

Effect of BMI on dynamic lung volumes in young males

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Abstract: Obesity can cause deleterious effects on respiratory function. Numerous studies have examined the association between body mass index and pulmonary function test variables¹ with variable results, and most of these tests have been conducted in males in younger age group and elderly^{2,3}. Studies considering BMI in young adults specially in eastern India are not adequate. This cross sectional study is to evaluate the effects of BMI on the pulmonary function in young male adults. Subjects were randomly selected from MBBS students aged 18-25 years who had no lung disease. They were categorized into control having BMI 18.5-22.9kg/m², overweight 23-24.9kg/m² and >25kg/m² as obese. Physical parameters such as height, weight, BMI, were recorded. Spirometry was performed in all subjects using Helios 401. Student "t test and ANOVA were used to analyze the data. The results showed obese group presented a significant lower value of forced vital capacity (FVC) (p<.002), as well as FEV₁ (p<.002) as compared to normal subjects and also the alterations evidenced in the FVC, FEV₁, ERV suggest lung function impairment due to damage to the chest mechanics caused by obesity. These factors probably contributed to a reduction of the MVV.

Keywords: Body Mass Index; Chest Mechanics; Maximal Voluntary Ventilation.

I. Introduction

Obesity is becoming a serious health issue in developed and developing countries like India. The prevalence of obesity has been increasing over several decades⁴. WHO predicts that, by 2015 around 700 million adults will be obese. It is a global health hazard and has been linked to numerous metabolic complications such as type II diabetes, respiratory and cardiovascular diseases. Because of their sedentary life style and altered food habits, young adults are falling a prey to the "escalating epidemic" of obesity. Although the physiology of obesity and its effects on lung function have been the subject of intense investigation over the last 50 years, still studies in young adults specially in India is not adequate and it is the young who represent the population. A large population of young adult suffers from epidemic of obesity in India. Globally obesity is one of the most significant contributors to morbidity and mortality among virtually all ages and socio-economic groups. and it is well recognized that severe clinical obesity is associated with impairment of lung function, such as alterations in respiratory mechanics, decrease in respiratory muscle strength and endurance, decrease in pulmonary gas exchange, lower control of breathing, limitations in pulmonary function tests and exercise capacity^{5, 6, 7}. 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, 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 muscle⁸. These changes are worsened by an increase in the BMI. Available literature had shown that obesity can result in pulmonary restriction and reduction in airways. These findings are consistent with those of some researchers who have shown lung volumes significantly lower among subjects with higher BMI⁹.

Obesity usually results in reduction in compliance of respiratory system leading to decrease in lung volumes resulting in a restrictive type of ventilatory defect. Compression of thoracic cage by excessive fat and pooling of blood in pulmonary vasculature mainly contribute towards reduction in respiratory compliance⁹. Previous studies have shown FEV₁, FVC, MVV significantly decreases in obese (p=<.0001) adolescent while FEV₁/FVC remains unaltered⁷. So this study was undertaken to determine the PFTs of male medical students of Kishanganj who represent a large population of young adult who suffer from epidemic of obesity.

II. Materials And Methods

2.1 Study Population: This cross sectional study was conducted in the Department of Physiology, MGM Medical college, Kishanganj, after getting an approval from the institutional ethics committee (IEC). 70 male students were randomly selected. Considering the objective of the study the selection was done observing the following criteria-

2.2 Inclusion criteria

Age between 18-25 years.

Physically and mentally fit
Cooperative and capable of understanding the procedure

2.3 Exclusion criteria

Not suffering from any cardiovascular or respiratory diseases
Non smokers, non-alcoholics and non-diabetics

2.4 Method:

All the subjects were informed about the test and a written consent was taken. **Weight** (kg) was recorded on a weigh machine without shoes and with light clothes. **Standing height** was recorded without shoes on a wall mounted measuring tape to the nearest of cm. **BMI** was calculated by the formula of weight (in kg) and height (in meters). $BMI = \text{weight (kg)} / \text{height in meter}^2$.

According to India reworks obesity guidelines¹¹ and Bhav S. Bavedkar et al¹⁰ considering BMI, the subjects were divided into three groups which is different from WHO cut off point¹².

Pulmonary function test was done by a computerized spirometer (Helios 401) in proper sitting position for standardization and uniformity in interpretation of results. Nose clip was applied to avoid air leakage from nasal passage. The subjects were asked to take rest for 5-10 min. Then to take a deep inspiration and breathe out as rapidly as and as long as possible into the mouth of spirometer. Flow volume curve was plotted with the best of three acceptable maneuvers being taken as final reading. MVV was recorded by asking the subject to breathe as rapidly and deeply as possible for 12 sec. The required technique was self demonstrated. Spirometric parameters which were recorded for analysis were-

2.5 Spirometric Parameters

- FVC (forced vital capacity) in liters,
- FEV₁ (Forced expiratory volume in 1st second in liters
- FEV₁ /FVC Ratio of Forced expiratory volume and forced vital capacity in percentage
- PEFR (peak expiratory flow rate) in liter
- MVV (maximum voluntary ventilation) in liter.
- ERV (expiratory reserve volume) in liter

2.6 Statistical Analysis:

Results were expressed as mean ±SD. Statistical analysis was done by analyzing the data by Graph Pad Prism 5 software, Student's t test, one way ANOVAs.

