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Correlation of body mass index and waist circumference with pulmonary function test parameters in adults: a cross-sectional observational study.

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Abstract

Background:

Excess adiposity, particularly central obesity, alters respiratory mechanics and can adversely influence spirometric performance. Although body mass index [BMI] is widely used to characterize obesity, waist circumference more directly reflects abdominal fat distribution.

Objectives:

To evaluate the association of BMI and waist circumference with pulmonary function test [PFT] parameters in adults and to compare the relative strength of these anthropometric indices with spirometric measurements.

Methods:

This cross-sectional observational study was conducted in the Department of Physiology, Jaipur National University Institute for Medical Sciences and Research Centre, Jaipur, Rajasthan, India, from August 2025 to April 2026. One hundred adults were enrolled. BMI and waist circumference were recorded using standard methods. Spirometry was performed under standardized conditions, and forced vital capacity [FVC], forced expiratory volume in one second [FEV1], FEV1/FVC ratio, peak expiratory flow rate [PEFR], and forced expiratory flow at 25%-75% [FEF25-75] were analyzed.

Results:

The mean age of participants was 38.9 ± 11.6 years. The mean BMI was 26.3 ± 4.8 kg/m², and the mean waist circumference was 91.6 ± 10.9 cm. Pulmonary function declined progressively with increasing BMI. Participants with elevated waist circumference also showed lower FVC, FEV1, PEFR, and FEF25-75 values. BMI demonstrated significant negative correlations with FVC, FEV1, PEFR, and FEF25-75, while waist circumference showed slightly stronger inverse correlations. The FEV1/FVC ratio was not significantly associated with either anthropometric measure.

Conclusion:

Both generalized obesity and central obesity were associated with lower pulmonary function values in adults. Waist circumference appeared to be a stronger correlate of spirometric impairment than BMI.

Recommendations:

Routine assessment of BMI and waist circumference during adult health evaluation can assist in early identification of individuals at risk of reduced pulmonary function and can support timely lifestyle intervention.

Keywords: *body mass index; waist circumference; pulmonary function test; spirometry; obesity; adults.*
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Introduction

Obesity has emerged as one of the most important public health concerns worldwide and is increasingly recognized as a determinant of respiratory morbidity in adults [1-3]. Excess body fat affects the respiratory system through several interrelated mechanisms, including reduced chest wall compliance, increased abdominal pressure on the diaphragm, altered respiratory muscle efficiency, and low-grade systemic inflammation [4,5]. These effects can lead to measurable impairment in lung volumes and expiratory airflow even in individuals without established respiratory disease. In routine practice, pulmonary function testing offers a practical and objective method for identifying such early physiological changes.

Body mass index [BMI] remains the most commonly used anthropometric index for classifying overweight and obesity in clinical and epidemiological settings. It is simple, inexpensive, and reproducible; however, it does not distinguish lean mass from fat mass and does not identify the pattern of fat distribution. In contrast, waist circumference serves as a surrogate marker of abdominal or central adiposity, which has stronger mechanical and metabolic consequences for lung function because truncal fat can directly restrict diaphragmatic descent and thoracic expansion [5-7]. This distinction is important because two adults with the same BMI can have different levels of visceral fat and, therefore, different respiratory risk profiles. Several studies have shown an inverse relationship between obesity indices and spirometric variables such as forced vital capacity [FVC] and forced expiratory volume in one second [FEV1] [8-10]. Waist circumference has often emerged as a better predictor of impaired pulmonary function than BMI, especially in apparently healthy adults [6,7,9,10,12,13]. Population-based evidence from the EPIC-Norfolk study, Canadian adult cohorts, and large rural Asian samples has strengthened the view that central adiposity exerts a substantial adverse effect on respiratory performance [10-12]. Recent data from NHANES have also highlighted a clinically relevant association between waist circumference and spirometric indices in middle-aged and older adults. Nevertheless, the magnitude and pattern of these associations vary across age groups, ethnic populations, and study settings.

In India, the burden of obesity and abdominal obesity is increasing steadily, and Asian Indians are known to exhibit higher cardiometabolic and central adiposity risk at relatively lower anthropometric thresholds [1]. Despite this, locally generated physiological data evaluating the combined role of BMI and waist circumference in relation to pulmonary function remain limited. Such evidence is relevant for early risk stratification, preventive counselling, and integration of anthropometric screening with basic respiratory assessment in adults. Against this background, the present study was undertaken to evaluate the relationship of BMI and waist circumference with pulmonary function test parameters in adults. The objectives were to compare spirometric indices across BMI categories, assess differences in pulmonary function according to waist circumference status, and determine the strength of correlation of BMI and waist circumference with major pulmonary function test parameters.

