Effect of the obesity on the pulmonary function test

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Abstract: Obesity is a global health hazard. As standards of living are continuing to rise, weight gain and obesity are posing a growing threat to health in countries all over the world. These obese individuals are at increased risk of morbidity and mortality because of its relationship with various metabolic disorders. It is also known to cause alterations in pulmonary functions, so the present study was planned to assess the effect of obesity on pulmonary function tests in adult males and females. To investigate the relationship between body mass index (BMI) and forced expiratory volume in one second (FEV1), forced vital capacity (FVC), ratio between FEV1/FVC, and peak expiratory flow (PEF) among nonsmoking adult males and females. Data were collected from 247 of adult healthy subjects with range age 32.63, There were 112 males and 135 females subjects, was classified on the basis of sex specific BMI as normal weight, overweight, obese, and moderate obese groups. Pulmonary function test (PFT) and body mass index (BMI) were compared among sex and BMI groups. Subjects underwent spirometry tests according to American thoracic society standards with measurement of the following values, the forced vital capacity (FVC), forced expiratory volume in one second (FEV1), peak expiratory flow rate (PEF). We found no significant differences in FVC and PEF (p value > 0.05) in comparison between the obese and non-obese subjects, but there were a significant FEV1and FEV1/FVC with increasing BMI for adult females. An increase in BMI had no significant effect on spirometric measurements in adult males. Mean FVC, FEV1, FEV1/FVC, and PEF were found a high significant differences (P- value <0.0001) between mean spirometric values of men and women for all range BMI overweight, obese, and moderate obese.

Keywords: healthy nonsmoker adults, obesity, Pulmonary function test, spirometer, and body mass index.

Introduction:

Obesity is a medical condition characterized by an excessive accumulation of fat on human body that causes a general increase in body mass [1]. In healthy Obesity and physical inactivity are two main factors that affect respirator function [2] [3]. Obesity has a clear potential to have a direct effect on respiratory weal- being, Since it increases oxygen consumption and carbon dioxide production, while at the same time it stiffens the respiratory system and increases the mechanical work needed for breathing[4]. BMI is a simple index of weight for height that is commonly used to classify individuals into normal weight, overweight, obese, and moderate obese categories in adults. It is defined as a person's weight in kilograms divided by the persons height in meter squared (Kg/m^2), Body mass index (BMI) of 18 to 24.9 Kg/m^2 is considered normal weight, a BMI of 25-29.9Kg/m^2 is considered overweight and 30Kg/m2 or higher is considered obesity [5]. weight may have effect on pulmonary function tests such as impairment on pulmonary function, small airway dysfunction, expiratory flow limitation, alterations in the respiratory mechanism, decreased chest wall and lung compliance, decreased respiratory muscle strength and endurance, decrease pulmonary gas exchange, lower control of breathing, and limitations in exercise capacity [6][7][8]. With regard to lung function the evidence suggests that changes in weight [9] [10] or changes in body mass [11] are negatively associated with changes in lung function in adults.

In 2010 Cheryl *et al.* study the effect of Physiology obesity on lung function. However, obesity has little direct effect on airway caliber. Spirometric variables decrease in proportion to lung volumes, but are rarely below the normal range, even in the extremely obese, while reductions in expiratory flows and increases in airway resistance are largely normalized by adjusting lung volumes [8].

Y chen *et al.* (2007) [12], have stated in their study that pulmonary function initially increase as weight increase and decrease as weight continued to increase, they consider that the pulmonary function with weight may reflect increasing muscle force and the decrease with further weight gain may be due to obesity which limits the mobility of thoracic cage, they have observed in their study that the body mass index at the baseline subsequent weight gain are significantly related to decline of pulmonary function test in adults.

Mohammed Al Ghobain (2012) [1] studied the effect of the interaction between obesity and PFT among healthy non-smoking adults in Saudi Arabia. The results showed that the Obesity does not have effect on the spirometry tests (except PEF) among health non-smoking adults.

The aim of this study is to investigate the obesity on spirometry tests among healthy non-smoking adults. Our study is limited to spirometry part of PFT because spirometry tests are considered to be the initial screening tool for pulmonary diseases, they are the most widely used tests, and they are easy to conduct using equipment that is available in all pulmonary functions laboratories.

