Research Article

Effect of obesity on pulmonary function tests in apparently healthy young women

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Received April 28, 2015. Accepted May 7, 2015

Abstract

Background: Obesity is considered to affect the respiratory functions.

Objective: To evaluate the effect of obesity on pulmonary functions by spirometry among healthy young women.

Materials and Methods: A cross-sectional study was conducted among 60 apparently healthy young women, who were further divided into two groups according to their body mass index (BMI). The first group consisted of nonobese subjects with a BMI of 18 to 24.9 kg/m^2, and the second group consisted of obese subjects with a BMI of 30 kg/m^2 and above. All the subjects underwent spirometry tests of the following variables such as the forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), peak expiratory flow rate (PEFR), and forced midexpiratory flow ($FEF_{25\%–75\%}$).

Results: After analyzing the data and comparing by independent sample *t* test, we did not observe significant differences in FEV1, FVC, and $FEF_{25\%–75\%}$ between the obese and nonobese subjects. However, there was a significant difference in FVC/FEV_1 ratio and PEFR between the two groups ($p = 0.036$ and $p = 0.048$, respectively).

Conclusion: Obesity has an impact on respiratory functions even in younger age group; therefore, they should be safeguarded against the hazards of obesity by taking corrective steps through our health programs.

KEY WORDS: Obese women, spirometry, body mass index, peak expiratory flow rate

Introduction

Obesity is a chronic condition characterized by an excessive accumulation of fat on human body, which causes a generalized increase in body mass.[1] Obesity is an important global health hazard and has been linked to the increased incidence of cardiovascular diseases, hypertension, metabolic disorders, and pulmonary dysfunction.[2] Besides genetic predisposition, adoption of sedentary lifestyle and inappropriate intake of calorie-rich easily available junk food has made the environment conducive to the development of obesity even in childhood.[3] The WHO classified obesity as follows: BMI of 18–24.9 kg/m^2 is considered normal weight, a BMI of 25.0–29.9 kg/m^2 is considered overweight, and a BMI of 30 kg/m^2 or higher is considered obesity.[1] Obesity is often associated with many health consequences such as diabetes, hypertension, dyslipidemia, ischemic heart diseases, obstructive sleep apnea, stroke, premature death, osteoporosis, and a reduction of the overall quality of life.[4] Obesity can cause various deleterious effects to respiratory functions, such as alterations in the respiratory mechanics, decrease in respiratory muscle strength and endurance, decrease in pulmonary gas exchange, lower control of breathing, and limitations in pulmonary function tests.[5] The pulmonary function tests (PFTs) are the battery of tests that are used to assess the physiological respiratory efficiency of an individual.[6] The factors that usually affect the values of pulmonary function tests are age, gender, height, weight, race or ethnicity,

Access this article online	
Website: http://www.ijmsph.com	Quick Response Code:
DOI: 10.5455/ijmsph.2015.28042015313	

and possibly obesity.[6] Weight may have effects on pulmonary function tests by causing small airway dysfunction and expiratory flow limitation, alterations in respiratory mechanics, decreased chest wall and lung compliance, decreased respiratory muscle strength and endurance, decreased pulmonary gas exchange, lower control of breathing, and limitations in exercise capacity.[5] Female subjects tend to have lower PFT values as their respiratory muscle endurance and chest wall compliance is lower than that of their male counterparts.[6] Even though the interaction between obesity and PFT has been addressed previously, the results have been inconsistent among the urban young female population. Therefore, we aimed to evaluate the effects of obesity on PFTs among healthy young women by spirometry, because it is considered to be the initial screening tool for pulmonary diseases, most widely used, economic, and easy to conduct using equipment that is available in all pulmonology laboratories.

Materials and Methods

Sixty apparently healthy young female medical student volunteers, in the age group of 18–25 years, were enrolled for this study. The subjects were subsequently divided into two groups according to their BMI. The first group consisted of nonobese (normal body weight) subjects with BMI of 18 to 24.9 kg/m^2, and the second group consisted of obese subjects with BMI of >30 kg/m^2. Individuals leading a sedentary life style were also included. Written informed consents were obtained from all the participants after explaining the study protocol. This study was conducted in the Department of Physiology, Osmania Medical College, Hyderabad, India, for a period of 2 years after obtaining the approval of the institutional ethics committee. All the subjects underwent a thorough evaluation of medical history and general physical examination. The clinical details and baseline parameters were recorded on a well-designed pro forma. All the female subjects enrolled did not have any respiratory complaints such as cough, shortness of breath, wheezes, or history of upper respiratory tract infection in the last 4 weeks. The subjects were asked to avoid hot drinks such as tea, coffee, and other stimulants before undergoing the tests. The laboratory was well ventilated throughout the recordings. All the recordings were taken between 10 a.m. and 1 p.m. at room temperature.

