Original article

Physiology Section

The Impact of Body Mass Index on the Expiratory Reserve Volume

SRINIVAS.C.H, RAVI SHEKHAR, MADHAVI LATHA M.

ABSTRACT

Background and objectives: Obesity is a common health problem all over the world and it is closely associated with many diseases that cause disturbances in the lung function. The objective of the present study was to assess the impact of increased body mass index (BMI) on the expiratory reserve volume (ERV).

Materials and Methods: This study was conducted on 80 subjects of ages ranging from 25-40 years, of both the sexes. Of these, 40 were non-obese (BMI < 25 kg/m^2) and 40 were obese (BMI > 30kg/m^2). This study was carried out in the Department of T.B and Chest Diseases at the Infections Disease Hospital, Guntur, by using a computerized spirometer (Spiro-232, PK Morgan limited).

Results: On the comparison of the results, the subjects with a BMI of more than 30 kg/m^2 showed a decrease in ERV by 48.13%, than the normal subjects.

Conclusion: An increased BMI resulted in decreased expiratory reserve volume and the changes were more marked in males than in the females.

Key Words : Expiratory Reserve Volume, Body Mass Index, Spirometry

INTRODUCTION

Obesity is a chronic disease which is prevalent in both the developed and the developing countries, affecting children as well as adults. As the standards of living are continuing to rise, weight gain and obesity are posing a growing threat to health in countries all over the world [1]. More than 300 million people are affected by obesity world wide [2]. and its prevalence is increasing at a significant pace. These obese individuals are at an increased risk of morbidity and mortality from conditions such as diabetes, heart disease, hypertension, sleep-disordered breathing and some forms of cancer [3].

Obesity causes various effects on respiratory function in the form of alteration in the respiratory mechanics, decreased respiratory muscle strength, decrease in the pulmonary gas exchange, a lower control of breathing and a limitation in the pulmonary function tests [4]. These changes in the lung function tests are due to the accumulation of adipose tissue in the abdominal cavity and also over the chest wall, thus causing a decreased displacement of the diaphragm, decreased lung and chest wall compliance, increase in the elastic recoil and a decrease in the lung volumes.

Body fat deposition may also have a distinct impact on the ventilatory function and it is often described in two distinct patterns- a central pattern which is also called as the upper body pattern, which is usually seen in obese men and a peripheral or lower body pattern which is seen in obese women. Importantly, the central pattern of obesity is the more significant one [5]. The most frequently reported obesity related abnormalities are reductions in the lung volumes and in the expiratory flow rate.[6] Some studies have shown a clear correlation between weight loss and improvement in the lung function tests [7] [8]. A significant improvement in the expiratory reserve volume (ERV) to up to 54%, has been observed after weight loss [7].

The objectives of the present study were 1) To compare the lung function tests in the local population of obese and non-obese adults and 2) To compare the severity of the impairment in the lung function between males and females.

MATERIALS AND METHODS

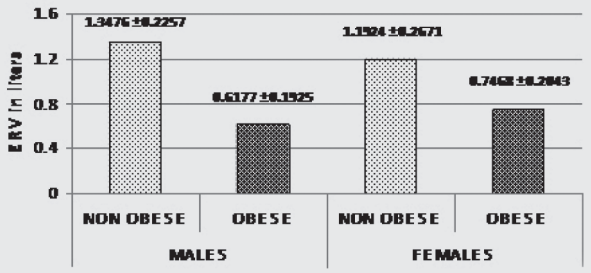
This study was conducted in the Department of T.B and Chest Diseases at the Infectious Disease Hospital, Guntur, Andhra Pradesh, after getting an approval from the institutional ethics committee (IEC), on 40 adult obese subjects (20 males and 20 females). Forty non-obese subjects (20 males and 20 females) were taken as the controls. All the subjects who were considered for the study were aged between 25-40 years and were non-smokers, non-alcoholics and non-diabetics. Moreover, they were not suffering from any cardiovascular or respiratory diseases. Thus, all the subjects who were chosen for the study were obese but were otherwise healthy. The BMI was calculated by using the formula - BMI = Weight/ Height2, where the weight is in kilograms and height is in meters. The subjects with a BMI of more than 30kg/m^2 were included in our study under the obese group and subjects with a BMI of less than 25kg/m^2 were included in the non-obese group. All the subjects were informed about the experimental protocol in their local language and their consent was obtained. Physical parameters such as height, weight, BMI, pulse, blood pressure and respiratory rate were recorded. The instrument which was used for the study was a computerized spirometer (spiro-232. PK Morgan limited). The expiratory reserve volume (ERV) was recorded in the sitting position by applying a nose clip.

