

## Original Research Article

# Effect of obesity on lung volumes among adults

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### ABSTRACT

**Background:** Obesity has long been recognized to have significant effect on respiratory functions. Many studies have reported exponential decrease in pulmonary function test (PFT) with increasing body mass index (BMI), which is a crude indicator of obesity. Also, the relationship between BMI and PFTs varies with age, race, geographical region and the different obesity standards used. To the best of our knowledge, not many studies have been done to examine the relationship between obesity and lung volumes among adults in our region, Jammu. This cross-sectional study was carried out with the objective of evaluating the effect of obesity on lung function test in obese but otherwise healthy adults of Jammu region.

**Methods:** This cross-sectional study was conducted in Jammu region on subjects selected randomly from different colleges in the age group of 18-40 years. The study involved 300 subjects; divided into three groups of 100 each, based on BMI into normal, overweight and obese groups. Four respiratory parameters viz. FVC (Forced Vital Capacity), FEV<sub>1</sub> (Forced Expiratory Volume in 1 second), FEV<sub>3</sub> (Forced Expiratory Volume in 3 seconds), and MVV (Maximum Voluntary Ventilation) were used to assess their lung functions.

**Results:** All the respiratory parameters exhibited statistically significant decrease in obese groups as compared to normal and overweight groups.

**Conclusions:** The present study suggests that obesity alters the respiratory physiology by producing a restrictive ventilatory pattern.

**Keywords:** Body Mass Index, Obesity, Pulmonary function tests, Restrictive ventilation

### INTRODUCTION

Obesity is currently one of the major global epidemics and is recognized as a significant and rapidly increasing cause of morbidity and mortality.<sup>1</sup> It has been established to be associated with wide range of CVS, metabolic and endocrine complications but its respiratory consequences, though known since long, are under-recognized.<sup>2</sup>

Obesity as per World Health Organization is defined as the abnormal or excessive collection of fat in the body to

the extent that health is impaired.<sup>3</sup> Obesity is categorized according to body mass index (BMI). BMI is a crude parameter to measure obesity at population level and is calculated as weight (kgms) divided by the square of height in meters (kg/m<sup>2</sup>).

Obesity can profoundly alter respiratory physiology by several mechanisms, due to direct mechanical changes caused by fat deposition on the chest wall and abdomen as well as due to systemic inflammation it produces.<sup>1</sup>

The respiratory mechanisms are altered significantly in obesity largely because of adipose tissue deposition in the mediastinum and the abdominal cavities. Fat accumulation in these areas restricts the downward movement of diaphragm and the outward movement of chest wall (events occurring during normal quiet respiration), leading to slight increase in intra-abdominal and pleural pressures.<sup>4</sup>

This mass loading effect of obesity alters the breathing pattern - reflected by a more restrictive ventilatory pattern on spirometry. There is a substantial reduction in lung volume and capacity in obese individuals as compared to healthy individuals; reduction of total lung capacity (TLC), reduction of forced vital capacity (FVC), accompanied with reduction of forced expiratory volume in one second (FEV<sub>1</sub>) are the most consistent findings in obese individuals.<sup>5</sup>

Due to the altered respiratory physiology total respiratory system compliance is reduced by as much as two-thirds of the normal value in obese individuals. The primary reason for this is decrease in chest wall compliance associated with accumulation of fat in and around the ribs but partly it is due to increased pulmonary blood volume seen in obese individuals.<sup>1,6</sup>

Reduced respiratory system compliance leads to increased work and O<sub>2</sub> cost of breathing. Obesity therefore has a clear potential to directly affect the respiratory well-being by causing stiffening of respiratory system; it increases the mechanical work needed for breathing.<sup>7</sup>

Exertional dyspnea is a common complaint among obese but the mechanism of breathlessness is not well defined. Dyspnea has been reported in 40% of obese individuals on exertion, whereas some studies report that obesity alone, without the presence of underlying lung disease can be a cause of dyspnea at rest in otherwise healthy man.<sup>8</sup>

It has been suggested that patterns of body fat distribution may influence the respiratory mechanics to some extent. Central abdominal obesity has a greater impact on pulmonary function when compared with back or lower body obesity. Changes in the chest wall compliance are more affected by the deposition of fat in both the chest and upper abdomen than by the presence of fat only in the chest.<sup>2</sup>

Weight loss is the key intervention in managing the patients with obesity related lung dysfunction. Studies suggest that weight loss can reverse many of the alterations in pulmonary function produced by obesity.<sup>9,10</sup> ERV (expiratory reserve volume), the pulmonary parameter that is most consistently altered in obesity, improves after weight loss.<sup>11,12</sup>

## METHODS

It was a cross-sectional study carried out in department of Physiology Jammu.