Methods

Waist-to-Hip ratio (WHR)

The waist circumference (cm) was measured at a point midway between the lower rib and iliac crest, in a horizontal plane. The hip circumference was measured in centimeters at the widest girth of the hip. The measurements were recorded to the nearest 0.1 cm and used to calculate the WHR.

BMI

The weight was measured with the subjects wearing light clothing and barefoot on a SECA weighing scale (Hamburg, Germany). The standing height was measured without shoes with the subject's back to a vertical backboard. Both the heels were placed together, touching the base of the vertical board. Normal weight and obesity were defined on the basis of WHO cutoff values. BMI was measured by calculating the weight in kilograms divided by the square of the height in meters [BMI = weight (kg)/height (m^2)].[2]

Spirometry:

The spirometry tests were conducted using an electronic computerized portable RMS Medspiror (Medicare system, Chandigarh, India) in the well-ventilated laboratory. All subjects underwent spirometry tests, in sitting position, using techniques recommended by the American Thoracic Society (ATS). The spirometry test was done in the morning by a trained qualified technician. The subjects were asked to take the maximum deep inspiration and then blow out with maximum effort into the mouthpiece of medspiror wearing a nose clip. The validity of the test was verified according to the ATS recommendations. The parameters that were measured by spirometry were as follows: the forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), peak expiratory flow rate (PEFR), and forced midexpiratory flow ($FEF_{25\%–75\%}$). In addition to these measured parameters, the ratio of FEV_1 to FVC (FEV_1/FVC, expressed as a percentage) was calculated.

Statistical Analysis

The statistical analysis was performed using the SPSS software, version 19 (SPSS, Chicago, IL). The variables were expressed as the mean and standard deviations, and p value < 0.05 was considered statistically significant. Independent samples test were used to compare the spirometry results of obese subjects with those of nonobese subjects.

Results

The baseline characteristics of study subjects are shown in Table 1. The spirometric analysis is described in Table 2. While comparing the variables of spirometry, there was a significant difference in FEV_1/FVC and PEFR observed between the two groups. The obese subjects exhibited significantly ($p < 0.05$) [Table 2] lower PEFR and FEV_1/FVC values than nonobese subjects. However, we did not observe any significant differences in FEV_1, FVC, and $FEF_{25\%–75\%}$ between the two groups. We did not find any significant difference in age and height, whereas significant difference ($p < 0.001$) [Table 1] was observed in WHR and BMI between the obese and nonobese subjects.

Discussion

PFT is a simple procedure for the assessment and monitoring of respiratory diseases. Previous studies have revealed that pulmonary function is influenced by BMI and WHR in men.[7,8] As all the participants of both the groups in this study

Table 1: Baseline parameters of the obese group and nonobese group

Parameters	Nonobese group (*N* = 30)	Obese group (*N* = 30)	*p*
Age (years)	19.75 (0.74)	19.66 (0.61)	0.609 (NS)
Height (m)	162.44 (5.13)	162.53 (4.97)	0.945 (NS)
Weight (kg)	54.34 (6.08)	71.66 (8.14)	<0.001**
WHR	0.82 (0.07)	0.90 (0.06)	<0.001**
BMI (kg/m^2)	21.68 (1.73)	27.96 (2.63)	<0.001**

Data are expressed as mean (SD).
$p > 0.05$: not significant; *$p < 0.05$; **$p < 0.001$.

Table 2: Comparison of spirometry variables of the obese group and nonobese group

Parameters	Nonobese group (*N* = 30)	Obese group (*N* = 30)	*p*
FVC (L)	4.1 (0.72)	3.82 (0.53)	0.091 (NS)
FEV_1 (L)	3.38 (0.67)	3.12 (0.29)	0.056 (NS)
FEV_1/FVC (%)	84.12 (4.26)	81.97 (3.47)	0.036*
$FEF_{25\%–75\%}$ (L)	3.64 (0.28)	3.49 (0.55)	0.188 (NS)
PEFR (L/min)	518.14 (94.88)	471.78 (83.11)	0.048*

Data are expressed as mean (SD).
$p > 0.05$: not significant; *$p < 0.05$; **$p < 0.001$.

did not exhibit any difference in terms of age and height but differed significantly in weight [Table 1], by this study, we tried to find the effect of body weight in terms of adipose tissue on lung functions. BMI is considered as the gold standard for measuring of accumulation of adipose tissue, because it is calculated using the height and weight of an individual.