Methodology

Study design and setting

This cross-sectional observational study was carried out in the Department of Physiology, Jaipur National University Institute for Medical Sciences and Research Centre, Jaipur, Rajasthan 302017, India, during the period from August 2025 to April 2026. The study was planned to examine the relationship between anthropometric indices of obesity and pulmonary function in adults using standardized physiological measurements under controlled laboratory conditions.

Study participants and eligibility criteria

Adults aged 18 years or older, of either sex, who were clinically stable, willing to participate, and able to perform technically acceptable spirometry were eligible. Individuals with an acute respiratory illness, previously diagnosed chronic pulmonary disease, active cardiopulmonary decompensation, thoracic deformity, pregnancy, or inability to understand or cooperate with the spirometric manoeuvres were excluded. Eligibility was established through a structured clinical history, brief physical assessment, and review of available medical information before enrollment.

Participant selection and recruitment

Potential participants available during the study period were screened against the predefined eligibility criteria. A non-probability consecutive enrollment approach was used, and eligible adults were recruited until the planned sample of 100 participants was achieved. Each enrolled participant underwent anthropometric assessment followed by standardized pulmonary function testing.

Sample size

The sample size was estimated for correlation analysis using Fisher's z transformation. Assuming a minimum clinically

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relevant correlation coefficient of 0.28 between an anthropometric index and a pulmonary function parameter, a two-sided alpha level of 0.05, and 80% statistical power, the minimum required sample was 98 participants. The value was rounded to 100 to provide an adequate analyzable sample.

Bias and its minimization

Selection bias was reduced by applying the same eligibility criteria to all potential participants and enrolling eligible individuals in sequence until the target sample was reached. Measurement bias was limited by using calibrated equipment, standardized anthropometric landmarks, daily spirometer quality checks, uniform participant instructions, and at least three technically acceptable spirometric manoeuvres. The best acceptable reading was used according to the prespecified protocol. Recall bias was limited because the primary exposure and outcome variables were measured directly rather than obtained from memory. Exclusion of participants with known major respiratory or unstable cardiopulmonary conditions reduced clinical confounding; however, residual confounding from unmeasured lifestyle and occupational factors remained possible. Blinding was not feasible because the anthropometric measurements were visible to the investigators.

Anthropometric assessment

Body weight was measured in light clothing without footwear using a calibrated weighing scale, and height was recorded using a stadiometer. BMI was calculated as weight in kilograms divided by the square of height in meters [kg/m²]. For analysis, participants were categorized as normal weight [18.5-24.9 kg/m²], overweight [25.0-29.9 kg/m²], and obese [≥30.0 kg/m²]. Waist circumference was measured with a non-stretchable measuring tape at the midpoint between the lower margin of the last palpable rib and the iliac crest at the end of normal expiration. Increased waist circumference was identified using sex-specific cutoffs recommended for Asian Indians [1].

Pulmonary function testing

Spirometry was performed according to accepted ATS/ERS technical standards using a calibrated computerized spirometer [2]. Participants were instructed regarding the procedure and were tested in the sitting position with a nose clip after adequate rest. At least three technically acceptable maneuvers were obtained, and the best reading was used for analysis. The pulmonary function parameters recorded were forced vital capacity [FVC], forced expiratory volume in one second [FEV1], FEV1/FVC ratio, peak expiratory flow rate [PEFR], and forced expiratory flow at 25%-75% of pulmonary volume [FEF25-75]. Equipment calibration and procedural quality checks were carried out daily before testing.

Statistical analysis

Data were entered into Microsoft Excel and analyzed using standard statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were summarized as frequency and percentage. Comparison of pulmonary function parameters across BMI categories was performed using one-way analysis of variance. Comparison between participants with normal and increased waist circumference was carried out using the independent samples t-test. Pearson correlation analysis was used to assess the relationship of BMI and waist circumference with spirometric variables. A p-value of less than 0.05 was considered statistically significant.

