

## Original Research Article

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# Effect of obesity on lung function test among adults

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## ABSTRACT

**Background:** Obesity is a chronic disease characterized by excessive body fat that causes damage to the individual's health and is associated with comorbidities such as diabetes and hypertension and vascular dysfunction. 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.

**Methods:** It was a cross-sectional study carried out at tertiary care institute of Gujarat, India. It was conducted over a period of 5 months. A total of 240 adult healthy subjects of both sexes were selected randomly belonging to varying socio-economic status. The study subjects were divided into 3 categories (normal body mass index i.e. BMI, overweight, obese). BMI were calculated for the randomly selected subjects from each list till the desired number in each BMI group were attained. Four respiratory parameters viz. forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), forced expiratory volume in 3 seconds (FEV3), and maximum voluntary ventilation (MVV) were used to assess their lung functions.

**Results:** Two hundred and forty subjects (each group having n=80). The mean age of group I, group II and group III were  $27.45 \pm 6.37$ ,  $28.18 \pm 6.42$  and  $28.98 \pm 6.74$  respectively. Lung volumes showed significant difference in relation to the BMI. FVC and FEV1 show significant decrease. Group III verses group I ( $p < 0.001$  and  $p < 0.017$  respectively) FEV3 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.

**Conclusions:** There is decline in pulmonary function in obese as compared to normal weight adults. These findings suggest deleterious effects on ventilatory mechanics caused by obesity, due to probable lung compression (reduction in the expiratory reserve volume i.e. ERV), leading to a compensatory increase in the inspiratory reserve volume (IRV) in an attempt to maintain a constant vital capacity (VC).

**Keywords:** Cross-sectional, Forced expiratory volume, Lung function, Obese

## INTRODUCTION

For more than two decades, the prevalence of both obesity and asthma in the developed western populations has been increasing in parallel.<sup>1</sup> According to data from the American national health and nutrition study (NHANES), the prevalence of obesity increased by 30.5% between 1999 and 2000, and by 37.9% between 2013 and 2014.<sup>2</sup> Obesity is a chronic disease characterized by excessive

body fat that causes damage to the individual's health and is associated with comorbidities such as diabetes and hypertension and vascular dysfunction.<sup>3-8</sup> Obesity in adults is defined by the World Health Organization (WHO) as having a body mass index (BMI) that is greater than or equal to 30 kg/m. The normal BMI range is between 18.5 and 24.99 kg/m. Currently, there are estimated to be one billion overweight adults, and at least 300 million of them suffer from clinical obesity. It was recently published that,

in Brazil, 41.1% of men and 40.0% of women are overweight; 8.9% and 13.1%, respectively, are obese.<sup>9-11</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>12</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>13</sup>

Obesity can cause various deleterious effects to respiratory function, such as alterations in respiratory mechanics, decrease in respiratory muscle strength and endurance, decrease in pulmonary gas exchange, lower control of breathing, and limitations in pulmonary function tests and exercise capacity.<sup>14-18</sup> These changes in lung function are caused by extra adipose tissue in the chest wall and abdominal cavity, compressing the thoracic cage, diaphragm, and lungs. The consequences are a decrease in diaphragm displacement, a decrease in lung and chest wall compliance, and an increase in elastic recoil, resulting in a decrease in lung volumes and an overload of inspiratory muscles. These changes are worsened by an increase in the BMI.<sup>19</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>20</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. 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. ERV (expiratory reserve volume), the pulmonary parameter that is most consistently altered in obesity, improves after weight loss.<sup>21,22</sup>

## METHODS

It was a cross-sectional study carried out at tertiary care institute of Gujarat, India from January 2020 to June 2020. It was conducted over a period of 5 months.

## 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) were included.

## 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 were excluded.

A total of 240 adult healthy subjects of both sexes were selected randomly belonging to varying socio-economic status. The study subjects were divided into 3 categories (normal BMI, overweight, and 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.

Total 240 subjects were taken and they were divided into three groups. Group I comprised of 80 subjects with normal BMI, group II comprised of 80 overweight subjects and group III comprised of 80 obese subjects.

The given classification was based on BMI ( $\text{kg/m}^2$ ) as given by revised guidelines for obesity and overweight for Asian Indians: over-weight category comprised of BMI  $\geq 23.0 \text{ kg/m}^2$  and  $\leq 24.9 \text{ kg/m}^2$  and obese category comprised of BMI  $\geq 25.0 \text{ kg/m}^2$ .

