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Study the Effects of Obesity and Body Fat Distribution on the Spirometric Pulmonary Function Tests

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Abstract

Background Obesity is one of the most frequently found health risks with increasing in its prevalence all over the world. Several measures of obesity like body mass index, waist circumference and percent of body fat had been used in many studies as predictor of pulmonary function tests.

Objectives To evaluate the effect of anthropometric measurements on pulmonary function tests, and explore the association between body fat percent and pulmonary function tests.

Methods A total of one hundred subjects were recruited from both sexes (fifty with normal and fifty with high body mass index). Body mass index, waist circumference and percent of body fat were measured for each subject.

Results This study shows a significant reduction in spirometric parameters (except for FEV1/FVC ratio) in high body mass index groups compared to those with normal body mass index in both sexes, with a significant negative correlation between percent of body fat and waist circumference with spirometric parameters in high body mass index groups had been identified.

Conclusion Obesity has a restrictive rather than obstructive pattern of lung impairment. Excess body fat and abdominal obesity have anadverse affect on lung function.

Keywords Pulmonary function test, BMI, WC, BF%

List of abbreviation: BMI = body mass index, PFT = pulmonary function test, WC = wait circumference, WHR = waist to hip ratio, BF% = percent of body fat, FVC = forced vital capacity, FEV1 = forced expiratory volumes in first second, FEF = forced expiratory flow, PEFR = peak expiratory flow rate**.**

Introduction

Obesity is a global health hazard and has been linked to numerous metabolic complications such as dyslipidemia, type II diabetes, and cardiovascular diseases and is negatively associated with the respiratory function [1]. The mechanism which influences lung function in obesity is still debated and the best marker of adiposity in relation to dynamic pulmonary function is still not clear [2]. Body mass index (BMI) can be easily measured and therefore is frequently used in large scale epidemiologic studies to find out the health hazards caused by obesity [3]. Pulmonary function test (PFT) is a basic and essential test for diagnosis and assessment of pulmonary dysfunction, pulmonary diseases, and treatment effects [4].

Obesity is measured using waist circumference (WC) and BMI. Body weight and BMI can be easily measured and therefore are frequently used in large scale epidemiological studies to find out the health hazards caused by obesity [5]. The association between BMI or body weight and PFT variables vary in different subpopulations [2,6,7], also the relation of WC and waist to hip ratio (WHR) to pulmonary function parameters revealed a controversial results [8]. PFT is a basic and essential test for diagnosis and assessment of pulmonary dysfunction, pulmonary diseases, and treatment effects. Predicted normal values of

PFT is calculated by an equation of regression reflecting gender, age, height, and body weight due to the significant correlation with PFT values [9]. Since other body measures have also been reported to have correlations with the result of PFT, studies to find an equation of regression of pulmonary functions values according to other body measures have continued [10].

An important respiratory abnormality in obesity is a decrease in total respiratory system compliance that may relate to the increased pulmonary blood volume seen in obese individuals. However, the primary reason is due to a decrease in chest wall compliance associated with the obese individual's resulted from accumulation of fat in and around the ribs, the diaphragm and the abdomen [11].

Total respiratory compliance is markedly reduced by recumbency in obese individuals compared with non-obese individuals [12]. This reduction is almost entirely due to the decreased compliance of the chest wall, although it may also be due to an increase in respiratory resistance [13].

Methods

A case control study done in the pulmonary function unit in AL-Imamain Al-Kadhimain Medical City during the period from December 2013 to April 2014. A total of one hundred normal healthy persons from 18-45 years old were recruited from both sexes; fifty persons with normal BMI (18.50-24.99 Kg/m^2), (25 females and 25 males) and fifty persons with high BMI (overweight and obesewith BMI≥25 Kg/m^2), (25 females and 25 males). Any person with lung disease, pregnant women, and smokers will be excluded from this study. Informed consent of all subjects was obtained, with approval of Institute Review Board.

BMI was calculated by measuring weight (kg) and height (cm) using digital height and weight scale, BMI is define as person's weight in kilograms divided by the square of his height in meters (kg/m^2) [5]. WC was measured to the nearest 0.1 cm using a measuring tape at the midpoint between the last floating rib and the top of the iliac crest [6].

