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Gender Differences and Obesity Influence on Pulmonary Function Parameters

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ABSTRACT

Objectives: Overweight and obesity are known to cause various patterns of alteration to the pulmonary function test (PFT) parameters. We sought to investigate gender differences in PFT parameters and examine the relationship between body mass index (BMI) and PFT parameters. ***Methods***: We conducted a retrospective study of 126 patients referred for a PFT by various medical specialties between January and December 2015. PFT was measured using spirometry, and BMI was calculated using Quetelet's index. ***Results:*** Female patients exhibited lower mean values for all PFT parameters compared to male patients. The forced vital capacity (FVC)% predicted was less than 80% for all patients while the ratio of forced expiratory volume in 1 second (FEV_1)/FVC was higher with increased BMI. BMI was positively correlated with peak expiratory flow in all patients, and with FEV_1/FVC ratio in males but not in females. ***Conclusions:*** In our studied population, males exhibited higher mean values of PFT parameters than females. Increased BMI may be associated with a restrictive pattern on spirometry.

Obesity is defined as excess fat storage in the body that is capable of causing various health problems leading to excess mortality.[1] In Malaysia, the prevalence of overweight is plateauing, but obesity is still rising based on the 2015 National Health and Morbidity Survey.[2] The percentage of overweight and obese adult males increased from 16.6% and 4.4%, respectively, in 1996[3] to 29.1% and 14.0% in 2006,[4] and 30.0% and 17.7% in 2015.[2] Among adult females, the prevalence of obesity was relatively higher; from 7.6% in 1996,[3] to 17.4% in 2006,[4] and 20.6% in 2015.[2]

The obesity epidemic poses a new challenge for health professionals caring for patients with chronic respiratory diseases.[5] Overweight and obesity are known to cause various patterns of alteration to the pulmonary function test (PFT) parameters depending on its severity. Both static and dynamic lung volumes and capacities are compromised in obesity. Obesity is found to decrease the lung volumes and capacities by decreasing both lung and chest wall compliance.[6] There is also an increase in resistance to outflow of air through the airways.[7] Most studies were conducted in healthy individuals of various age groups.

There is a dearth of information on the alteration of the PFT parameters across gender and body mass index (BMI). Therefore, we sought to investigate gender differences in PFT parameters and examine the relationship between BMI and various PFT parameters.

METHODS

We conducted a retrospective study in the Universiti Sains Malaysia (USM) using data recorded from patients referred for PFT to the Physiology Laboratory, School of Medical Sciences, USM, between January and December 2015 by various medical specialties. Selection criteria included males and females between 19 and 90 years old. Patients were excluded if they were referred for pre- and post-bronchodilator assessment. Ethical approval for the usage of these data was obtained from the Human Research Ethics Committee of USM (USM/JEPeM/16110417).

Body weight data were obtained using a standardized electronic weighing machine and recorded to the nearest 0.1 kg. During body weight measurement, patients stood without footwear and wearing only light clothing. The heights of

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Table 1: Mean values of PFT parameters among male and female patients.

Parameter	Male (n = 85)	Female (n = 41)	Mean difference (95% CI)	t-statistic (df)	*p*-value*
Age, years	61.7 ± 13.2	53.2 ± 14.2	8.55 (3.44–13.65)	3.31 (124.0)	0.001
BMI	24.8 ± 5.1	25.4 ± 6.2	-0.53 (-2.61–1.54)	-0.51 (124.0)	0.612
FVC% predicted	71.2 ± 18.4	57.6 ± 19.9	13.54 (6.42–20.67)	3.76 (124.0)	< 0.001
FEV_1% predicted	67.6 ± 22.2	56.4 ± 19.1	11.16 (3.14–19.17)	2.76 (124.0)	0.007
FEV_1/FVC ratio	74.6 ± 13.4	82.6 ± 12.4	-4.60 (-10.41–1.21)	-1.57 (124.0)	0.119
PEF, L/sec	4.5 ± 1.9	2.9 ± 1.3	1.59 (0.99–2.17)	5.34 (107.1)	< 0.001

PFT: pulmonary function test; CI: confidence interval; BMI: body mass index; FVC: forced vital capacity; FEV1: forced expiratory volume in 1 second; PEF: peak expiratory flow .
Values are means±stRahimah Zakaria, et al.Rahimah Zakaria, et al.andard deviation unless otherwise specified.
**p < 0.050 by independent t-test.*

the patients were measured using the stadiometer and recorded to the nearest centimeter. BMI was calculated using Quetelet's index.[8] Subjects were stratified by BMI ranges as per WHO classification: Underweight (< 18.5 kg/m^2), normal weight (18.5 to 25.0 kg/m^2), overweight (25.0 to 30.0 kg/m^2), and obese (> 30.0 kg/m^2).

