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A Cross-Sectional Study of Pulmonary Impairment Pattern in Adults With Central Obesity

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ABSTRACT

Background: Obesity impacts the respiratory system through various mechanisms, with numerous studies investigating the relationship between BMI and respiratory function. However, only a limited number of studies have utilized waist circumference as an indicator of adiposity. Furthermore, the findings regarding whether obesity leads to restrictive or obstructive alterations in lung function remain uncertain. **Objectives:** To determine the predominant pattern of pulmonary impairment associated with central obesity. **Methods:** A comparative cross-sectional study enrolled ninety non-smoking adults aged 20-40 years. The study group consisted of forty-five individuals with waist circumference ≥ 90cm in males and ≥ 80cm in females, while the control group comprised forty-five gender and age matched subjects with waist circumference < 90cm in males and < 80cm in females. Dynamic lung function parameters, including FEV_1, FVC, FEV_1/FVC ratio, PEFR, and FEF_{25-75}, were assessed using the spiro module of the MEC PFT system in both groups. Statistical analysis employed the Independent Student's t-test. **Results:** In centrally obese adults, there were significant reductions observed in FEV_1 (P = 0.04) and FVC (P = 0.01). However, there were no significant differences noted in the FEV_1/FVC ratio, PEFR, and FEF_{25-75} between the two groups. **Conclusion:** Our findings indicate a restrictive pattern of pulmonary impairment in centrally obese adults. This study aims to emphasize the impact of increasing waist circumference on pulmonary function, thereby advocating for appropriate intervention measures to reduce obesity and its associated health risks.

INTRODUCTION

Obesity stands as a global health issue that continues to rise in prevalence worldwide[1]. Currently, India is experiencing a rapid epidemiological transition from under-nutrition, which was common in the past due to poverty, to a rising tide of obesity. This transition is primarily attributed to declining levels of physical activity and the adoption of unhealthy dietary habits[2]. Obesity stems from a complex interplay of genetic predispositions, behavioral choices, environmental factors, cultural influences, and socio-economic disparities. These influences disrupts the balance between energy intake and expenditure, ultimately contributing to the development of obesity[3].

The correlation between obesity and its influence on respiratory function has been acknowledged for an extensive period[1]. The primary respiratory challenges associated with obesity encompass increased ventilation requirements, heightened respiratory effort, inefficiency of respiratory muscles, and reduced respiratory compliance[4]. Obesity impacts the respiratory system through various mechanisms, including direct mechanical alterations stemming from fat accumulation in the chest wall, abdomen, and upper airway, alongside systemic inflammation[1].

While body mass index (BMI) is commonly utilized as an obesity indicator due to its simplicity in calculation, it lacks the ability to provide insights into fat distribution across the body, which is crucial for understanding the physiological impact of obesity, particularly on respiratory function[5,6]. In contrast, waist circumference (WC) serves as a measure of adiposity that considers the accumulation of abdominal fat[7].

Despite numerous studies investigating the relationship between BMI and respiratory function, there has been limited exploration utilizing WC as an indicator of adiposity. Therefore, the aim of this study was to assess the impact of obesity, as measured by WC, on spirometric parameters among adults in South India. Spirometry, being the most commonly performed lung function test, plays a crucial role in evaluating the state of respiratory function[2,8].

Brazzalle et al. emphasized the significance of spirometry assessment in confirming obstructive alterations in the respiratory physiology of obese individuals, whereas Melo et al. concluded that the majority of obese subjects are prone for developing a restrictive pattern. Conversely, certain studies have indicated normal spirometric results in obese individuals[9]. Consequently, the findings regarding the specific alteration (restrictive or obstructive) in lung function in obesity remain a matter of dispute. Therefore, the objective of present study was to determine the predominant pattern of pulmonary impairment associated with central obesity.

Subjects & methods:

A cross-sectional observational study was undertaken following approval from the Institutional Ethical Committee. The research was conducted at the Life Style Laboratory in the Department of Physiology. Sample size determination utilized the formula: Sample Size (n) = [(Zα + Z(1-β))^2 σ^2]/d^2, where Zα represents the Alpha Error, Z(1-β) denotes the Beta Error, σ signifies the Standard Deviation, and d represents the Effect Size.

