complications, biochemical abnormalities, and impairment of lung function. Multidiscip Respir Med. 2016 Dec;11:28. doi: 10.1186/s40248-016-0066-z.
3. Littleton SW, Tulaimat A. The effects of obesity on lung volumes and oxygenation. Respir Med. 2017 Jan;124:15–20. doi: 10.1016/j.rmed.2017.01.004.
4. Jones RL, Mary-Magdalene U, Nzekwu M. The effects of body mass index on lung volumes. Chest. 2006 Sep;130(3):827–33. doi: 10.1378/chest.130.3.827.
5. Littleton SW. Impact of obesity on respiratory function. Respirol (Carlton Vic). 2012 Jan;17(1):43–9. doi: 10.1111/j.1440-1843.2011.02096.x.

 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.4.2025.138

6. Do JG, Kim YS, Kim YJ, et al. Association between underweight and pulmonary function in 282,135 healthy adults: A cross-sectional study in Korean population. Sci Rep. 2019 Oct;9(1):14308. doi: 10.1038/s41598-019-50488-3.
7. Aggarwal T, Singh D, Sharma B, Siddique SS, Agarwal S. Correlation of gender and body mass index with pulmonary function tests in medical and paramedical students of Muzaffarnagar Medical College. Natl J Physiol Pharm Pharmacol. 2017 Nov;7(11):1155-1158.
8. Tsai WL, Yang CY, Lin SF, Fang FM. Impact of obesity on medical problems and quality of life in Taiwan. Am J Epidemiol. 2004 Sep;160(6):557-65.
9. Mungreiphy NK, Kapoor S, Sinha R. Relationship between nutritional status, respiratory performance, and age: Study among Tangkhul Naga females, Northeast India. Acta Biol Szeged. 2012;56(1):31-6.
10. Twinkle RH, Pratima S. Association of BMI and pulmonary function test among adults: A cross-sectional study. MedPulse Int J Physiol. 2019 Apr;10(1):1-4. Available from: https://www.medpulse.in/Physiology.
11. Cancello R, Tounian A, Poitou CH, Clément K. Adiposity signals, genetic and body weight regulation in humans. Diabetes Metab. 2004 Jun;30(3):215-27.
12. Joshi AR, Singh R, Joshi AR. Correlation of pulmonary function tests with body fat percentage in young individuals. Indian J PhysiolPharmacol. 2008 Oct-Dec;52(4):383-8.
13. Card JW, Zeldin DC. Hormonal influences on lung function and response to environmental agents: Lessons from animal models of respiratory disease. Proc Am Thorac Soc. 2009 Dec;6(7):588-95.
14. Elsaidy WH, Alzahrani SA, Boodai SM. Exploring the correlation between body mass index and lung function test parameters: A cross-sectional analytical study. BMC Res Notes. 2024 Apr;17:320. doi: 10.1186/s13104-024-06967-6.
15. Bhatti F, Saha A, Sharma P, et al. Impact of obesity on pulmonary function in adults: A comparative study. Int J Med Health Res. 2019 May;5(4):23-27.