Effect of different classes of obesity on the pulmonary functions among adult Egyptians: a cross-sectional study

Ashraf M. Hatem, Mohamed S. Ismail, Yasmine H. El-Hinnawy

Introduction Obesity is a common chronic disease, representing a major health hazard. Obesity has several delirious effects on the respiratory functions.

Aim of the study To study the effect of obesity on pulmonary functions among our local population of obese adults and to assess the correlation between the severity of lung function impairment and the degree of obesity.

Patients and methods Healthy nonsmoker adult patients were recruited in our cross-sectional study. After full medical evaluation, measurement of height and weight, and calculation of BMI, patients underwent spirometry tests with measurement of forced expiratory volume in first second (FEV1), forced vital capacity (FVC), forced mid-expiratory flow, and peak expiratory flow rate. Then, they were classified according to their BMI into five groups.

Results The study included 293 patients divided into five groups according to their BMI. Significant statistical differences were noticed between nonobese patients and patients with classes II and III obesity regarding FVC, FEV1, and forced mid-expiratory flow, but no differences regarding peak expiratory flow rate and FEV1/FVC ratio. Overall, 28.9% of the total obese patients presented with restrictive pattern of spirometry, 2.8% with obstructive, and 2.4% with mixed patterns.

Conclusion Obesity of especially marked degrees with BMI of more than 35 kg/m^2 negatively affects the spirometric parameters. Restrictive pattern was the commonest abnormality observed in the spirometry of obese patients.
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Department of Pulmonary Medicine, Cairo University, Cairo, Egypt

Correspondence to Mohamed S. Ismail, MD, Tiba Gardens, 6th October City, Giza, 12566, Egypt. Tel: +20 111 001 4998; fax: +20 111 001 4998; e-mail: mohammed.hassan@kasralainy.edu.eg

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Introduction

Obesity is abnormal or excessive body fat accumulation, which increases the hazards of morbidities [1]. It is the most common metabolic disease worldwide [2]. Obesity represents a major health problem, where it has been associated with increased incidence of cardiac and metabolic diseases as well as some cancers [3]. Obesity can be associated with many different adverse effects on the respiratory functions, including alterations in the respiratory mechanics, weakness of the diaphragmatic and other respiratory muscle strength, and impairment in the gas exchange, leading to limitations in pulmonary function tests (PFT) [4]. One of the widely used measures of obesity is the BMI [3]. The highest level of obesity among adults was observed among Egyptians according to a publication in 2017 [5].

Aim of the study

The aim was to study the effect of obesity on pulmonary functions among our local population of obese adults and to assess the correlation between the severity of lung function impairment and the degree of obesity.

Patients and methods

This is a cross-sectional study that was conducted at Chest Department, Kasr Al Ainy hospitals, Cairo University, during the period between 2016 and 2018. This work was approved by the ethical committee of the Faculty of Medicine, Cairo University. A total of 293 patients of both sexes within the age of 18–60 years were included. We included patients who were referred for prebariatric surgery evaluation, in addition to volunteers and hospital visitors. Full clinical assessment including thorough history taking, physical examination, and PFT was done for all the study participants. Signed informed consent was obtained from each patient. We excluded cases with any active cardiopulmonary complaint or disease, any past history of cardiopulmonary disease, or evidence of chest wall deformities.

Anthropometric measures (height and body weight) were obtained for all included patients. BMI was calculated according to the formula of weight in kilogram divided by height square in meters.

The cases were categorized into five groups according to BMI with reference to the WHO cutoffs [6].

(1) Group 1 (normal weight) with BMI of 18.5–24.9 kg/m^2.

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(2) Group 2 (overweight) with BMI of 25–29.9 kg/m^2.
(3) Group 3 (class I obesity) with BMI of 30–34.9 kg/m^2.
(4) Group 4 (class II obesity) with BMI of 35–39.9 kg/m^2.
(5) Group 5 (class III obesity) with BMI of more than or equal to 40 kg/m^2.

Spirometry (prebronchodilator and postbronchodilator) was performed for all the study population by using ZAN 100 spirometer, 1999 (ZAN Messgeraete GmbH Company, Oberhulba, Germany) according to the American Thoracic Society criteria [7].

The measured pulmonary function parameters included the forced expiratory volume in first second (FEV1), forced vital capacity (FVC), peak expiratory flow rate (PEFR), forced mid-expiratory flow (FEF 25–75%), and the ratio of FEV1 to FVC (FEV1/FVC) in terms of percentage.