Each subject provided informed written consent after receiving a thorough explanation of the study protocol. Subsequently, all participants underwent a comprehensive history-taking and relevant clinical examination. A total of 90 non-smoking adults aged 20–40 years were selected using a simple random sampling method, adhering to predetermined eligibility criteria. Exclusion criteria encompassed individuals exhibiting gross clinical abnormalities of the vertebral column and thoracic cage, neuromuscular diseases, known cases of bronchial asthma, tuberculosis, chronic obstructive pulmonary disease, any allergic or endocrine disorders, nasolaryngeal disorders, history of occupational lung diseases, excessive daytime sleepiness, daytime fatigue, or a history of snoring

Height, weight, and waist circumference were meticulously measured during the study. A constant tension non-stretchable measuring tape was employed to determine waist circumference, with measurement taken at the midpoint between the iliac crest and the lowermost margin of the ribs at the end of a normal expiration. Individuals with waist circumference measurements equal to or exceeding 90 cm in males and 80 cm in females were included in the study group, totaling 45 subjects. Additionally, 45 gender- and age-matched participants with waist circumference measurements below 90 cm in males and 80 cm in females were selected for the control group[10].

Recording of dynamic lung function parameters: Dynamic lung function parameters were recorded for all participants in accordance with the guidelines by the American Thoracic Society/European Respiratory Society (ATS/ERS).[11] Using the Spiro Module (Pocket-Spiro 12C) of the MEC PFT System (Medical Electronic Construction, Brussels, Belgium; Model No. - B1070), FEV_1, FVC, FEV_1/FVC ratio, PEFR, and FEF_{25-75} were measured. Prior to the spirometry session, participant details such as name, date of birth, gender, ethnic group, height, and weight were entered into the instrument. Participants were then briefed on the procedure and maneuvers were demonstrated. They were instructed to utilize a nose-clip during the measurement of all respiratory parameters and to ensure a tight seal around the mouthpiece provided. The forced spirometry maneuver, involving a deep inspiration followed by a forceful maximum expiration lasting for 6 seconds, was performed to record FEV_1, FVC, FEV_1/FVC ratio, PEFR, and FEF_{25-75}. Three recordings were taken with a 5-minute interval between each, and the best recording out of the three was selected for analysis. All recordings were conducted with participants in a seated position, and measurements were taken during the morning hours to minimize potential diurnal variations.

The selection and interpretation of spirograms followed the guidelines outlined by the American Thoracic Society (ATS) and the European Respiratory Society (ERS) in 2005. The Lower Limit of Normal (LLN) served as the cutoff for adults, defined as the 5th percentile of a healthy, non-smoking population. LLN was calculated using the formula LLN = Mean – (1.645 * SD), where Mean represents the mean value and SD denotes the standard deviation[12]. Subsequently, the pattern (normal/obstructive/restrictive/mixed) was identified as shown in Figure 1.[13].

Statistical Analysis: In this study, both descriptive and inferential statistical analyses were conducted. Continuous measurements are reported as mean ± standard deviation (SD). A two-tailed Independent Student's t-test was employed to compare the two groups, with statistical significance set at a p-value of less than 0.05. LibreOffice Calc software was utilized for statistical analysis and table generation.