RESULTS

The data which was obtained from the 40 obese and 40 non-obese subjects was statistically analyzed. Initially, the mean and standard deviations were calculated. The unpaired Students t-test was used to test the statistical significance of the difference

	Non-obese		Obese		t-value	p-value
	Mean	SD	Mean	SD		
Age	31.4	±3.5358	31.85	±4.00992		
BMI kg/m²	21.55	±1.2999	34.65	±2.0575		
ERV in liters	1.1924	±0.2671	0.6185	±0.15709	11.71384	p < 0.001

[Table/Fig-1]: Comparison of the mean BMI and ERV in non-obese and obese subjects



[Table/Fig-2]: Comparison of the mean ERV in non-obese and obese male and female subjects

between the ERV of the non-obese and the obese groups. When the results were compared, it was found that the mean ERV in the obese group was lower than that in the non-obese group (p <0.001). The mean ERV was decreased by 48.13% in the obese group as compared to that in the non-obese group [Table/Fig-1].The mean ERV in the obese males (n=20) was decreased by 54.17% as compared to that in the non-obese males (n=20), with a t value of 11.01 and (p < 0.001). The female obese subjects showed a 37.4% decrease in the mean ERV, with a t value of 5.93 (p < 0.01) [Table/Fig-2].

DISCUSSION

The present study showed that there was a significant decrease in the expiratory reserve volume in the obese group, whose BMI was more than 30kg/m². Zerah et al [9] (1993) found that with an increase in the BMI, most of the lung volumes were changed and the analysis of variance (ANOVA) showed highly significant reductions in the functional residual capacity (FRC) and ERV. The above study also confirmed that decreased ERV is the most sensitive lung function test in obesity. The findings of the present study are in consistence with the findings of Zerah et al (1993) and other authors [4] [10] [11] [12] [13]. This reduction in ERV can be attributed to a decrease in the mobility of the diaphragm towards the abdomen during inspiration, which is caused by an increased abdominal volume in the obese individuals [4]. Apart from the reduced movement of the diaphragm as a cause for decreased ERV, Ladosky et al (2001) suggested that the main consequence of a burden on the chest wall which is caused by increased adipose mass, is the reduction in its compliance, thus making inspiration increasingly difficult and resulting in lower static volumes and flows [14]. There is an increased intra-abdominal pressure with an accumulation of fat in the abdominal cavity. This raises the intra abdominal pressure due to the visceral obesity and pushes the diaphragmatic muscle upwards, thus causing a compression of the lung parenchyma, especially at the basal region of the lung. Visceral fat produces the over-stretching of diaphragm, thus leading to an elevation of the diaphragmatic domes, which in turn causes a decreased efficiency of the diaphragmatic muscle [15].

In this study, we found that the decreased ERV was more marked in the obese males than in the obese females. This could be due to a difference in the weight distribution in the obese males and females. Males tend to deposit fat centrally, while in females, the deposition is typically peripheral. Thus, the mechanical effect on the diaphragm in men, impeding the expansion of the lungs during inspiration, could justify their higher impairment of the ventilatory function [16].

There were certain limitations in the present study, as the study was a cross sectional assessment of the lung function at one time point. So, it would be ideal to undertake a longitudinal study over a period of time, to understand the progression of the deformity with an increase in the BMI or the improvement in the lung functions with a decrease in the BMI by using weight reduction measures.

CONCLUSIONS

Increased BMI causes a significant decrease in the ERV in obese subjects as compared to that in the non-obese subjects and these changes are more marked in obese males than in the obese females.