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. forced vital capacity (FVC) and maximum voluntary ventilation (MVV) accumulated all the necessary data.

### Parameter studied

Anthropometry, age, height, weight and BMI (weight in kg/height in m<sup>2</sup>), lung volumes. FVC, forced expiratory volume in one minute (FEV<sub>1</sub>), forced expiratory volume in three minutes (FEV<sub>3</sub>) and MVV.

### Statistical analysis

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft excel 2007) and then exported to data editor page of statistical package for the social sciences (SPSS) version 15 (SPSS Inc., Chicago, Illinois, USA). For all tests, confidence level and level of significance were set at 95% and 5% respectively.

## RESULTS

Two hundred and forty subjects (each group having n=80). The mean age of group I, group II and group III were 27.45±6.37, 28.18±6.42 and 28.98±6.74 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 27.4 years whereas in overweight group it was 28.1 years and in obese group 28.9 years.

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

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

Variable	Normal (mean±SD)	Overweight (mean±SD)	Obese (mean±SD)	P value
<b>Age</b>	27.45±6.37	28.18±6.42	28.98±6.74	0.1
<b>Gender</b>				
Female	41	42	38	0.09
Male	39	38	42	

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

Variable	Normal (mean±SD)	Overweight (mean±SD)	Obese (mean±SD)	P value
<b>FVC</b>	3.15±1.08	2.91±1.03	2.45±0.70	0.05*
<b>FEV<sub>1</sub></b>	2.45±0.70	2.38±0.86	2.27±1.25	0.02*
<b>FEV<sub>3</sub></b>	3.18±1.11	2.87±1.01	2.42±0.71	0.01*
<b>MVV</b>	93.62±25.92	88.22±28.57	81.27±24.26	0.04*

## DISCUSSION

Among the harmful effects of obesity to health, the respiratory changes represent an additional factor of functional limitation and detriment to the quality of life of obese individuals.

Pulmonary functions decrease due to fatty thorax and the associated decrease in diaphragm motility in obese patients. The systemic and local inflammation caused by fat tissue further enhances these effects and complicates asthma control in obese respondents.<sup>23</sup>

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 over-weight adults. In a cross-sectional study carried out by Leone et al involving 121,965 patients who referred to their clinics between 1999 and 2006, a significant decrease was noted in pulmonary function as BMI values increased.<sup>24</sup> In another study, Bruno et al reported that FEV<sub>1</sub>, FVC, and FEV<sub>1</sub>/FVC values decreased as BMI increased, and people with normal BMIs recorded the highest pulmonary function values.<sup>25</sup> In line with the above findings, Steier et al found that the FEV<sub>1</sub>, FVC, and FEV<sub>1</sub>/FVC values of obese people were significantly lower than those recorded in people with normal BMI values (p<0.05).<sup>26</sup> 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>27</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>28</sup> Sin and Man reported an inverse association of serum leptin concentration with FEV1.<sup>29</sup> Therefore, inflammation may be the link between obesity and pulmonary function. The overall effect is decreased lung compliance in obesity.

The MVV test evaluates the respiratory endurance and is influenced by the respiratory muscle strength, the lung and chest compliance, and the control of breathing and airway resistance.<sup>30</sup> In the case of obese individuals, this variable is reduced mainly by mechanical injury to the respiratory muscles, caused in particular by the excessive weight on the thorax. A significant finding of this study was decrease in MVV in obese group. Similar decrease in MVV was observed by Ho et al and Sahebajami et al. Wang et al have reported that FVC notably decreased in obese people, but not FEV1, FEV1/FVC, peak expiratory flow (PEF), and forced expiratory flow (FEF) 25-75%.<sup>31,32</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

This study has some limitations. First of all, the results of the study cannot be extrapolated to the entire population, as it study was conducted at a single center. In addition, due to limited research period, the study was conducted only during the spring months and may reflect results specific to this season. 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. These findings suggest deleterious effects on ventilatory mechanics caused by obesity, due to probable lung compression (reduction in the ERV), leading to a compensatory increase in the IRV in an attempt to maintain a constant VC. Harming the ventilatory mechanics associated with ERV reduction may have contributed to the reduction in the MVV.

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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