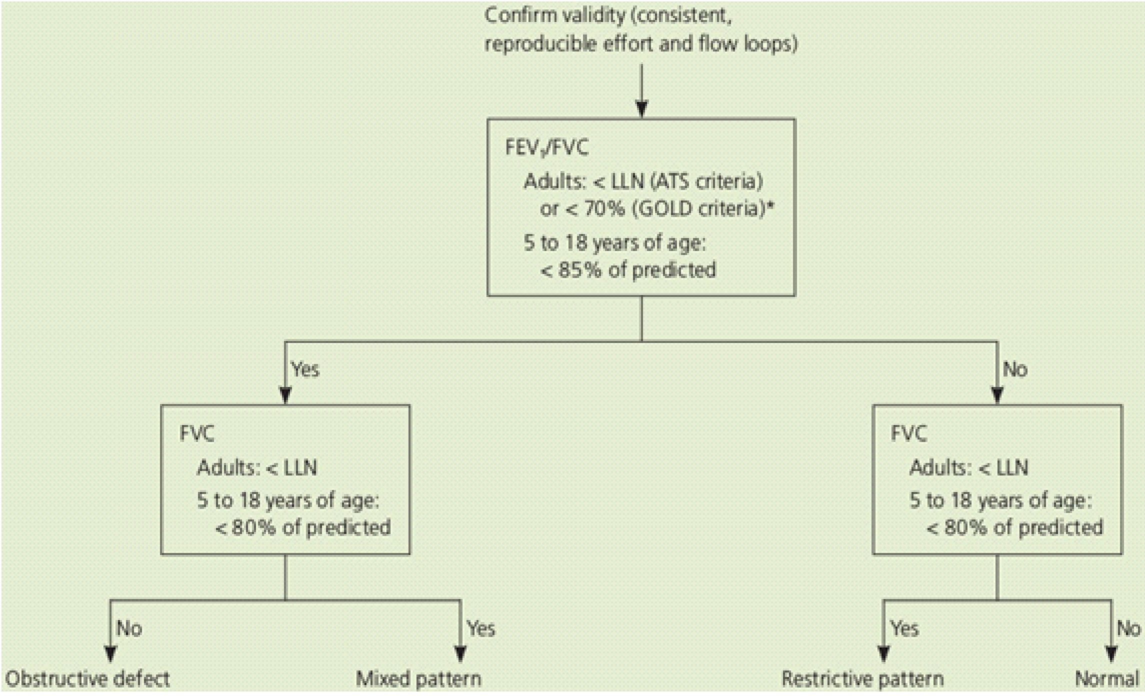

Figure 1: Interpretation of dynamic lung function parameters

The severity of the defect was graded using FEV_1 percent predicted as depicted in Figure 2.[13]

American Thoracic Society Grades for Severity of a Pulmonary Function Test Abnormality

Severity	*FEV_1 percentage of predicted*
Mild	> 70
Moderate	60 to 69
Moderately severe	50 to 59
Severe	35 to 49
Very severe	< 35

Figure 2. Grading of severity

RESULTS

Baseline characteristics of the subjects are summarized in Table 1. There were no significant differences observed in terms of age or height between the two groups, suggesting homogeneity in these variables. The study group comprised 22 males and 23 females, while the control group consisted of 23 males and 22 females. As anticipated, weight, BMI, and waist circumference were notably elevated in the study group compared tothe control group, with statistical significance, P-value < 0.0001.

Table 1: Baseline characteristics of the subjects

	Study Group	Control Group	P-Value
Age (years)	24.69 ± 3.27	24.29 ± 3.09	0.55
Weight (kg)	75.78 ± 14.34	60.5 ± 10.82	**0.0001 ***
Height (cm)	165.49 ± 9.18	165.5 ± 9.97	1
BMI (kg/m^2)	27.53 ± 3.54	21.98 ± 2.68	**0.0001***
Waist Circumference (cm)	90.87 ± 8.88	73.41 ± 8.63	**0.0001***

Table 2 presents a comparison of dynamic lung function parameters between the two groups. Significantly reduced values were observed in both FEV_1 (P = 0.04) and FVC (P = 0.01) in the study group compared to the control group. However, there were no significant differences noted in the FEV_1/FVC ratio (P = 0.24), PEFR (P = 0.23), and FEF_{25-75} (P = 0.25) between the two groups

Table 2: Comparison of dynamic lung function parameters of study group and control group

	Study Group	Control Group	P-Value
FEV_1 (L)	2.55 ± 0.63	2.79 ± 0.42	**0.04***
FVC (L)	2.85 ± 0.73	3.19 ± 0.53	**0.01***
FEV_1/FVC (%)	89.05 ± 6.2	87.54 ± 5.9	0.24
PEFR (L/s)	6.14 ± 1.86	5.7 ± 1.55	0.23
FEF_{25-75} (L/s)	3.39 ± 1.02	3.15 ± 0.87	0.25

Within the study group, 24 subjects (53.3%) exhibited a restrictive pattern, while the remaining 21 displayed a normal pattern according to the ATS-ERS 2005 recommendations. Statistical analysis using chi-square indicated a highly significant difference (P < 0.0001). None of the participants in the study group demonstrated an obstructive or mixed pattern. All subjects in the control group exhibited a normal pattern.

Among the 24 subjects in the study group who had restrictive pattern, 18 had mild (75%) and 6 had moderate (25%) restriction as graded on the basis of FEV_1 % predicted (ATS-ERS 2005 recommendations)

DISCUSSION

The current study demonstrated decline in certain dynamic lung function parameters among centrally obese individuals. Importantly, both groups were meticulously matched for gender and age, and all participants shared a common South-Indian ethnic origin. Therefore, the key distinguishing factors between the groups were weight, BMI, and waist circumference. Additionally, subjects were divided into study and control groups based on their waist circumference measurements. Thus, it is plausible to suggest that central obesity may be the contributing factor responsible for the observed reductions in lung function parameters within the study group.

Our study revealed significant reductions in FEV_1 and FVC among subjects with central obesity compared to controls. This finding aligns with the observations of Soundariya K et al. and Baruah K et al., who similarly reported significant reductions in FEV_1 and FVC among obese subjects[8,14]. However, in contrast to these studies, Ajmani S et al. reported no significant changes in FEV_1 and FVC among obese subjects[15].

Furthermore, our study indicated no significant difference in the FEV_1/FVC ratio between the two groups, consistent with the findings reported by Soundariya K et al. and Baruah K et al[8,14]. However, this result contrasts with the findings of Ajmani S et al., who reported a reduction in the FEV_1/FVC ratio among obese subjects. It is worth noting that the study conducted by Ajmani S et al. involved sedentary subjects who had been working in air-conditioned environments for a minimum of six years and they grouped subjects based on their BMI[15].