III. Result and Analysis

Table:1 Standard anthropometric measurements of the control, overweight and obese groups in males

| | Control (n=25) Mean ± SD | Overweight (n=15) Mean ± SD | Obese (n=30) Mean ± SD |
|-------------------------|--------------------------------|-----------------------------------|------------------------------|
| Age (yrs) | 18.76 ± 0.88 | 19.08±0.99 | 19.1±0.852 |
| Height(cm) | 170.33±4.37 | 167.33±4.88 | 173±5.87 |
| Weight(kg) | 59.76 ± 4.61 | 66.33±4.27 | 87.6±11.5 |
| BMI(kg/m ²) | 20.72±1.41 | 23.93±.653 | 29.8 ± 4.04 |

Table 1 shows a comparison of baseline characteristics between control, overweight and obese males, showing significant difference in weight and BMI in obese than control.

Table: 2 Distribution of PFTs according to their mean ± SD in relation to BMI in males

| Parameters | Control(n=25) Mean ± SD | Overweight(n=15) Mean ± SD | Obese(n=30) Mean ± SD | ANOVAs one way P value |
|-------------|----------------------------|-------------------------------|--------------------------|------------------------|
| FVC(L) | 4.48 ±0.56 | 4.36 ± 0.339 | 4.035±0.42 | 0.002** |
| FEV1(L) | 3.72 ±0.48 | 3.54 ±0.429 | 3.30 ± 0.36 | 0.0026** |
| FEV1/FVC(%) | 83.05 ±0.98 | 82.8 ±1.51 | 82.20 ± 1.58 | 0.030* |
| PEFR(L) | 7.49 ± 1.53 | 7.57 ± 1.43 | 7.34 ± 1.27 | 0.695 |
| MVV(L) | 114.2 ± 13.65 | 108 ±14.11 | 95.37±14.24 | <0.0001*** |
| ERV(L) | 1.13 ±.19 | 1.06 ± 0.21 | 0.832 ±0.30 | 0.0003*** |

P <0.05 significant, p<0.0001 highly significant

Table 2 shows significant reduction in MVV, ERV, FEV₁ and FVC in obese male. Slight increase in PEFR seen in overweight though in obese PEFR decreases.

Table 3 : Inter group comparison of different lung parameters

| parameters | Control overweight | versus | Control obese | versus | Overweight versus obese |
|-----------------------|-----------------------|--------|------------------|--------|-------------------------|
| FVC | No significance | | yes | | no |
| FEV ₁ | no | | Yes** | | no |
| FEV ₁ /FVC | no | | yes | | no |
| PEFR | no | | no | | no |
| MVV | no | | Yes*** | | Yes* |
| ERV | no | | Yes*** | | Yes* |

Table 3 shows MVV, and ERV highly significant reduction in obese in comparison to control and significant reduction in obese in comparison to overweight.

IV. Discussion

Young adults are falling a prey to the escalating “epidemic of obesity” particularly in India. Lack of physical activities, sedentary life style and altered food habits promote development of obesity. Adequate data is not available in literature regarding effect of obesity on PFTs among young. So; this study was to evaluate the association of PFTs with BMI in young males in eastern India.

Earlier studies available have reported the relationship between lung functions and body weight, height and body mass index. All the dynamic functions of lung depend upon the compliance of the thorax lung system, airway resistance, and muscular strength of the respiratory muscles.¹⁴

In our study Obese subjects had significant lower values of FVC% and FEV₁ (p<0.001) in comparison to control. Reduction in lung volume, suggest some structural or functional changes in the airways that were specifically associated with increase in BMI¹³. A reduction in FEV₁ with increased BMI, may be due to narrowing of the airways than expected on the basis of reduction in lung volume. It suggests some structural or functional change in airways associated with increase weight gain. King et¹⁴ al also reported similar reduction in FEV₁. A reduction in FEV₁/FVC indicates airway narrowing. We too found lowered ratio of FEV₁/FVC. As no obstructive impairment was detected in any of the obese, so results are indicative of airflow limitation without significant obstruction.

A significant decrease in MVV (p<0.0001) was observed in obese .MVV depends on movement of air into and out of the lungs. A similar decrease in MVV also was observed by Paralikar while studying PFTs in adolescent boys¹⁵, Ho et al¹⁶, Inselman¹⁷ et al in children and Sahebjami et al¹⁸ in adults .Obese subjects due to peripheral airway abnormality face air trapping. As a result of air trapping, inspiratory muscles are placed at a mechanical disadvantage leading to lower inspiratory flow and reduced respiratory muscle strength causing low MVV.