It was conducted over a period of 3 months w.e.f. October to December 2018.

### Inclusion criteria

- Subjects in the age group of 18-40 years of either sex
- Normal, overweight and obese subjects - categorized on the basis of their BMI by recording their weight (in kg) and height (in meters)

### Exclusion criteria

- Smokers
- Subjects suffering from any medical ailments like diabetes mellitus, heart diseases and any respiratory diseases
- Subjects displaying anxiety, apprehension or non-co-operative attitude

A total of 300 adult healthy subjects of both sexes were selected randomly from different colleges of Jammu province belonging to varying socio-economic status. The subjects were selected from the various colleges located in Jammu city, including Government Medical College, Jammu. A list of colleges was decided upon after mutual consent from principals of concerned institutions. Out of the list, 4 colleges were selected with 75 subjects from each college. Among the colleges the study subjects were divided into 3 categories (normal BMI, overweight, obese). BMI were calculated for the randomly selected subjects from each list till the desired number in each BMI group were attained. The selection process was carried strictly on the basis of eligibility criteria till the desired number of overweight and obese subjects was achieved.

Subjects underwent general physical examination and clinical examination of respiratory and cardiovascular system to rule out any co-morbidity. The subjects were given a questionnaire which they were required to fill up with certain details regarding their dietary habits, extent of physical activity, personal habits (smoking etc.), relevant past or present medical history and family history etc. Total 300 subjects were taken and they were divided into three groups:

- Group I: comprised of 100 subjects with normal BMI
- Group II: comprised of 100 overweight subjects
- Group III: comprised of 100 obese subjects.

The above classification was based on BMI (kg/m<sup>2</sup>) as given by revised guidelines for obesity and overweight for Asian Indians<sup>13</sup>:

Over-weight → BMI  $\geq$ 23.0 kg/m<sup>2</sup>  $\leq$ 24.9 kg/m<sup>2</sup>

Obese → BMI ≥25.0 kg/m<sup>2</sup>

Before taking the record, the subjects were fully assured, thoroughly familiarized with the apparatus and demonstration was given to them as how to perform the tests.

The procedure was demonstrated number of times to each subject individually up to our satisfaction. Three recordings were taken at the same time of the day in sitting position and the best of the three readings was incorporated in the study.

Lung function tests were conducted on all the eligible subjects with the help of DT spiro (Meastros Mediline Systems Limited). Only two manoeuvres i.e. FVC and MVV accumulated all the necessary data.

**Parameter studied**

*Anthropometry*

Age, height, weight and BMI (Wt in kgs/Ht in m<sup>2</sup>).

*Lung volumes*

Forced vital capacity (FVC), forced expiratory volume in one minute (FEV<sub>1</sub>), forced expiratory volume in three

minutes (FEV<sub>3</sub>) and maximum voluntary ventilation (MVV).

**Statistical analysis**

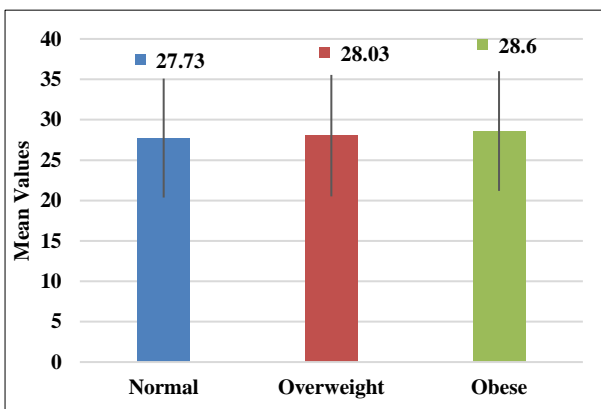
The data was entered into Microsoft excel and analysed with the help of computer software SPSS 17.0. mean and standard deviation were calculated for lung volumes as well as anthropometric variables. One-way ANOVA applied to evaluate differences in means among three groups. Bonferroni ‘t’ test was applied to assess intergroup comparison. A p-value of less than 0.05 was considered as statistically significant. Categorical variables were analyzed using the chi square test.