Ethical considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of Jaipur National University Institute for Medical Sciences and Research Centre before commencement of the study. Confidentiality of all participant information was maintained throughout the study, and data were used strictly for academic and research purposes.

Informed consent

Before enrollment, each participant received an explanation of the study purpose, procedures, expected time commitment, potential discomfort during spirometry, confidentiality safeguards, and the voluntary nature of participation. Written informed consent was obtained in a language understood by the participant. Participants were informed that they could decline participation or withdraw at any stage without affecting their clinical care or institutional services. Personal identifiers were not included in the analytical dataset.

Results

Participant recruitment and flow

During the study period, 100 adults were assessed against the predefined eligibility criteria. All 100 were confirmed eligible, provided written informed consent, completed anthropometric assessment and acceptable spirometry, and were included in the final analysis. No participant was excluded after screening, and no record was omitted from the analysis (Figure 1).

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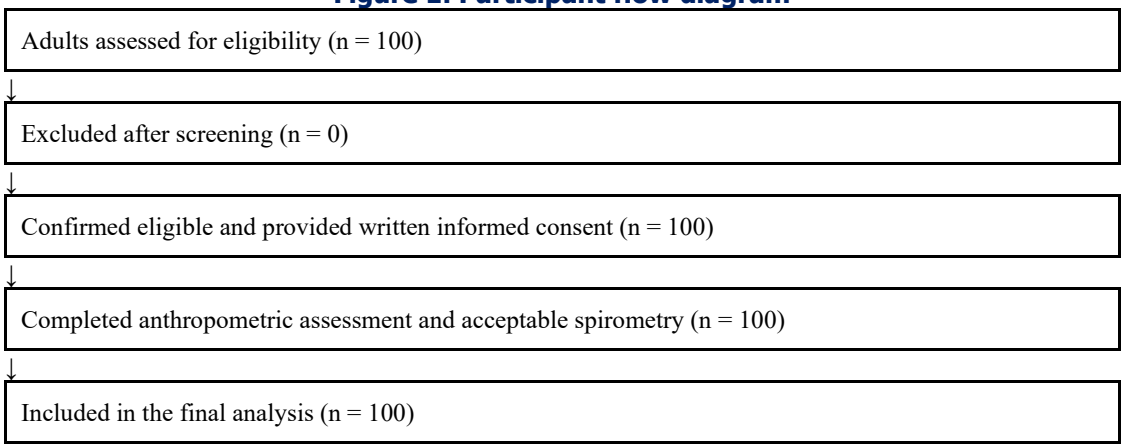
Figure 1. Participant flow diagram



The mean age of the participants was 38.9 ± 11.6 years. Among them, 54 were males, and 46 were females. The mean body mass index [BMI] was 26.3 ± 4.8 kg/m², while the mean waist circumference was 91.6 ± 10.9 cm. Based on BMI classification, 36% of participants had normal BMI, 38% were overweight, and 26% were obese. Increased waist circumference suggestive of central obesity was observed in 58% of the study population [Table 1].

Table 1. Baseline characteristics of the study participants [N = 100]

Variable	Category	n [%] / Mean ± SD
Age [years]	Mean ± SD	38.9 ± 11.6
Sex	Male	54 [54%]
	Female	46 [46%]
BMI [kg/m²]	Mean ± SD	26.3 ± 4.8
BMI category	Normal [18.5-24.9]	36 [36%]
	Overweight [25.0-29.9]	38 [38%]
	Obese [≥30.0]	26 [26%]
Waist circumference [cm]	Mean ± SD	91.6 ± 10.9
Waist circumference category	Normal	42 [42%]
	Increased	58 [58%]

Pulmonary function parameters showed a declining trend with increasing BMI. Participants in the normal BMI group had higher mean forced vital capacity [FVC], forced expiratory volume in one second [FEV1], peak expiratory flow rate [PEFR], and forced expiratory flow at 25%-75% [FEF25-75] compared to overweight and obese participants. The reduction was most marked in the obese group. However, the FEV1/FVC ratio did not differ substantially across BMI categories, indicating that the predominant effect was on lung volumes rather than a marked obstructive pattern [Table 2].

