# Correlation of Body Mass Index and Pattern of Pulmonary Function among South Indian Adult Males

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***Research Article***

***Abstract:*** **Background and Objectives:** Obesity is acclaimed to be a problem of the newer world with rapidly changing lifestyles involving consumption of highly processed and calorie rich foods added with decreased physical activity. Increase in body fat as measured by BMI has been well documented to alter the respiratory functions in a negative manner. But the effects of obesity on respiratory functions have been shown to vary depending on its severity, pattern, racial factors and so on. This study was done to document the effect of increasing body fat, measured by BMI on the pattern of pulmonary function among South Indian males, with an intention to observe if there exists any difference in the association between the two as against information available for rest of the country and world. **Materials and Methods:** This study was done on 150 native South Indian adult males in Bangalore. Following the selection, the subjects were divided into normal, overweight and obese groups, anthropometric parameters and spirometric parameters were measured using a computerized spirometer. Statistical analysis was done by applying student-t test, considering a 95% confidence limit for significance between groups. **Results:** FVC was significantly increased $p<0.05$ in the obese group compared to the normal. The FEV1 showed a significant reduction $p<0.01$ in the higher BMI group compared with normal. A linear pattern of rise in severity of abnormality in pulmonary function was observed in the order of restrictive followed by mixed and obstructive patterns with increase in BMI among the groups. **Conclusion:** This study grossly validated the negative effect of obesity on respiratory functions as suggested by earlier studies. The study also documented an increase in FVC with increasing BMI which is contrasting to the findings of other studies, suggesting a possible onset of an emphysematous change secondary to obstruction with greater degrees of obesity.

***Keywords:*** Body mass index, pulmonary function pattern, South Indian males

## Introduction

Obesity the newer chronic non – communicable disease, though is increasing in an epidemic proportion is one of today's most neglected public health problems according to the World Health Organization [1]. The prevalence of adult overweight and obesity is estimated to rapidly increase worldwide from 937 and 396 million in 2005 to 1.35 billion and 573 million in 2030 [2]. India, a country with multiple ethnicities, has a varied prevalence of overweight and obesity moving across from the north to south. Also the incidence of overweight and obesity has been found to increase with age, with the middle aged people being under higher risk compared to both their younger and older counterparts. The burden of overweight and obesity in India compared with rest of the world, is equally worse with 36.9 % and 7.8 % of subjects aged between 35 – 44 years being overweight and obese respectively [3]. This picture is expected to further worsen for the reason that in India the percentage of people in the 30 – 40 year range is rapidly increasing, to nearly 50% of the entire population. Overweight and obesity are associated with an increased burden of diabetes, hypertension, cardiovascular diseases, some types of cancers and premature mortality [4]. Overweight and obesity are also known to affect the respiratory function in various forms depending on its severity. Both static, dynamic lung volumes and capacities are compromised in obesity. Obesity is found to decrease the lung volumes and capacities by decreasing both lung and chest wall compliance [5]. There is also an increase in resistance to outflow of air through the airways in obesity [6]. The pattern of pulmonary function is found to worsen with the degree of obesity moving from a restrictive pattern in mild to moderate obesity with both $FEV_1$ and FVC reduced and $FEV_1$/FVC ratio being normal to an obstructive pattern in severe and morbid obesity with significant decrease in $FEV_1$ as against FVC and $FEV_1$/FVC ratio being decreased [7,8]. The incidence and prevalence of Type-II DM and its associated neuro-cardio-vascular complications is more in the southern region of India compared with the rest of India for reasons not still clearly understood and obesity is said to be one of the major risk factor for the same. With this background, this study was done to observe if the

alteration in respiratory function, one of the complications of obesity, has any unusual relation with changes in BMI among South Indians when compared with data from the Northern regions of India and rest of the world.