Extremity skinfolds were measured at the triceps and biceps and trunk skinfolds were measured at the suprailiac and subscapular areas, the skinfold was picked up between the thumb and the forefinger and the readings were taken 5 seconds after the caliper was applied [7]. Three consecutive readings were taken and recorded at each site, the average of the three readings at each site was calculated and the sum of these values was entered into the table given by Durnin and Womersley to estimate body density [7] and then percent of body fat (BF%) was calculated using Siri Equation [8].

Spirometric parameters of PFTs were conducted by measuring forced vital capacity (FVC), forced expiratory volumes in first second (FEV1), FEV1/FVC ratio, forced expiratory flow (FEF25%, FEF50% and FEF75%) and peak expiratory flow rate (PEFR) using a spirometer (Jaeger, Germany) after careful explanation of the test to the participant [9].

Statistical analysis was performed with SPSS V. 17 and Excel 2010. Data were expressed as mean±SD. Data analysis was done using unpaired t–test and Pearson correlation. P-value<0.05 was considered statistically significant.

Results

The present study shows a significant reduction in spirometric parameters FEV1 (L), FVC (L), FEF 25%, FEF 50%, FEF 75% and PEFR in high BMI males and females compared to normal BMImales and females, ($p < 0.001$), respectively; while no significant changes in FEV1/FVC ratio (L) regarding males and females with normal and high BMI had been identified, ($P>0.05$), as noticed in tables 1 and 2, respectively.

Table 1. Pulmonary function tests in males with normal and high body mass index

Parameter	Body mass index		p value
	Normal mean±SD	High mean±SD	
FEV1 (L)	3.49 ± 0.56	2.27 ± 0.3	<0.001
FVC (L)	4.07 ± 0.57	2.65 ± 0.31	<0.001
FEV1/FVC ratio (L)	0.86 ± 0.06	0.86 ± 0.08	0.743
FEF25% (L/S)	7.2 ± 0.74	5.28 ± 0.44	<0.001
FEF50% (L/S)	4.5 ± 0.54	4.18 ± 0.51	0.035
FEF75% (L/S)	2.57 ± 0.19	1.64 ± 0.32	<0.001
PEF (L/S)	8.26 ± 0.95	5.87 ± 0.48	<0.001

FEV1 = forced expiratory volumes in first second, FVC = forced vital capacity, FEF = forced expiratory flow, PEF = peak expiratory flow

Table 2. Pulmonary function tests in females with normal and high body mass index

Parameter	Body mass index		p value
	Normal mean±SD	High mean±SD	
FEV1 (L)	3.36 ± 0.58	2.11 ± 0.21	<0.001
FVC (L)	4.0 ± 0.61	2.3 ± 0.22	<0.001
FEV1/FVC ratio (L)	0.85 ± 0.18	0.92 ± 0.09	0.101
FEF25% (L/S)	6.91 ± 0.86	5.0 ± 0.29	<0.001
FEF50% (L/S)	4.46 ± 0.57	3.78 ± 0.39	<0.001
FEF75% (L/S)	2.41 ± 0.22	1.56 ± 0.27	<0.001
PEF (L/S)	8.15 ± 1.0	5.56 ± 0.33	<0.001

FEV1 = forced expiratory volumes in first second, FVC = forced vital capacity, FEF = forced expiratory flow, PEF = peak expiratory flow

This study shows a significant negative correlation between BF% and spirometric parameters FEV1 (L), FVC (L), FEF 25%, FEF 50%, FEF 75% and PEF in females and males with high BMI ($p < 0.001$), while no significant correlation between BF% and FEV1/FVC ratio (L) had been observed in both sexes, ($p > 0.05$) as shown in table 3.

Table 3. Correlations between percent of body fat and pulmonary function test in high body mass index groups

Parameters	Percent of body fat			
	Female		Male	
	r value	p value	r value	p value
FEV1 (L)	-0.488	0.013	-0.772	<0.001
FVC (L)	-0.430	0.032	-0. 869	<0.001
FEV1/FVC ratio (L)	-0.107	0.609	0.031	0.882
FEF 25% (L/S)	-0.743	<0.001	-0.990	<0.001
FEF50% (L/S)	-0.415	0.039	-0.694	<0.001
FEF75% (L/S)	-0.560	0.004	-0.983	<0.001
PEF (L/S)	-0.853	<0.001	-0.987	<0.001

FEV1 = forced expiratory volumes in first second, FVC = forced vital capacity, FEF = forced expiratory flow, PEF = peak expiratory flow

This study shows a significant negative correlation between WC and spirometric parametersFEV1 (L), FVC (L), FEF 25%, FEF 50%, FEF 75% and PEF in females and males with high BMI ($p < 0.001$), while no significant correlation between WC and FEV1/FVC ratio (L) had been identified in both sexes, ($p > 0.05$) as demonstrated in table 4.