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Table 2. Comparison of pulmonary function test parameters across BMI categories

PFT parameter	Normal BMI [n = 36] Mean ± SD	Overweight [n = 38] Mean ± SD	Obese [n = 26] Mean ± SD	p value
FVC [L]	3.64 ± 0.56	3.28 ± 0.51	2.94 ± 0.47	<0.001
FEV1 [L]	3.05 ± 0.48	2.76 ± 0.44	2.43 ± 0.39	<0.001
FEV1/FVC [%]	83.8 ± 4.9	84.1 ± 5.2	82.7 ± 5.6	0.412
PEFR [L/sec]	6.91 ± 1.12	6.31 ± 1.01	5.68 ± 0.94	0.001
FEF25-75 [L/sec]	3.29 ± 0.71	3.01 ± 0.63	2.71 ± 0.58	0.006

A similar pattern was noted with waist circumference. Participants with elevated waist circumference had lower mean FVC, FEV1, PEFR, and FEF25-75 values than those with normal waist circumference. This suggests that central adiposity had an adverse association with pulmonary function [Table 3].

Table 3. Comparison of pulmonary function test parameters according to waist circumference

PFT parameter	Normal waist circumference [n = 42] Mean ± SD	Increased waist circumference [n = 58] Mean ± SD	p value
FVC [L]	3.58 ± 0.55	3.04 ± 0.49	<0.001
FEV1 [L]	2.98 ± 0.46	2.55 ± 0.41	<0.001
FEV1/FVC [%]	83.4 ± 5.1	82.9 ± 5.4	0.538
PEFR [L/sec]	6.79 ± 1.08	5.92 ± 0.97	<0.001
FEF25-75 [L/sec]	3.21 ± 0.68	2.82 ± 0.60	0.003

Correlation analysis demonstrated a statistically significant negative correlation of BMI with FVC [$r = -0.42$, $p < 0.001$], FEV1 [$r = -0.39$, $p < 0.001$], PEFR [$r = -0.34$, $p = 0.001$], and FEF25-75 [$r = -0.28$, $p = 0.005$]. Waist circumference also showed significant negative correlations with FVC [$r = -0.47$, $p < 0.001$], FEV1 [$r = -0.43$, $p < 0.001$], PEFR [$r = -0.37$, $p < 0.001$], and FEF25-75 [$r = -0.31$, $p = 0.002$]. The correlation of BMI and waist circumference with FEV1/FVC ratio was weak and not statistically significant [Table 4].

Overall, both general obesity and central obesity were associated with lower pulmonary function values, with waist circumference showing a slightly stronger inverse relationship than BMI.

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Table 4. Correlation of BMI and waist circumference with pulmonary function test parameters

PFT parameter	BMI r value	p value	Waist circumference r value	p value
FVC [L]	-0.42	<0.001	-0.47	<0.001
FEV1 [L]	-0.39	<0.001	-0.43	<0.001
FEV1/FVC [%]	-0.11	0.264	-0.15	0.132
PEFR [L/sec]	-0.34	0.001	-0.37	<0.001
FEF25-75 [L/sec]	-0.28	0.005	-0.31	0.002

Discussion

The present study demonstrated a clear inverse relationship of both BMI and waist circumference with major spirometric indices in adults. FVC, FEV1, PEFR, and FEF25-75 progressively decreased across increasing BMI categories, while individuals with elevated waist circumference also showed significantly lower pulmonary function values. In contrast, the FEV1/FVC ratio remained relatively preserved, suggesting that the predominant physiological effect in this cohort was a reduction in lung volumes rather than a strong obstructive ventilatory defect. This pattern is consistent with the restrictive mechanical burden imposed by excess adiposity on the thoracoabdominal compartment [5].

Our findings are in agreement with the work of Chen et al., who reported that waist circumference was negatively and consistently associated with pulmonary function across normal-weight, overweight, and obese subjects [6]. Similar observations were made in the EPIC-Norfolk study by Canoy et al., where abdominal obesity showed an adverse association with respiratory function in both men and women [7]. In young Indian adults, Saxena et al. also documented deterioration in pulmonary function with increasing abdominal obesity, underscoring the physiological relevance of central fat accumulation in Indian populations [8]. These convergent findings support the view that central adiposity is not merely a metabolic marker but a mechanical determinant of reduced ventilatory efficiency.