**RESULTS**

Three hundred subjects (each group having n=100). The mean age of Group I, Group II and Group III were 27.73±7.36, 28.03±7.52 and 28.60±7.41 respectively. Comparison of mean age among three groups showed no statistically significant difference. Gender too did not differ significantly among the three groups (Table 1). Mean age in group with normal BMI was 27.73 years whereas in overweight group it was 28.03 years and in obese group 28.6 years (Figure 1).

**Table 1: Comparison of mean of age, sex among three groups of BMI.**

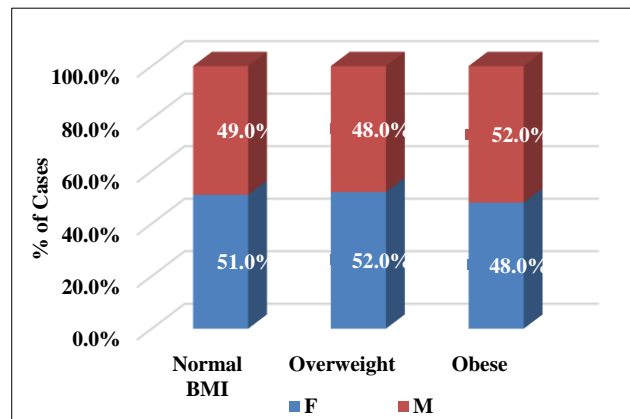
Parameters	Normal	Overweight	Obese	p value
	Mean±SD	Mean±SD	Mean±SD	
Age	27.73±7.36	28.03±7.52	28.60±7.41	0.702
Sex	51 (F)	52 (F)	48 (F)	0.841
	49 (M)	48 (M)	52 (M)	



**Figure 1: The comparison of mean age among the three groups.**

All the three groups had equal proportion of males and females: normal BMI Group: 49% males; 51% female;

overweight group: 48% males; 53% females, obese group: 52% males; 48% females (Figure 2).



**Figure 2: Comparison of sex distribution among three groups.**

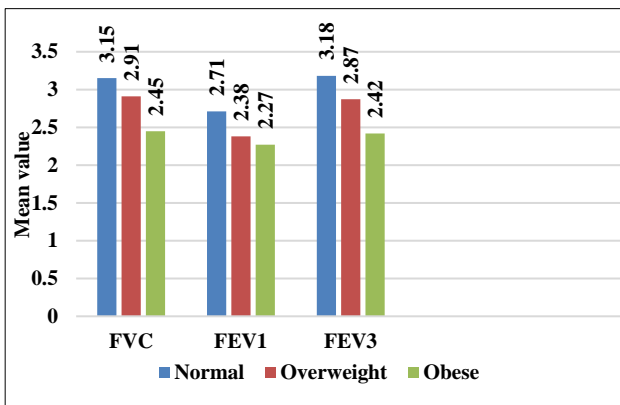
Mean values for pulmonary function parameters (FVC, FEV<sub>1</sub>, FEV<sub>3</sub> and MVV) for the different BMI groups are

summarized in Table 2.

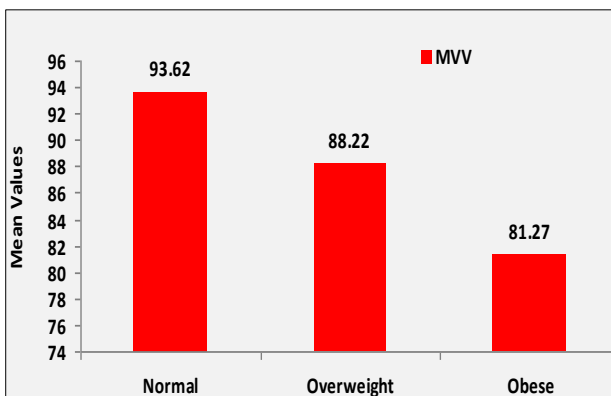
**Table 2: Comparison of respiratory system parameters among groups according to BMI.**

Respiratory system	Normal (Group I)	Overweight (Group II)	Obese (Group III)	p value	Bonferroni "t" test
	Mean±SD	Mean±SD	Mean±SD		
FVC	3.15±1.08	2.91±1.03	2.45±0.70	<0.001*	I vs II- NS I vs III- S II vs III- NS
FEV <sub>1</sub>	2.71±1.20	2.38±0.86	2.27±1.25	0.017*	I vs II- NS I vs III- S II vs III- NS
FEV <sub>3</sub>	3.18±1.11	2.87±1.01	2.42±0.71	<0.001*	I vs II- NS I vs III- S II vs III- S
MVV	93.62±25.92	88.22±28.57	81.27±24.26	0.004*	I vs II- NS I vs III- S II vs III- NS

S: Significant, NS: Non-significant. p value <0.05 taken as significant.