In this study, it was observed that there were no significant differences in FEV_1, FVC, and $FEF_{25\%–75\%}$ between the young women who were obese and nonobese; however, there was a significant difference ($p < 0.05$) [Table 2] with regard to FEV_1/FVC and PEFR. The obese subjects showed lower FEV_1/FVC ratio and PEFR values than the nonobese subjects [Table 2]. The lower level of these spirometry variables may be owing to the decrease in total respiratory system compliance.[9] Our study is supported by the work of Naimark and Cherniack,[10] who have also reported similar findings in their study. They have demonstrated that total respiratory compliance is reduced by as much as two-thirds of the normal value in obese individuals. This is because, in part, of a decrease in lung compliance that may relate to the increased pulmonary blood volume seen in obese individuals.[11] However, the primary reason is owing to a decrease in chest wall compliance associated with the accumulation of fat in and around the ribs, the diaphragm, and the abdomen of women who are obese.[12] Total respiratory compliance is markedly reduced by recumbency in obese individuals when compared with nonobese individuals. This reduction is almost entirely because of the decreased compliance of the chest wall, although it may also be owing to an increase in respiratory resistance.[13] This study is concurrent with that of Sahebjami and Gartside,[14] who reported reductions in FEV_1, FVC, and maximal inspiratory flow rate in obese subjects and found the association of obesity with a low maximum voluntary ventilation (MVV). They found that both FEV_1 and FVC to be significantly reduced (in terms of percentage predicted) and the FEV_1/FVC ratio and static lung volumes to be lower in their study, suggesting the reduction may be owing to restriction as opposed to air flow obstruction.[14] Lazarus et al.[15] found that the FEV_1 to FVC ratio decreases with increasing BMI in overweight and obese men and in morbidly obese women [defined as individuals with a body weight (in kilograms) to height (in centimetres) ratio greater than 0.9 kg/cm]. In a similar study by Biring et al.,[16] a reduction in midexpiratory flows and the FEV_1 to FVC ratio has been observed. Therefore, it appears that spirometric abnormalities in subjects with mild to moderate obesity represent a restrictive defect placed on the system, whereas in subjects with severe and morbid obesity, it represents true air flow obstruction. The mechanism may be related to small airway collapse owing to decreased lung volume with increasing obesity or it may be independent.[17] According to Joshi and Ratan,[18] WHR, which is highly correlated with abdominal fat mass, is, therefore, used as a surrogate marker for abdominal or upper body obesity. This study showed a highly significant increase in WHR in obese group. So, clearly, the subjects in this study were having a central pattern of fat distribution that may affect the lung function by altering the mechanics of ventilation. Hence, we suggest that, obesity may decrease the lung and chest wall compliance owing to the increase in the weight of the chest wall and the higher position of diaphragm in the thoracic cavity, resulting in a decrease in the FEV_1 to FVC ratio and PEFR, which subsequently leads to the increase in work of breathing. In addition, the central pattern of deposition of fat on the chest wall may impede the expansion and excursion of the rib cage, through a direct loading effect or by altering the intercostal muscle function.

Limitations

This study could not quantify the effect of different patterns of fat distribution on spirometry in obesity. As abdominal and thoracic fat are likely to have direct effects on the downward movement of the diaphragm and on chest wall properties, the fat on the hips and thighs would be less likely to have any direct mechanical effect on the lungs.

Conclusion

Young women who are overweight exhibit mechanical modifications of spirometric variables such as decrease in FVC/FEV_1 ratio and PEFR without compromising other pulmonary functions. Further study has to be conducted in a large sample size to validate these preliminary findings.

Acknowledgment

We are thankful to all the female medical student participants of Osmania Medical College and Hospital, Hyderabad, for volunteering to participate in this study.

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How to cite this article: Devershetty J, Metta S, Uppala S, Kamble G. Effect of obesity on pulmonary function tests in apparently healthy young women. Int J Med Sci Public Health 2015;4:1519-1522

Source of Support: Nil, **Conflict of Interest:** None declared.