Additionally, our study revealed no significant differences between the two groups in terms of PEFR and FEF_{25-75} values. This observation aligns with the findings of Paralikar S J et al., although their study specifically focused on adolescent boys[16]. In contrast, Soundariya K et al. reported decreased PEFR in obese subjects compared to controls, diverging from our study's findings[8].

The observation of reduced FEV_1 and FVC with a preserved FEV_1/FVC ratio suggests that both FEV_1 and FVC were similarly affected by central obesity. Reduction in FVC and FEV_1 without affecting FEV_1 / FVC ratio indicates a restrictive pattern of impairment. In addition, the lack of significant differences between obese subjects and controls in terms of flow rates (PEFR and FEF_{25-75}) is also suggestive of a non-obstructive pattern of impairment.

In our study, 53.3% of obese subjects exhibited a restrictive pattern, with none displaying an obstructive or mixed pattern. This observation is consistent with the findings of Melo et al., who also reported a prevalence of restrictive respiratory pattern among obese subjects[17]. Conversely, Supriyatno B et al. observed that the most common abnormality in obese subjects is a mixed pattern, followed by restrictive and obstructive patterns. It's important to note that their study was conducted in Indonesia, with a different ethnic group, and focused on obese adolescents aged 10-12 years[18].

Obesity exerts its impact on the respiratory system through various mechanisms[1]. One potential mechanism involves the mechanical constraints imposed on chest expansion during the forced vital capacity (FVC) maneuver. The increased mass around the abdomen may hinder the descent of the diaphragm, consequently elevating thoracic pressure[19]. This interference with pulmonary mechanics can restrict breathing, leading to reduced respiratory volumes such as FEV_1 and FVC. This mechanical effect is particularly pronounced if central obesity is considered instead of overall or peripheral fat[20]. Additionally, abdominal adiposity is likely to diminish expiratory reserve volume by compressing the lungs and diaphragm, further contributing to lower FVC measurements[19].

Moreover, inflammatory changes associated with obesity can induce airway inflammation, contributing to impaired lung function[21]. Visceral adipose tissue plays a role in modulating circulating concentrations of various cytokines, including interleukin-6, tumor necrosis factor-alpha, leptin, and adiponectin. These cytokines may promote systemic inflammation, thereby exerting negative effects on pulmonary function. Studies have reported an inverse relationship between serum leptin concentrations and FEV1, alongside elevated levels of markers of systemic inflammation such as C-reactive protein, leukocytes, and fibrinogen. Thus, inflammation serves as another potential mechanism linking visceral obesity to pulmonary function[16].

However, Van de Kant et al. did not observe evidence of airway inflammation based on the fraction of exhaled nitric oxide, suggesting the need for further research to validate data regarding airway inflammation in obese patients[9]. While obesity is recognized as a risk factor for pulmonary morbidity, it's noteworthy that not all obese adults experience pulmonary impairment. Nevertheless, the factors underlying pulmonary impairment in specific obese individuals remain unclear. Further investigations are warranted to elucidate these factors.

Considering our findings pointing towards a potential link between obesity and restrictive pulmonary function, it underscores the importance of maintaining an ideal body weight to prevent such dysfunctions. Given that many respiratory function abnormalities observed in obesity stem from the mechanical burden of adipose tissue and subsequent deconditioning, it is logical to anticipate that weight reduction could lead to improvements in these physiological disturbances[22]. Doing regular exercise and adopting a balanced diet have been shown to effectively decrease weight and enhance respiratory function[2].

However, our study had few limitations. Firstly, the findings were derived from cross-sectional analyses, meaning that waist circumference and dynamic lung function parameters were measured at a single time point. As such, the cross-sectional study design does not offer insights into the temporal sequence of exposure-outcome relations. Secondly, the study involved South-Indian adults, potentially limiting the generalizability of the findings to other populations or ethnic groups. Therefore, further longitudinal studies are necessar, encompassing a larger and more diverse sample of subjects spanning various age groups and socioeconomic backgrounds from different ethnicities and regions. Additionally, longitudinal investigations should extend to children and adolescents to verify the effects in these age groups.

CONCLUSION

Our study revealed a notable decrease in FEV_1 and FVC among subjects with central obesity. However, there were no significant differences observed in the FEV_1/FVC ratio, PEFR, and FEF_{25-75} between the two groups. These findings indicate a restrictive pattern in centrally obese adults. This study is an attempt to highlight the effects of increasing WC on pulmonary function so that appropriate intervention measures can be instituted to reduce obesity and its related diseases.

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