Ladosky et al (2001)⁷ showed significant reduction in ERV in obese, and suggested reduction in ERV can be attributed to a decrease in the mobility of the diaphragm towards the abdomen during inspiration. Increased adipose mass, raises the intra abdominal pressure and pushes the diaphragmatic muscle upwards, thus causing a compression of the lung parenchyma, especially at the basal region of the lung, resulting in low lung compliance. The findings of PEFR showed an statistically insignificant increase in overweight . In 2010, Yogesh Saxena et al¹⁹ has shown a significant lowered PEFR in obese males but only in the higher age group. The primary factors that affect PEFR are strength of expiratory muscles; elastic recoil pressure of the lung and the airway size. Decrease in FVC and PEFR may not be the most suitable variable to detect early deterioration of the ventilatory function . Non significant change in the lung parameters in overweight males can be explained by the fact that with weight gain, there is a related increase in muscle strength and so pulmonary function initially increases in parallel with weight gain though subsequently increase in body weight would reduce lung function due to obesity effect²⁰.

V. Conclusion

To conclude, pulmonary functions decreases with increase BMI as compared to normal subjects. Though results of the present study were inconclusive, it suggests that obesity has effects on the lung function that can reduce respiratory wellbeing even in the absence of specific respiratory diseases and may exaggerate effects of existing airway disease due to lower respiratory reserve and more importantly weight loss can reverse these problems. It highlights the need to aggressively reduce weight in young. In future longitudinal studies with a larger sample should be conducted for better assessment of the relationship between increased body weight and PFTs.

References

- [1]. Overweight and obese. American Journal of Clinical Nutrition : 2007 ;85(1);35-39
- [2]. C S Ra et al; Effects of obesity on respiratory function.American Rev Respiratory disease.128(3),183:501-506
- [3]. H Sahebajami ,Dyspnoea in obese healthy men Chest, 1998;114:1373-77.
- [4]. Sahebajami H, Dyspnoea in obese healthy men, Chest; 109: 144-151, 1996
- [5]. Faintuch J, Souza SAF, Valexi AC, Sant'ana AF, Gama-Rodrigues JJ. Pulmonary function and aerobic capacity in asymptomatic bariatric candidates with very severe morbid obesity. Rev Hosp Clin Fac Med S Paulo. 2004;59:181-86.
- [6]. Koeing S M, Pulmonary complications of obesity .Am J Med Sci.2001;321:249-79.
- [7]. Ladosky W, Botelho MAM,et al, Chest mechanics in morbidly obese nonhypoventilated patients .Respir Med 2001; 95:281-286. [8] Canoy D ,Luben R , Welch A . et al. Abdominal obesity and respiratory function in men and women in the EPIC-Norfolk study. United Kingdom. Am J Epidemiology 2004;159:1140-1149
- [8]. Canoy D, Luben R,et al. Abdominal obesity and respiratory function in men and women in EPIC-Norfolk study. United Kingdom .Am J Epidemiology 2004;159:1140-1149
- [9]. Richard I. Jone ,Mary Magdalene. U et al.The effects of BMI on lung volumes. Nzekwu Chest 2006 ; 130 : 827-833
- [10]. Bhav S, Bavedkar A, Oliv M. IAP National Task Force for prevention of adult disease: childhood obesity. Indian Pediatr 2004; 41: 559-575.
- [11]. India reworks obesity guidelines, BMI lowered: [http://www.igovernment.in/ site/ India-reworks-obesity-guidelines-BMI](http://www.igovernment.in/site/India-reworks-obesity-guidelines-BMI).
- [12]. Park K . Park's Textbook of Preventive and Social Medicine. 18th ed. Jabalpur: Banarasidas Bhanot 2005 : 290,296, 313, 317
- [13]. Jain SK and Ramaiah TJ. Normal study of pulmonary function tests for healthy Indian men 15- 40 yrs & comparison of different regression equations .Indian J Med Res 1969;57:1453-66 .
- [14]. King GG,Brown NJ, Diba C et al. The effects of body weight on airway caliber.Euro Resp J 2005;25;896-901
- [15]. Swapnil J Paralikar et al. Assessment of Pulmonary functions in obese adolescent boys.<http://www.lungindia.com> june 2013
- [16]. Ho TF ,Ta JF, et al, Evaluation of lung function in Singapore obese children. J Singapore Paed society.1989; 31 :46-52.
- [17]. Inselman et al.Effect of Obesity on pulmonary function in children. Paed. Pulm 1993;16:130-7
- [18]. Sahebajami H , et al. Pulm function in obese subjects with a normal FEV1/FVC ratio. Chest 1996;110:1425-9
- [19]. Saxena Yogesh, Purwar Brijesh and Upmanyu Rashi . Adiposity: Determinant of Peak Expiratory Flow Rate in Young Indian Adults Male. The Indian Journal of Chest Diseases & Allied Sciences 2011;Vol.53 : 29-33.
- [20]. Schoenberg J, Beck G and Bouhys A. Growth and decay of pulmonary function in healthy blacks and whites. Respir Physiol 1978; 33: 367-93.