The lung function tests are carried out by the same team of technicians according to the recommended standard [13]. The best of at least three technically acceptable values for forced expiratory volume is in one second (FEV1), forced vital capacity (FVC), and peak expiratory flow (PEF).

Patients and methods:

The data of this study was carried out at the pulmonary function test unit of al- Imamain kadhmayia hospital, during the period from february to June 2013, A total subject of (247) were selected from the adult (112) male and (135) female of healthy volunteers or hospital visitors. The subjects were Iraqi non-smokers for either cigarettes or water pipes (shisha) with their age ranged 32.63 ± 4.02 year. Weight was measured using a digital scale (Kg), with measurement error in weight < 0.5 Kg due to clothes weight. Height was measured by stadiometer, then assessed by calculating body mass index (BMI= weight/ (height) ^{2}[Kg/m^2]).

In this study, the instrument used to measure respiratory parameters was (Jaeger, Germany (1992- 1997)). The following parameters were assessed by computerized spirometry for both the control and study groups - Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), and peak Expiratory Flow (PEF).

Subjects rested for 5 minutes before measurements and were informed about the procedure. The tests were done by inserting the mouthpiece into the subject's mouth adjusting the height of the mouth- piece to suit comfort of the subject and fix the nose- clip and support the subject's head with a pillow in order to keep the patient relaxed and breathing normally, each subject was asked to do a forced quick expiration after maximum inhalation. After doing at least two acceptable and repeatable FVC, FEV1, and PEF was recorded after examining.

Then, the subjects were briefed about the procedure. It was said that they have to make a full expiratory and inspiratory loop as a single manoeuvre. They were instructed that they will be asked to place nose clip and take a rapid full inspiration to total capacity from room air through the mouth, then to insert the disposable mouth piece and without hesitation to perform an expiration with maximum force until no more air can be expelled, followed by a quick maximum inspiration at which point, the manoeuvre will be finished.

The subjects were divided into four groups according to their BMI. the first group consisted of non- obese (normal body weight) subjects with BMI of 18 to 24.9 Kg/m^2, the second group (Overweight) consisted of obese subjects with BMI of < 25 Kg/m^2 and > 30 Kg/m^2, and the third group, which is considered obese, consisted of a 30 > BMI < 35 Kg/m^2, and higher than that is considered moderate obese with BMI > 35 [5].

We compare the control group (normal BMI) with each group of males and females for Overweight, obese, and moderatobese and measurement spirometric vales which include FVC (Forced Vital Capacity), FEV1 (Forced Expiratory Volume in first second), and PEF (Peak Expiratory Flow) rate, another comparison for each group according to the body mass index (BMI) Overweight, obese, and moderatobese among the males and female.

The mean and the standard deviation for each group parts data were estimated employing Microsoft Excel program. A paired sample T-test was used comparing the data for the Control group and Overweight, obese, and moderate obese. The difference was considered statistically significant, when the P-value was less than 0.05 [14].

Results: Two hundred and forty-seven (112 males and 135 females) of healthy volunteers or hospital visitors subjects with mean age 32.63 ± 4.02 years that Concerns the mean of height, weight, and BMI respectively is illustrated in tables. As well as mean of spirometric values of FVC, FEV1, FEV1/FV%, and PEF.

Table (1) shows the finding that includes 135 females with mean age 32.78 ± 5.03 years. And there is no statistical difference between mean spirometric values FVC for body mass index (BMI) with P-value > 0.05 in compared obese group and moderateobese with the Control group, but the FVC of overweight females was significant with P-value ≤ 0.05 only. FEV1 was significantly different among overweight, obese group, and moderateobese in comparison with the Control group with P-value ≤ 0.05, while the ratio of FEV1/FVC% was not significant in comparison with overweight, but it is significant for BMI of obese and moderateobese with P- value ≤ 0.05. The spirometric value of PEF for BMI of female groups were no significant P-value > 0.05 in comparison with the Control group.

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Table (1): Comparison between spirometric values for BMI of study sample females.