We interpreted the spirometric results where obstructive pattern was diagnosed when FEV1/FVC ratio was less than 70% of the predicted value, whereas a restrictive pattern was diagnosed with FVC% less than 80% of the predicted value in the presence of normal FEV1/FVC, and a mixed pattern was diagnosed with the combination of the both [8].

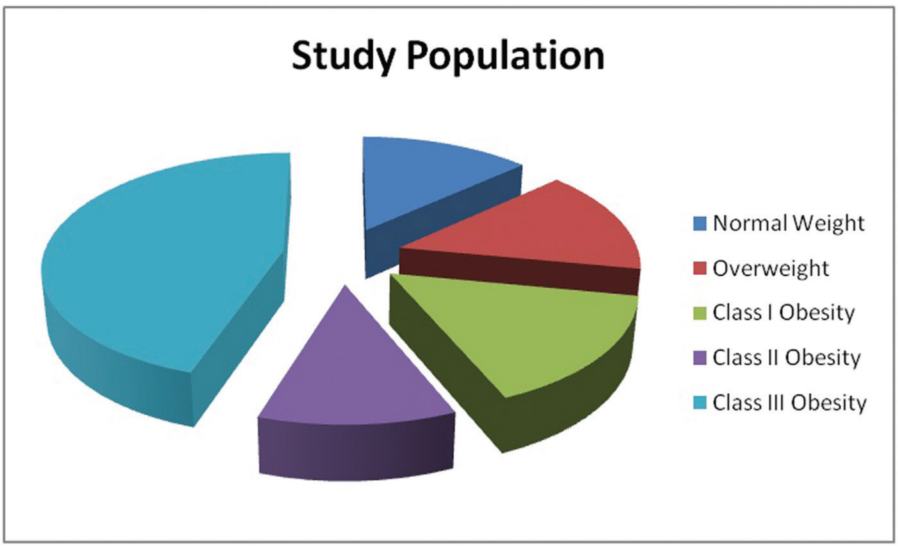
Statistical analysis

Data were coded and entered using the statistical package SPSS, version 25 (SPSS, IBM Corporation, New York, USA). Data were summarized using mean and SD for quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical variables. Comparisons between groups were done using analysis of variance with multiple comparisons post-hoc test in normally distributed quantitative variables, whereas nonparametric Kruskal–Wallis test and Mann–Whitney test were used for non-normally distributed quantitative variables [9]. For comparing categorical data, χ^2 test was performed. Exact test was used instead when the expected frequency is less than five [10]. *P* values less than 0.05 were considered as statistically significant.

Results

Our study population (Fig. 1) included 293 patients, who were divided according to their BMI into five groups irrespective of age or sex. A total of 93 (13.3%) patients formed the normal BMI group. The group with overweight patients contained 43 (14.6%) patients, class I obesity group had 46 (15.7%) patients, class II obesity group had 33 (11.3%) cases, whereas class III obesity group had the greatest share, where it included 132 (45%) patients. Data from males and females were grouped together because we did not find significant statistical differences between both sexes regarding the effects of BMI on the spirometric values. Patient characteristics and mean values for age, weight, height, and BMI are summarized in Table 1. It was observed that obese cases were older than the normal and overweight patients, with significant statistical difference. Our study included 168 males and 125 females within all groups, with male sex significantly predominant among

Figure 1

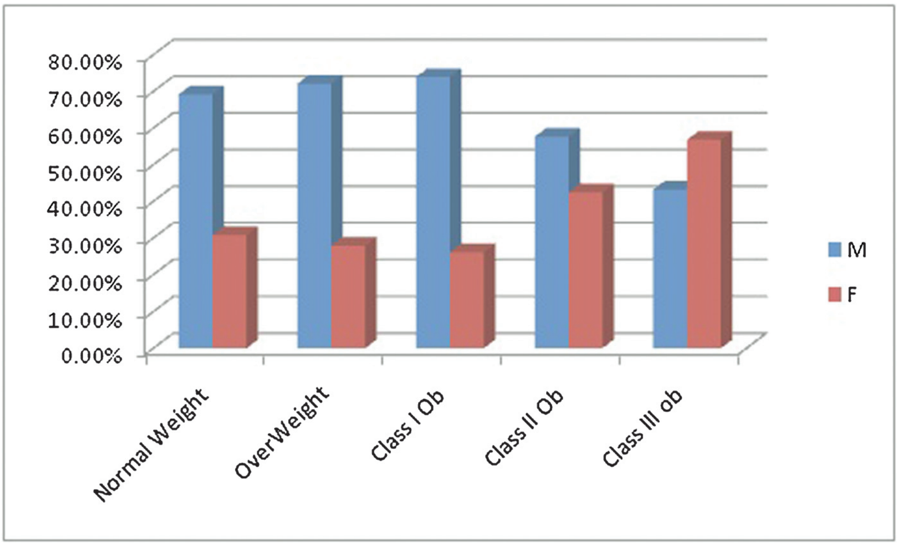


Study groups.