Table 3. Correlations between percent of waist circumference and pulmonary function test in high body mass index groups

Parameters	Waist circumference			
	Female		Male	
	r value	p value	r value	p value
FEV1 (L)	-0.510	0.009	-0.628	0.001
FVC (L)	-0.585	0.002	-0.677	<0.001
FEV1/FVC ratio (L)	0.040	0.851	0.002	0.993
FEF 25% (L/S)	-0.660	<0.001	-0.684	<0.001
FEF50% (L/S)	-0.517	0.008	-0.411	0.041
FEF75% (L/S)	-0.593	0.002	-0.666	<0.001
PEF (L/S)	-0.846	<0.001	-0.732	<0.001

FEV1 = forced expiratory volumes in first second, FVC = forced vital capacity, FEF = forced expiratory flow, PEF = peak expiratory flow

Discussion

Reduced pulmonary function is an important predictor of mortality in the general population [14]. Analysis for the values of lung subdivisions including total lung capacity, residual volume and functional residual capacity demonstrated that standing and sitting height were the best predictors of lung volumes Lung volumes are also considerably influenced by the amount of body fat; gross obesity decreases the total and chest wall compliance and thus diminishes expiratory reserve volume and functional residual capacity [15,16].

This study shows a significant reduction in spirometric parameters (except for FEV1/FVC ratio) in high BMI groups compared to normal BMI groups among both males and females, tables 1 and 2, respectively. This result agrees with other studies done by Shinde et al [10]; Lad et al [17] and Soundariya and Neelambikai [18] but disagrees with a study done by Ajmani [2]. This difference possibly due to small sample size in this study, factors affecting PFTs (environmental conditions, altitude, and socioeconomic status).

The reduction in spirometric parameters with increasing BMI can be explained by the mechanical resistant to the movement of thorax and abdomen, reduced chest wall compliance and peripheral airway size, while the no difference in FEV1/FVC ratio indicates a restrictive impairment in individuals with higher BMI and rules out any obstructive pattern of lung diseases [19].

This study shows a significant negative correlation between BF% and all studied spirometric parameters (except for FEV1/FVC ratio) in high BMI groups among both females and males (Table 3). This result agrees with a study done by Lad et al [17]. A study done by Steele et al [20] shows a significant negative correlation between BF% and [FEV1 (L) and FVC (L)] in high BMI groups; another study done on female subjects by Kim et al [4] shows a significant negative correlation between BF% with FEV1 and FVC.

The present study shows no correlation between BF% and FEV1/FVC ratio (L). This result agrees with other studies done by Kim et al [4] and Behera and Pradhan [20].

There are several mechanisms by which excess body fat might lead to reduced lung function, broadly categorized into mechanical and inflammatory [21]. With increasing obesity, intra-abdominal fat deposition and accumulation may impede the descent of the diaphragm during inspiration [22]. In addition, the deposition of fat on the chest wall may impede expansion and excursion of the rib cage, through a direct loading effect or by altering intercostal muscle function [23].

This study shows a significant negative correlation between WC and spirometric parameters (except for FEV1/FVC ratio) in both females and males with high BMI (Table 4). This result is concordance with other studies done by Chen et al [3] and Khan [23]. Abdominal adiposity (central fat distribution) may restrict the descent of the diaphragm, limit lung expansion and increase the thoracic pressure, leading to restrictive respiratory impairment [23].

We conclude that obesity has a restrictive rather than obstructive pattern of lung impairment. Excess body fat (increase BF%) and abdominal obesity (as measured by WC) have adverse effect on lung function, suggesting use of these indices in evaluation of lung function in high BMI individuals.

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Conflict of interest

No conflict of interest

Author contribution

Dr. Abdul-Wahab put the setting, computes the parameters and participates in writing the article; Mejebl collects the data, did the statistical analysis and write the article.

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