Value spirometric	BMI			
	Control N= 28 Mean± SD	Overweight N= 38 Mean± SD	Obese N= 30 Mean± SD	Moderate N= 39 Mean± SD
Age (year)	26.8 ± 6.45	31.66 ± 7.9	33.7 ± 4.51	38.95 ± 6.1
Weight (Kg)	55.21 ± 5.38	68.63 ± 6.2	78.47 ± 6.74	98.33 ± 16.77
Height (m)	153 ± 5.25	157.13 ± 6.2	154.93 ± 6.12	154.33 ± 6.17
BMI (Kg/m^2)	23.31 ± 1.61	27.7 ± 1.29	32.65 ± 1.49	≥ 35 ± 6.64
FVC P- value	2.61 ± 0.33	2.86 ± 0.53 0.02	2.85 ± 0.68 0.086	2.5 ± 0.45 0.26
FEV1 P- value	2.53 ± 0.29	2.73± 0.41 0.026	2.7 ± 0.69 0.022	2.36 ± 0.41 0.05
FEV1/FVC% P- value	97 ± 3.62	95.79 ± 9.1 0.57	94.7 ± 5.5 0.028	94.7 ± 5.33 0.029
PEF P- value	4.9 ± 0.93	5.29 ± 1.29 0.15	5.25 ± 1.07 0.18	4.82 ± 0.95 0.74

Table (2) illustrate the results included of 112 males with mean age 31.15 ± 1.56 years. There is no statistical difference between mean spirometric values FVC, FEV1, FEV1/FV%, and PEF for BMI for male groups in comparison with the Control group, except PEF for obese male.

Table (2): Comparison between spirometric values for BMI of study sample males

Value spirometric	BMI			
	Control N= 28 Mean± SD	Overweight N= 38 Mean± SD	Obese N= 30 Mean± SD	Moderate N= 39 Mean± SD
Age (year)	29.9± 6.75	30.76 ± 7.86	33.42 ± 5.48	30.52 ± 6.07
Weight (Kg)	63.85 ± 7.64	81.24 ± 7.31	92.71 ± 9.82	111.4 ± 10.01
Height (m)	170.1 ± 6.95	171.5 ± 5.7	169.71 ± 7.13	168.76 ± 5.99
BMI (Kg/m^2)	21.98 ± 8.9	27.57 ± 1.44	32.2 ± 1.86	≥ 35 ± 2.3
FVC P- value	3.82 ± 0.59	3.76 ± 0.53 0.6	3.78± 0.51 0.76	3.89 ± 0.49 0.65
FEV1 P- value	3.63 ± 0.54	3.57 ± 0.41 0.62	3.59 ± 0.53 0.76	3.63 ± 0.47 0.99
FEV1/FVC% P- value	95 ± 5.46	94.9 ± 9.1 0.98	94.97 ± 5.3 0.91	93.33 ± 5.4 0.25
PEF P- value	6.86 ± 1.34	7.55 ± 1.71 0.07	8.08 ± 2.3 0.04	7.64 ± 1.93 0.12

Table (3) reveals the results of spirometry variables FVC, FEV1, FEV1/FVC%, and PEF for BMI and comparison between males and females for overweight, obese, and moderatobese. The spirometric values were lower in females groups in comparison with the male groups, the results demonstrate a high significant difference ($P < 0.0001$) in the mean values FVC, FEV1, and PEF, but there is no statistical significant difference of FEV1/FVC% among the BMI (overweight, obese, and moderateobese) for males and females with P-value > 0.05.

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Table (3): Comparison of spirometric values for BMI of study sample among males and females.

value spirometric	BMI					
	Overweight males N= 33 Mean± SD	Overweight females N= 38 Mean± SD	Obese males N= 24 Mean± SD	Obese females N= 30 Mean± SD	Moderate males N= 21 Mean± SD	Moderate females N= 39 Mean± SD
FVC	3.76 ± 0.42	2.86 ± 0.53	3.78± 0.51	2.85± 0.68	3.89 ± 0.49	2.5 ± 0.45
P- value	<0.0001		<0.0001		<0.0001	
FEV1	3.57 ± 0,41	2.73 ± 0.41	3.59 ± 0.53	2.7 ± 0.69	3.63 ± 0.47	2.36 ± 0.41
P- value	<0.0001		<0.0001		<0.0001	
FEV1/FVC%	95 ± 4.76	95.5 ± 4.3	95 ± 5.2	94.7 ± 5.5	93.3 ± 5.3	94.4 ± 5.31
P- value	0.56		0.66		0.39	
PEF	7.55 ± 1.71	5.29 ± 1.29	8.03 ± 2.3	5.25± 1.07	7.64 ± 1.93	4.82 ± 0.95
P- value	<0.0001		<0.0001		<0.0001	