## Materials and Methods

**Source of data:** This study was conducted in the Department of Physiology, Bangalore Medical College, Bangalore between April - December 2008. Data was obtained from male attenders of patients admitted to Victoria hospital, Bangalore. **Sample selection criteria:** A total of 150 subjects - 50 in each of the three BMI categories i.e., obese, overweight and normal were selected by stratified random sampling technique after applying the inclusion and exclusion criteriae. Subjects were categorized into the three groups based on the BMI classification for the world's population [9]. Ethical clearance was obtained from the institutional ethical committee before starting the study. **Inclusion criteria:** Subjects aged 30 years and above, native South Indians, having an apparently normal general health, not practicing any form of breathing exercises or doing regular physical exercises and volunteering for the study by giving a written consent. **Exclusion criteria:** Subjects with known respiratory, cardiovascular and neuro-muscular diseases, thoracic skeletal deformities, thyroid dysfunction, diabetes mellitus, history of tobacco smoking/chewing and alcohol consumption. **Parameters recorded:** Following the selection of subjects, a general physical examination was performed and the following anthropometric measurements and pulmonary function tests were performed on them. **Anthropometric measurements:** Height (in meters) - using a stadiometer, weight (in kilograms) - using a digital weighing scale (precision of 100 grams), were measured. Body mass index (BMI) was calculated using the formula ***BMI = Wt (kilograms)/Ht $^2$ (meters)***. **Pulmonary function tests (PFTs):** Following explaining and demonstrating the procedure to the subject, a trial run of the procedure of spirometry was done for each subject. Once the procedure was satisfactorily performed, the final recording of PFT parameters was done on each subject. Three recordings were obtained and the best of them selected for analysis. Forced Expiratory Volume in the first second ($FEV_1$), Forced Vital Capacity (FVC) and $FEV_1$/FVC ratio were recorded one and half hour after a light breakfast, using a Computerized spirometer (***Kit-Micro, software - Version 7.1***). The necessary ethnic correction for the population is selected, the predicted value for each parameter is calculated by the software automatically using the inbuilt normative database for the population under consideration. The pattern of pulmonary function was evaluated by the software by comparing with predicted value for each parameter and expressed as % of the predicted value. The same was also confirmed by manually working out using the data. $FEV_1$, FVC, and $FEV_1$/FVC values ≥ 80% of predicted value was considered normal for this population [10]. **Characteristics of spirometric parameters in different patterns of pulmonary function** [11]: Normal pattern = $FEV_1$ (n), FVC (n), $FEV_1$/FVC (n), Restrictive pattern = $FEV_1$ (↓), FVC (↓), $FEV_1$/FVC (n/↑), Mixed pattern = $FEV_1$ (↓), FVC (↓), $FEV_1$/FVC (↓), Obstructive pattern = $FEV_1$ (↓), FVC (n), $FEV_1$/FVC (↓) [n = normal, ↓ = decreased, ↑ = increased]

**Statistical Analysis:** Data entry and statistical analysis were performed using MS-Excel and Epi-Info software respectively. Difference and statistical significance of mean values and standard deviations of physical characteristics and PFT parameters between the three groups was analyzed using Student-t test (un-paired). A two tailed P-value < 0.05 was considered statistically significant.

## Results

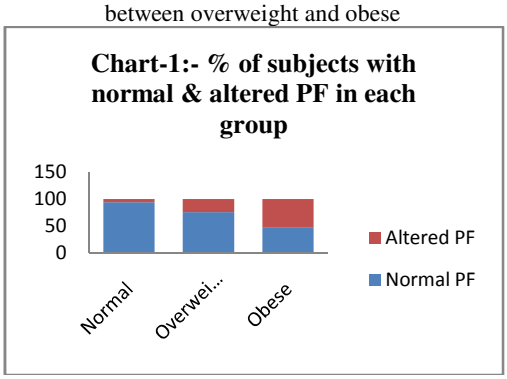
The present study included 150 male subjects (50 in each of normal, overweight and obese categories of BMI), aged 25 years and above who were apparently healthy.