Table 1 Study population demographics

	Normal weight		Over weight		Class I obesity		Class II obesity		Class III obesity		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P* value
Age	32.90	9.79	38.63	14.60	42.63	14.16	47.91	15.87	43.67	13.49	<0.001
Weight	66.21	9.34	80.05	7.72	95.80	10.03	105.79	12.78	137.77	26.19	<0.001
Height	169.13	8.58	170.07	6.98	171.35	7.33	167.21	10.98	166.61	11.02	0.032
BMI	22.89	1.96	27.49	1.21	32.51	1.57	37.70	1.52	49.52	7.98	<0.001

Figure 2



Sex distribution among study groups. F, female; M, male.

Table 2 Mean values for pulmonary function parameters

	Normal weight		Overweight		Class I obesity		Class II obesity		Class III obesity		*P* value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
FVC	4.38	0.79	4.40	0.85	3.85	1.03	3.22	1.27	3.26	1.10	<0.001
FVC%	103.22	12.05	103.70	10.37	89.53	22.97	88.94	26.01	87.78	17.46	<0.001
FEV1	3.61	0.65	3.60	0.73	3.09	.81	2.62	1.08	2.69	.89	<0.001
FEV1%	100.67	11.05	102.50	10.34	89.89	19.48	87.09	26.35	86.56	17.63	<0.001
FEV1/FVC	82.74	7.83	81.87	6.80	81.88	7.65	80.83	8.53	82.49	7.32	0.800
FEF 25–75%	88.76	18.74	91.17	17.42	82.87	26.79	75.81	29.62	76.55	25.68	0.005
PEF%	89.72	14.10	92.27	21.96	86.09	16.69	80.71	21.26	81.77	18.88	0.006

FEV1, forced expiratory volume in first second; Flow FEF 27–75, forced mid-expiratory flow; FVC, forced vital capacity; PEF, peak expiratory flow.

all the study groups (Fig. 2), except within class III obesity group, where female sex was predominant, with statistical significance.

Mean values for pulmonary function parameters (FVC, FEV1, PEFR, FEF 25–75%, and FEV1/FVC ratio) for the different BMI categories are summarized in Table 2. There were significant differences in pulmonary functions in relation to the BMI of the patients. Although the mean values of these spirometric parameters lie within the normal range for all the groups, they were significantly lower when compared with those for the normal and overweight groups. On comparing the spirometric values between nonobese and obese patients, we found statistically significant differences in FVC and FVC% ($P<0.001$), FEV1 and FEV1% ($P<0.001$), and FEF 25–75% ($P<0.001$) between nonobese groups and classes II and III obesity. Differences regarding these parameters were found also between nonobese groups and class I obesity group but without significant statistical differences. No significant differences were found between our study groups regarding PEFR and FEV1/FVC ratio.

From Table 3, abnormal PFT was found in 34.1% (72 of 211 patients) of the total number of obese patients;

Table 3 Percentage of normal and abnormal pulmonary function test among obese patients

BMI	Normal PFT	Restrictive PFT	Obstructive PFT	Mixed	Total
Class I obesity (BMI 30–34.9)	34 (73.9)	11 (23.9)	1 (2.17)	0 (0)	46 (100)
Class II obesity (BMI 35–39.9)	21 (63.6)	8 (24.2)	2 (6)	2 (6)	33 (100)
Class III obesity (BMI ≥40)	84 (63.6)	42 (31.8)	3 (2.27)	3 (2.27)	132 (100)
Total	139 (65.9)	61 (28.9)	6 (2.8)	5 (2.4)	211 (100)

Values are expressed in *n* (%). PFT, pulmonary function test.

of which, the commonest pattern was restrictive (28.9%) followed by the obstructive and mixed patterns (2.8 and 2.4%, respectively). It was found that BMI has a direct influence on the spirometric measures, as the number of patients with abnormal PFT pattern increased at higher BMI values.

Discussion

We conducted this study to highlight the effect of obesity on the pulmonary functions of healthy individuals. Our study included 293 participants between volunteers and obese patients referred for prebariatric surgery evaluation. These patients were categorized according to their BMI into five groups. To our knowledge, this is the first study to address the relationship between different classes of obesity in otherwise healthy individuals and spirometric values among the Egyptian population.