Spirometry was performed to measure pulmonary function by experienced laboratory technicians using automated testing equipment (Cosmed Pony FX Desktop Spirometer, USA) according to recommended standards by the American Thoracic Society.[9] The test was performed while patients were standing or seated on stiff chairs, in rooms with adequate ventilation and stable temperature (environmental temperature between 29°C and 33°C). Patients were instructed to sit comfortably and breathe normally three times and then take a deep breath and breathe out forcefully. All steps were repeated three times and the best results according to their predicted values were selected and recorded.

Data entry and statistical analysis were performed using SPSS Statistics (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). Values were reported as means±standard deviation (SD) unless otherwise specified. A *p*-value < 0.050 was considered significant in all analyses. The PFT data was recorded as an absolute value and predicted value based on gender, age, weight, and height. Comparison between genders was performed using Student's *t*-test while comparison across BMI subgroups was performed using analysis of variance (ANOVA) with post-hoc testing of significant variables with Bonferroni adjustment for multiple comparisons. Pearson's correlation coefficient was used to measure the relationship between BMI and PFT parameters.

RESULTS

Our study included 126 patients (85 males and 41 females) aged 19–90 years referred for a PFT between January and December 2015. Male patients were older than female patients (61.7±13.2 vs. 53.2±14.2 years).

The mean values of PFT parameters of male and female patients are shown in Table 1. There was a significant difference in the mean age between males and females ($p = 0.001$, 95% confidence interval (CI): 3.44–13.65). There were also significant differences in the mean values for forced vital capacity (FVC)% predicted ($p < 0.001$, 95% CI: 6.42–20.67), forced expiratory volume in 1 second (FEV_1)% predicted ($p = 0.007$, 95% CI: 3.14–19.17) and peak expiratory flow (PEF) ($p < 0.001$, 95% CI: 0.99–2.17). The mean values for FVC% predicted, FEV_1% predicted, and PEF were higher in males compared to females: 71.2±18.4 vs. 57.6±19.9, 67.6±22.2 vs. 56.4±19.1, and 4.5±1.9 vs. 2.9±1.3, respectively. However, the mean values for FEV_1/FVC ratio and BMI between males and females were not significantly different.

Our results showed no significant differences in the mean values for FVC% predicted, FEV_1% predicted, FEV_1/FVC ratio, PEF, and mean age among the BMI categories [Table 2].

Table 3 shows the results of Pearson correlation between BMI and various PFT parameters. The results showed a significant but weak positive correlation between BMI and FEV_1/FVC ratio,

Table 2: Demographic data and mean values of PFT parameters among various BMI subgroups.

Variable	Underweight	Normal weight	Overweight	Obese
Sex, n	11	53	43	17
Male	8	36	30	9
Female	3	17	13	8
Age, years	63.1 ± 22.4	61.0 ± 14.2	56.1 ± 12.3	56.8 ± 11.2
Male	68.8 ± 22.6	63.0 ± 13.0	59.4 ± 10.5	58.7 ± 11.4
Female	48.0 ± 15.7	57.3 ± 16.0	48.1 ± 12.5	54.8 ± 11.3
FEV_1% predicted	60.2 ± 19.4	63.4 ± 24.4	67.4 ± 20.4	62.9 ± 18.4
Male	63.5 ± 20.9	67.1 ± 24.9	70.0 ± 20. 3	65.1 ± 21.1
Female	51.4 ± 13.7	53.7 ± 21.3	58.8 ± 20.1	60.5 ± 15.9
FVC% predicted	64.2 ± 17.7	66.7 ± 22.3	69.8 ± 18.7	60.5 ± 16.6
Male	66.9 ± 18.7	72.7 ± 19.6	72.9 ± 17.2	63.3 ± 17.6
Female	56.8 ± 15.0	53.6 ± 22. 2	63.4 ± 20.7	57.4 ± 16. 0
FEV_1/FVC ratio	75.7 ± 16.6	76.0 ± 14.4	78.2 ± 10.9	84.6 ± 5.9
Male	74.6 ± 18.1	71.4 ± 14.5	76.7 ± 12.0	81.3 ± 4.3
Female	78.6 ± 14.6	83.8 ± 13.0	78.5 ± 14.1	88.2 ± 5.4
PEF, L/sec	3.2 ± 1.6	3.7 ± 2.1	4.5 ± 1.6	4.4 ± 1.8
Male	3.5 ± 1.8	4.2 ± 2.1	5.0 ± 1.5	5.1 ± 2.0
Female	2.5 ± 0.5	2.4 ± 1. 4	3.3 ± 1.3	3.6 ± 1.3

PFT: pulmonary function test; BMI: body mass index; FEV1: forced expiratory volume at 1 second; FVC: forced vital capacity; PEF: peak expiratory flow.
Values are means±standard deviation unless otherwise specified.
**p < 0.050 vs. normal weight.*

and between BMI and PEF. There were no significant correlations between BMI and the other parameters.