**Table 1:** shows the characteristics of the three groups with regard to various parameters recorded in this study. The means of the age showed no significant difference between the three groups. The obese and overweight groups significantly differed from the normal group with their mean BMIs ($p<0.001$). Among the Pulmonary function test parameters recorded, FVC means showed a significant increase in the obese group compared with normal ($p<0.05$). Mean of $FEV_1$ showed a significant reduction in the obese group compared with the normal ($p<0.01$). The mean of $FEV_1$ as a percentage of FVC ($FEV_1$/FVC) was significantly lower in the obese group compared with the normal ($p<0.05$).

**Table 1:** Mean and SD of the anthropometric and PFT parameters in the three groups

| Parameters | Normal weight | Overweight | Obese |
|---|---|---|---|
| Age (years) | 38.00±12 | 36.00±12 | 40.06 ±13.21 |
| BMI | 21.44±2.07 | 27.6±0.87# p<0.001 | 33.16 ±3.06* p<0.001 |
| FVC (% pred) | 88.86±14.65 | 90.42±12.65 | 89.76 ±23.16* p<0.05 |
| $FEV_1$ (% pred) | 86.61±12.67 | 85.84±11.46 | 81.00± 28.97* p<0.01 |
| $FEV_1$/FVC(% pred) | 109.05±6.75 | 108.06±7.78 | 104.08 ±12.57* p<0.05 |

* Significant difference between normal and obese # Significant difference between normal and overweight ǂ Significant difference between overweight and obese



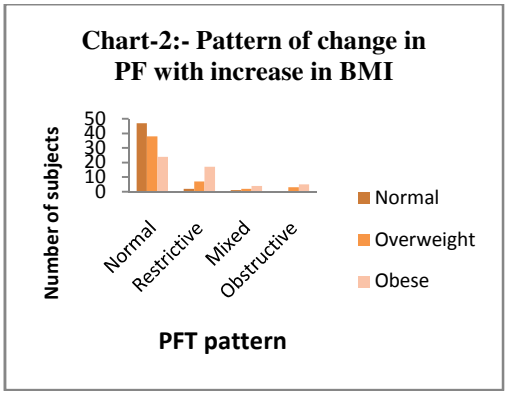




**Table 2:** shows the pattern of pulmonary function analyzed from $FEV_1$, FVC and $FEV_1$/FVC ratio recorded in all the three groups. The normal pattern of pulmonary function decreased with increasing BMI, which was significantly lower in obese group compared with the normal ($p<0.001$). Restrictive pattern of pulmonary function, was the predominant type of abnormality found among all three groups with 26 subjects (i.e., 17.33%) having this pattern in all and the obese group having a significantly higher restrictive pattern than the normal group ($p<0.01$).Mixed pattern of pulmonary function was seen as a transition between restrictive and obstructive patterns with 7 subjects (i.e., 4.66%) having this pattern in all, which was again significantly higher in the obese group compared with normal ($p<0.01$).Obstructive pattern of pulmonary function was seen only among the overweight and obese groups with 8 subjects (i.e., 8%) having this pattern out of 100, which was significant @ $p<0.001$ and $p<0.01$ in obese and overweight groups respectively compared with the normal. The obese group also had a significantly higher obstructive pattern compared with the overweight as well ($p<0.05$).