This study used spirometry as it is a simple, economic, and reproducible tool for pulmonary function assessment in obese patients. We did not include other PFTs (e.g. lung volumes and diffusion capacity). This was also attributed to the fact that most of our obese patients were selected from those who were referred for prebariatric surgery assessment, where physical examination, chest radiography, and spirometry were routinely required.

From our results, spirometric parameters were decreased with increasing BMI, where the mean values of FVC, FEV1, and FEF 25–75% were significantly lower in patients with classes II and III obesity when compared with the nonobese patients. These findings were consistent with Schoenberg *et al.* [11] who declared that increase BMI was associated with a decrease in the pulmonary function values. Decline in the pulmonary function measures is directly proportional with the increase in the BMI and was more marked in patients with extreme obesity (BMI>35 kg/m^2), which was also the conclusion of other studies [12].

Ratio between FEV1 and FVC was preserved in our study, and no significant differences were noticed between nonobese and obese groups of patients regarding FEV1/FVC ratio, indicating equal reduction in both parameters (FEV1 and FVC) and denoting that there were no direct relations between obesity and airway obstruction [13,14]. Regarding that point, other studies were opposite to ours, where increase in BMI was associated with associated with increased incidence of airflow limitation and subsequent decrease in FEV1/FVC ratio [15]. Lazarus *et al.* [16] found that the FEV1 to FVC ratio decreases with increasing BMI in overweight and obese men and in morbidly obese women.

We did not find any significant differences between nonobese and obese groups regarding PEFR. This was different from previous research findings which showed negative correlation between obesity and the PEFR values, which were lower in the obese patients [17,18].

Abnormalities of the BMI, by either increase or decrease (underweight), were associated with a decline in the pulmonary functions. This was the conclusion of a previous work which showed the correlation between increasing of BMI and decrease of FVC, but without significant effects on FEF 25–75 rates [19].

Several factors related to obesity could be responsible for this relative decline in the pulmonary function parameters in our study including impairment of the respiratory system elasticity, elevated mechanical load of breathing [20], impaired respiratory muscles strength [21], in addition to decrease in chest wall compliance and improper expansion of the diaphragm by the mechanical effects of abdominal accumulation of excess fat [22].

Similar results were obtained by Mahajan *et al.* [23] where significant decline in FVC and FEV1 was observed between obese and nonobese patients, accompanied by insignificant differences regarding PEFR and FEF 25–75% between the nonobese and obese patients, irrespective of age, but this study was conducted on adult males only.

Moreover, FVC decline with increased BMI was observed in a long-term Canadian study [24]. According to Jones and Nzekwu [25], it was assumed that for every increase in body weight by approximately 10 kg, there was a fall of FEV1 of 51 ml in women, and they concluded that increased BMI has significant negative effects on all of the lung volumes.

Our results showed a significant reduction in the FEF 25–75 rates which was proportionate with the increase in BMI. A similar study showed that FEF 25–75% declined significantly in severe obesity [26]. On the contrary, insignificant differences between nonobese and obese patients regarding FEF 25–75% were declared by other studies [23].

In contrast to our study, there was no effect of increased BMI on different spirometric parameters when studied over a small sample size of obese adult women [27].In our study, abnormal PFT with predominance of the restrictive pattern was observed among obese group of patients. The ratio of the abnormal function tests increased significantly with the increase in BMI, reaching its highest proportion among the group of patients with BMI more than 40 kg/m^2 (31.8%). This was consistent with the findings of Prajapati *et al.* [28] where abnormal PFT was observed in 58% of the included obese patients, from which the commonest pattern was restrictive, representing 32%.

Spirometric values can be affected by increased BMI regardless of age. In a cross-sectional study addressing children between 7 and 18 years old, it was shown that spirometric parameters were adversely affected with obesity especially in cases with extreme obesity [29].

Many studies were conducted in different parts of the world and showed different results. Ethnical differences could be present affecting the relation between obesity and pulmonary functions, for example, a similar study conducted in Saudi Arabia showed different results from ours [18]. On the contrary, a Jordanian study showed results nearly resembling ours [17]. These differences could also be attributed to the distribution of body fat in obese patients which was not addressed in our study and was one of our study limitations.

Conclusion

Obesity is a major health problem in our country. Our study showed a statistically significant correlation between increasing of BMI and decline of pulmonary functions, and the more the BMI the more the function impairment. Therefore, obesity of especially moderate and severe degrees is associated with increased risk of pulmonary function impairment. This would emphasize the importance of weight control among Egyptians.

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Conflicts interest

There are no conflicts of interest.

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