Discussion

Obesity presents the intriguing questions of whether and how to anticipate its effect on pulmonary function. Relating normal physiological function in relationship to body size seems appropriate. According to this, the larger the organism, the greater the amount of organ system function needed to maintain homeostasis. Most equations for predicting pulmonary function are based on data from normal subjects, using age and height as variables. Further by including body weight as a parameter to these equations the predictive ability can be improved [15], this study is an attempt to find the effect of gain of body weight on lung functions. Body mass index is a better indicator of accumulation of adipose tissue since it is calculated using height and weight of an individual.

The present study illustrated that the FVC was significantly in overweight subjects when compare to the normal subjects, table (1).the result of the present study was consistent with study done by chen *et al.* (2007) [12], they have observed that there was negative associated between the BMI and FVC in overweight when compared to the normal weight subjects. They further state it was likely the cause of pulmonary function decline and respiratory function was determined by the interaction of lungs and chest wall and muscles, but no significant difference was observed in values of FVC in obese females (BMI> 30) when compared to the control group, this findings agreement with the results of costa et al (2008) [16].

In current study FEV1 exhibited significant with body mass index (BMI) in comparison with control groups, Amit Bandyopadhyay (2011) [17] observed significant correlation with body mass. There was also a significant difference in the mean values ratio of FEV1 between control and obese female groups ((BMI> 30), but non-significant in FEV1/ FVC have been observed only in overweight female groups. One proposed mechanism is that abdominal fat displaces the diaphragm into abdomen [18].

In addition, our data show that there is no significant in values of PEF between in all groups of body mass index and control BMI. The increase in airway obstruction and not improved ventilator machines after increasing BMI for female in compare with normal BMI [19].

Further in the present study when the FVC, FEV1, FEV1/FVC, and PEF were compared between the normal weight and overweight, obese, and moderate obese subjects for male, the results was not statistically significant table (2), similar to the finding of Canoy *et al.* [20] and the result of the present study was consistent with the study done by yogesh sexena *et al.* [21] in 80 healthy volunteers from both the sexes of the age group 20-40 year, they have compared the FEV1 between the control group with obese group males and have observed that there was no significant in FEV1.

Hani et al 2012[22] have found that measures of body mass index were inversely related to the spirometric variable of PEF.

Adiposity, especially of chest and abdomen was considered to restrict the normal movements of chest and diaphragm [23].

There are important sex differences with regard to cardiovascular function, thermoregulation, substrate metabolism, and pulmonary function [24]. Results of our study showed that there were a significant differences between the males and females with respect to the body mass index (BMI) and The female subjects had lower values than the males in FVC, FEV1, and PEF, however, there was no significant difference between the two groups in regard to FEV1/FVC% for overweight, obese, and moderate obese with P-value > 0.05, table (3).

The volume of adult females lungs is typically 10-12% smaller than that of males who have the same range height and age, differences in thoracoabdominal configuration could impact the function of respiratory muscles, the rib cage cross sectional area is smaller in females than males [25], and the sex differences in the lung capacity can be explained by fewer total number of alveoli (small surface area) and smaller airway diameter relative to lung size in woman as compared to men [24].

The effects of obesity on spirometric values are not consistent across all studies with some studies shown no effects and some other studies shown positive effects. This discrepancy between studies could be explained by the wide variations in ethnicity of different population in PFT values or this may be a result of methodological differences in these studies.

Conclusion

Spirometry is useful clinical in respiratory medicine and a proper utilization of it requires a clear understanding between the subject, the technician, and the way in which the test is performed and how it is interpreted. Even though this type of study is carried in different parts of the world, they have used different various measures of adiposity to rule out the association between body mass index and effect of it on lung function. So in the present study we conclude that mean FVC, FEV1, and PEF were higher in male than in female in each body mass index group, but FEV1/ FVC% was not significantly associated with the most of body mass index of overweight, obese, and moderate obese in comparison between male and female.

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