**Table 2:** Pattern of pulmonary functions among the three groups analyzed from $FEV_1$, FVC and $FEV_1$/FVC

| Pulmonary function pattern | Normal weight (n/50) | Overweight (n/50) | Obese (n/50) |
|---|---|---|---|
| Normal | 47 | 38 | 24 * p<0.001 |
| Restrictive | 2 | 7 | 17* p<0.01 |
| Mixed | 1 | 2 | 4* p<0.01 |
| Obstructive | 0 | 3# p<0.01 | 5*ǂ * p<0.001, ǂ p<0.05 |

## Discussion

The effect of alterations in body composition on body functions in a population depends on their racial, ethnic and other environmental factors. Similarly the effect of increasing body fat content on pulmonary functions also depends on the above factors [12]. In the present study, we intended to observe the pattern of change in pulmonary functions with increasing body fat as measured by BMI in South Indians males. Bangalore being a cosmopolitan city, with good number of people of all the southern states and Victoria hospital being one of busiest tertiary care hospitals in the heart of the city, was best suited for this study. Obesity or increase in BMI generally is found to affect the pulmonary functions in a negative manner [13] with decrement in all the pulmonary function parameters conventionally measured. In our study we observed that the abnormal pattern of pulmonary function increased with increase in BMI which matched with the findings of Naimark and Cherniack [5] who demonstrated that the total respiratory compliance is reduced significantly in the obese people compared to the normal. The individual parameters of lung function (FVC, $FEV_1$, and $FEV_1$/FVC), when matched with the BMI showed a similar relation. It was found that FVC was significantly higher in the obese group compared with the normal. Results of studies conducted earlier on the same, demonstrated a decrease in FVC than its increase among obese individuals [7,8]. This is explained by the restrictive effect on lung and chest wall imparted by obesity, particularly of abdominal type. The probable reason for increased FVC in obese individuals seen in our study could be an early sign of ensuing emphysematous change in morbidly obese people. In our study, $FEV_1$ was found to be significantly lower in the obese group compared with the normal. This is in line with the findings of earlier studies, demonstrating a decrement in $FEV_1$ with increasing grades of obesity [14,15]. In lower grades of obesity this is due to decreased FVC, seen in pure restrictive pattern of lung function whereas with higher grades of obesity,

the airways undergo narrowing and close at a higher than normal closing volumes due to its hyper-responsiveness and increased smooth muscle tone induced by obesity seen in mixed and obstructive patterns of lung function [13]. Obesity is also said to be a pro-inflammatory condition, induces inflammation of airways and also increases their sensitivity, acting as a risk factor for development of bronchial asthma [14]. The pattern of pulmonary functions in the three groups assessed from FEV1, FVC and its ratio indicated restrictive pattern to be the predominant type of abnormality and the earliest effect of increasing body fat. This was followed by mixed pattern, which was more in the overweight and obese groups, indicating the onset of obstructive effects of obesity and a clear obstructive pattern seen only in the overweight and obese groups. The overweight group did not show much significant difference from the normal or obese groups in most parameters studied. This could probably be attributed to the higher BMI cut-off value considered in this study. Asians are said to accumulate more fat for the same height and weight compared with rest of the world's population [16]. Hence there would be a spillover of overweight individuals into the normal group and obese individuals into the overweight group, causing this insignificance. The results of our study shows the trend in pulmonary function changing from restrictive to obstructive, with mixed pattern appearing as a transition between the two with increase in BMI. This can be probably explained by the effects of increasing body fat on pulmonary function that it reduces the lung and chest wall expansion causing decreased FVC and hence restrictive pattern. This is followed by a collapse of smaller airways with inflammation of other airways causing a partial obstruction along with restriction – the mixed type, which leads to a clear obstructive pattern with further increase in BMI due to hyper-responsive airways leading to decreased flow velocity.

## Conclusion

The study concludes that increasing BMI has a negative effect on pulmonary functions and the severity of altered state of pulmonary function increases in the order of restrictive – mixed – obstructive patterns with increase in the degree of fatness as indicated by increase in BMI in this study. South Indians have a similar effect of obesity on pulmonary functions as with rest of India and the world. The true effects of increasing BMI on pulmonary function among South Indians would have been better demonstrated if other measures of obesity were also included in the study viz waist-hip ratio, skin fold thickness with a much bigger sample size considering the BMI cut offs prescribed for Asians.

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