The slightly stronger inverse correlations observed for waist circumference than for BMI in the present study are also biologically plausible. Waist circumference reflects abdominal and truncal fat more directly, and such fat distribution can impede diaphragmatic excursion, reduce chest wall compliance, and lower functional lung expansion [9]. Pekkarinen et al. showed that abdominal obesity and body composition were important correlates of pulmonary function even among normal-weight and overweight adults [9]. Rowe et al. further concluded that waist circumference was a more informative anthropometric measure than BMI for examining lung function in Canadian adults [10]. More recent evidence from a large Chinese adult population and a recent systematic review likewise indicates that central obesity is strongly linked to poorer lung function [11,12].

The present results also align with longitudinal evidence. Peralta et al. showed that higher BMI and weight gain over time were associated with less favorable adult lung function trajectories, suggesting that the observed cross-sectional relationship has relevance beyond a single time point [13]. Xu et al., using NHANES data, also emphasized an association between waist circumference and lung function in middle-aged and older adults [14]. Taken together, these findings suggest that anthropometric excess contributes to measurable physiological compromise across diverse settings and that abdominal obesity deserves specific attention when evaluating respiratory health.

From a clinical perspective, the present study highlights the utility of integrating simple anthropometric assessment with spirometry in adult health screening. BMI remains valuable as an overall measure of obesity, but waist circumference appears to provide additional discriminatory value for respiratory risk. Early recognition of reduced pulmonary function in overweight and centrally obese adults can support timely counselling regarding weight control,

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physical activity, and risk reduction for future cardiopulmonary disease.

Generalizability

The present findings are generalizable primarily to apparently healthy adult populations undergoing anthropometric and spirometric assessment in teaching hospitals or community-based settings. The observed inverse association between adiposity and pulmonary function is likely to be relevant to urban and semi-urban Indian adults with a comparable age distribution and obesity profile. However, extrapolation to smokers, elderly individuals with frailty, patients with established chronic respiratory disease, pregnant women, and highly trained athletes should be undertaken with caution.

Conclusion

This study demonstrated that increasing body mass index and greater waist circumference were associated with lower pulmonary function test values in adults. Significant inverse correlations were observed for FVC, FEV1, PEFR, and FEF25-75, whereas the FEV1/FVC ratio remained largely unchanged, indicating a predominantly restrictive influence of excess adiposity on respiratory mechanics. Waist circumference showed a slightly stronger negative association with spirometric parameters than BMI, emphasizing the importance of central obesity in determining respiratory compromise. These findings support the inclusion of both general and central obesity assessment in routine physiological evaluation. Early identification of obesity-related pulmonary impairment can strengthen preventive strategies and encourage timely lifestyle modification in adult populations.

Limitations

The study was conducted at a single center with a sample size of 100 adults, which restricts broader external applicability. The cross-sectional design does not establish temporal direction or causality. Sex-specific stratified analysis, smoking exposure quantification, body composition imaging, and assessment of physical activity or occupational factors were not incorporated. These unmeasured variables can influence pulmonary function, and residual confounding remains possible.

Recommendations

Routine measurement of BMI and waist circumference should be incorporated into adult physiological assessment, especially in individuals with a sedentary lifestyle or increasing adiposity. Spirometric screening can be considered in overweight and centrally obese adults to identify early respiratory compromise before symptomatic disease develops. Health education programs should emphasize weight reduction, abdominal fat control, regular aerobic exercise, and breathing-friendly lifestyle practices. Future studies should include larger multicenter samples, sex-stratified analysis, longitudinal follow-up, and detailed body composition measures to clarify causal pathways and refine predictive models linking obesity indices with pulmonary function decline in Indian adults.

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Abbreviations

BMI - Body mass index
FEF25-75 - Forced expiratory flow at 25%-75%
FEV1 - Forced expiratory volume in one second
FVC - Forced vital capacity
PEFR - Peak expiratory flow rate
PFT - Pulmonary function test
WC - Waist circumference

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Conflict of interest

The authors declare that they have no conflict of interest related to this work.

Author contributions

Anshul Singhai contributed to conceptualization, study design, methodology, data interpretation, manuscript drafting, supervision, and approval of the final manuscript. Ayesha Munawar contributed to methodology, participant assessment, data acquisition, literature review, data interpretation, critical revision of the manuscript, and approval of the final version. Both authors agree to be accountable for the accuracy and integrity of the work.

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Data availability

The de-identified dataset generated and analyzed during the current study is available from the corresponding author on reasonable request, subject to approval under applicable institutional and ethical requirements.

Author biographies

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