**Figure 3: Comparison of respiratory parameters among three groups according to BMI.**



**Figure 4: Decrease in MVV values in overweight and obese groups in comparison to normal BMI group.**

Lung volumes showed significant difference in relation to the BMI. FVC and FEV<sub>1</sub> show significant decrease

Group III verses Group I (p<0.001 and p<0.017 respectively) FEV<sub>3</sub> showed significant difference between Group I and Group III and between Group II and Group III (p<0.001).

MVV was significantly lower in Group III when compared to Group I (p<0.004).

The respiratory parameters viz. FVC, FEV<sub>1</sub>, FEV<sub>3</sub> had lower values in the overweight group and obese group when compared to the group with normal BMI (Figure 3).

**DISCUSSION**

In this study, lung function was assessed using four respiratory parameters (FVC, FEV<sub>1</sub>, FEV<sub>3</sub> and MVV). These parameters were chosen because they help in early screening of pulmonary diseases and are easy to perform as well as are reliable indices. There was statistically significant difference in the above-mentioned respiratory parameters among the three groups; with adults in the obese groups reporting lower respiratory parameters (poor lung function) as compared to normal and overweight adults. Similar results were reported by several studies.<sup>1,4-6,14</sup> Reduction in lung capacity and FVC accompanied by reduced FEV<sub>1</sub>, were the most frequent findings in these studies, suggesting the presence of a restrictive ventilatory pattern associated with obesity.

Reasons given for reduction in pulmonary function in obesity are:

- Mechanical limitation of chest expansion and restricted movement of the diaphragm due to fat accumulation within the thoracic and abdominal cavities. The diaphragm is elevated and gets pushed

into the chest by the enlarged abdomen, directly affecting lung volume. This results in the decline of pulmonary function and causes extra work of breathing.<sup>6,14</sup>

- Also, obesity causes increased release of many inflammatory markers such as interleukin-6, tumor necrosis factor-alpha, leptin and adiponectin. These may act via systemic inflammation to negatively affect pulmonary function.<sup>15</sup> Sin DD and Man SF reported an inverse association of serum leptin concentration with FEV<sub>1</sub>.<sup>16</sup> Therefore, inflammation may be the link between obesity and pulmonary function. The overall effect is decreased lung compliance in obesity.

A significant finding of this study was decrease in MVV in obese group. MVV is a simple informative parameter which depends on the movement of air into and out of the lungs during continual maximal effort throughout a preset interval. Similar decrease in MVV was observed by Ho et al, and Sahebjami et al.<sup>17,18</sup> Paralikar SJ et al gave following reasons for lower MVV among obese subjects:<sup>19</sup>

- Extrinsic mechanical compression on the lung and the thorax.
- Manifestation of peripheral airway abnormalities as suggested by reduced maximum expiratory flow rates at low lung volumes and air-trapping. Air trapping places inspiratory muscles at a mechanical disadvantage leading to lower inspiratory pressure and flow, and reduced respiratory muscle strength causing low MVV.

Wang S et al, have reported that FVC notably decreased in obese people, but not FEV<sub>1</sub>, FEV<sub>1</sub>/FVC, PEF, and FEF<sub>25-75%</sub>.<sup>20</sup> This could be because of ethnic differences (study done in northern Chinese urban community). Ethnic differences in lung function have been proved, especially for Asians.

Limitations of this study were; BMI was used as an indicator of obesity in this study. But BMI is a crude indicator as does not take into account the pattern of fat distribution. Fat distribution patterns do vary among different races, ethnicities and countries. The difference in fat distribution may cause change of lung function. In future, it is suggested that other parameters which help in differentiating obesity such as chest circumference, abdomen circumference and hip circumference or the ratio between them is used instead of BMI. Another limitation of the study was that small number of subjects was recruited. In future a large sample size and large prospective cohort study should be planned so as to enhance the generalizability of the findings.

## CONCLUSION

There is decline in pulmonary function in obese as compared to normal weight adults. Although more

research is needed to give final view regarding the effect of obesity on PFT, yet the effect of obesity on respiration cannot be ignored, especially in view of the fact that the respiratory changes produced were reversed after weight loss.

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