ACKNOWLEDGEMENT

The authors wish to thank Mrs. K. Naga Saritha, lecturer in Statistics, NRI Medical College, for extending her support in the statistical analysis of the data.

REFERENCES

[1] World Health Organization Obesity: preventing and managing the global epidemic. WHO Obesity Tech Report Series 894 Geneva, Switzerland- 2000.
[2] Sharma AM. Managing weighty issues on lean evidence: the challenges of bariatric medicine. *Canadian Med Assoc J*, 2005; 172: 30-31.
[3] DeLorey DS, Wyrick BL, Babb TG. Mild to moderate obesity: implications for respiratory mechanics at rest and during exercise in young men. *Int J Obes* 2005; 29: 1039-1047.
[4] Costa D, Barbalho MC, Miguel GPS, Forti EMP, Azevedo JLMC. The impact of obesity on pulmonary function in adult women. *Clinics* 2008; 63: 719-24.
[5] Lazarus R, Sparrow D, Weiss ST. Effects of obesity and fat distribution on ventilatory function. The normative aging study. *Chest* 1997;111:891-898.
[6] Li AM, Chan D, Wong E, Yin J, Nelson EAS, Fok TF. The effects of obesity on pulmonary function. *Arch Dis Child* 2003; 88:361-363.
[7] Thomas PS, Cowen ER, Hulands G, Milledge JS. Respiratory function in the morbid obese before and after weight loss. *Thorax* 1989;44:382-6.
[8] Hakala K, Mustajoki P, Aittomaki J, Sovijiarvi AR. Effect of weight loss and body position on pulmonary function and gas exchange abnormalities in morbid obesity. *Int J Obes Relat Metab Disord* 1995; 19: 343-346.
[9] Zerah F, Harf A, Perlemuter L, Lorino H, Lorino A-M, Atlan G. Effect of obesity on respiratory resistance. *Chest* 1993; 103:1470-1476.
[10] Sahebjami H, Gartside PS. Pulmonary function in obese subjects with a normal FEV1/FVC ratio. *Chest* 1996; 110:1425-29.
[11] Jones RL, Nzekwu M-MU. The effects of body mass index on lung volumes. *Chest* 2006; 130: 827-833.
[12] Ochs-Balcom HM, Grant BJB, Muti P, Sempos CT, Freudenheim JL, Trevisan M, Cassano PA, Lacoviello L, Schunemann HJ. Pulmonary function and abdominal adiposity in the general population. *Chest* 2006 129: 853-862.

[13] Luce JM. Respiratory complications of obesity. Chest 1980; 78: 626-631.
[14] Ladosky W, Botelho MA, Albuquerque JP Jr. Chest mechanics in morbidly obese non-hypoventilated patients. *Respir Med* 2001;95:281-6
[15] Busetto L, Sergi G. Visceral fat and respiratory complications. *Diabetes Obes and Metab* 2005; 7:301-305.
[16] Bottai M, Pistelli F, Di Pede F, Carrozzi L, Baldacci S, Matteelli G, Scognamiglio A, Viegi G. Longitudinal changes of body mass index, spirometry and diffusion in a general population. *Eur Respir J* 2002;20:665-73

AUTHOR(S):
1. Dr Srinivas C.H.
2. Dr Ravi Shekhar
3. Dr Madhavi Latha M.

PARTICULARS OF CONTRIBUTORS:
Department of Physiology, NRI Medical College,
Guntur, Andhra Pradesh, India.

NAME, ADDRESS, TELEPHONE, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr Srinivas.C.H., Assistant Professor
Department of Physiology,
NRI Medical College, Chinakakani, Guntur district,
Andhra Pradesh -522503, India.
Phone: 08645 23677 (Ext 173) Mobile: 9848403293.
E-mail: chadalavadasrinivas@yahoo.com.

DECLARATION ON COMPETING INTERESTS:
No competing Interests.

Date of Submission: **Mar 15, 2011**
Date of per review: **Mar 17, 2011**
Date of acceptance: **Mar 24, 2011**
Online first: **Apr 13, 2011**
Date of publishing: **Jun 13, 2011**