Table 3: Pearson correlation between BMI and PFT parameters.

Correlation of BMI with	Pearson correlation coefficient, r	*p*-value
FEV_1% predicted	0.079	0.379
Male	0.093	0.398
Female	0.097	0.548
FVC% predicted	-0.033	0.716
Male	-0.029	0.792
Female	-0.003	0. 983
FEV_1/FVC ratio	0.262	0.003**
Male	0.277	0.010*
Female	0.234	0.142
PEF, L/sec	0.282	0.001**
Male	0.308	0.004**
Female	0.408	0.008**

BMI: body mass index; PFT: pulmonary function test; FEV1: forced expiratory volume in 1 second; FVC: forced vital capacity; PEF: peak expiratory flow.
**Correlation significant at the 0.05 level (two-tailed).*
***Correlation significant at the 0.01 level (two-tailed).*

DISCUSSION

Our study had three main findings: 1) male patients had higher mean values of all PFT parameters compared to females, 2) there were no significant differences in the mean values of PFT parameters among various BMI categories, and 3) there were significant weak positive correlations between BMI and FEV_1/FVC ratio, as well as between BMI and PEF. The effects of BMI on PFT parameters were more pronounced in males than females.

Our data analyses on the mean values of PFT parameters between genders revealed significant gender differences for FVC% predicted, FEV_1% predicted, and PEF despite no difference in their BMI. Our results correspond with other studies that reported higher mean values of PFT parameters in male patients compared to females.[10,11] This trend, however, contrasts with another report where females exhibited higher PFT parameters compared to males.[12] Several other studies, reported no significant gender differences in the pulmonary function profiles in the sample studied.[13–16] Possible explanations on the gender differences include differences in lung geometry between the genders; females, on average, would be expected to have smaller airways and lung volumes than males.[17] Hormonal differences may be another contributing factor.[18]

Despite no significant difference in the PFT parameters among the various BMI categories, the FEV_1/FVC ratio demonstrated an increasing trend with increasing BMI ranges in our study. We also found a significant, albeit weak, positive correlation between BMI and FEV_1/FVC ratio as well as between BMI and PEF. These findings suggest the restrictive effects of increased BMI as all our patients exhibited FVC < 80%. This phenomenon has also been reported in other earlier studies.[12,19–21]

A previous study looked at the relationship between obesity and airway obstruction and found that obese participants were at lower risk for airflow obstruction.[19] The authors concluded that mechanisms other than airflow obstruction may be responsible for dyspnea in their obese population.[19]

In another study, the effect of BMI on pulmonary function in Japanese patients attending general clinics was investigated.[20] The researchers found that patients with higher BMI had less obstructive pulmonary dysfunction compared to normal BMI patients and concluded that high BMI status alone might be inappropriate as a predictor of obstructive lung dysfunction, particularly in populations with a low prevalence of obesity.

Moreover, one study found a restrictive pulmonary function profile in obesity specific to non-asthmatics.[21] Similar findings were noted in another study whereby a significant increase in the FEV_1/FVC ratio demonstrated throughout increasing BMI ranges is suggestive of the restrictive effects of increased BMI.[12]

Other investigators found that obesity does not have an effect on the spirometry tests (except PEF) among healthy non-smoking Saudi adults.[22] This discrepancy could be due to the differences in the study populations as our study included both smokers and non-smokers. In addition, Biring et al,[14] found a reduction in expiratory reserve volume, FVC, FEV_1, functional residual capacity, forced expiratory flow 25–75%, and maximum voluntary ventilation in their study on adults with extreme obesity. Our study population categorized adults with BMI > 30.0 kg/m^2 as obese and did not further subcategorized obese into class I (30.0 to < 35.0), II (35.0 to < 40.0), and III or extreme obesity (40.0 or higher).

CONCLUSION

Males have higher mean values of PFT parameters than females, and a higher BMI seems to be associated with a restrictive pattern on spirometry.

Disclosure

The authors declared no conflict of interest. No funding was received for this study.

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