Research Article

Effects of Obesity on Lung Functions in Young Adults

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Abstract | Obesity is a global health problem and its prevalence is increasing continuously. It is the fifth leading cause of death worldwide and is associated with decreased lung functions.
Objective: This study was designed to compare the pulmonary functions in obese and non-obese subjects. Additionally, we aimed to correlate the body mass index (BMI), waist circumference (WC), and waist-to-hip ratio (WHR) with pulmonary function tests (PFT's).
Material and Methods: This cross sectional comparative study was conducted at the Institute of Chest Medicine, King Edward Medical University, Lahore, Pakistan. One hundred and twenty individuals consisting of 60 obese (30 males, 30 females) and 60 non-obese (30 males, 30 females), fulfilling the inclusion criteria, were enrolled through non-probability purposive sampling. Informed written consent was taken from all subjects. The demographic information of these subjects such as name, age, sex, height, weight, body mass index, waist circumference, and waist-to-hip ratio were recorded. Spirometry of all the subjects was performed on Spirolab iii. Correlation between FVC, FEV1, FEV1/ FVC ratio and body mass index, waist circumference, and waist to hip ratio was measured by Pearson coefficient. A p value <0.05 was considered as significant.
Results: In this study mean age of subjects was 28.92 ± 6.34 years. The mean FVC in obese cases was 3.18 ± 0.92 L and in non-obese cases was 3.68 ± 0.93 L with p value of 0.021. The mean value of FEV_1 in obese was 2.83 ± 0.82 L and in non-obese cases was 3.19 ± 0.71 L with p value 0.011 and mean FEV_1/FVC ratio in obese cases was 84.73 ± 11.86 and in non-obese cases it was 90.27 ± 6.89 with p value of 0.002. In this study, there was a negative correlation between FVC, FEV1 and body mass index, waist circumference, and waist to hip ratio with p value <0.05.
Conclusions: It is plausible to conclude that obese individuals in this sample had significantly lower FVC and FEV1 values compared to non-obese. Body mass index, waist circumference and waist-to-hip ratios were negatively associated with FVC and FEV1.

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Introduction

Obesity is a serious health problem, which is increasing rapidly throughout the world. Overweight and obesity are the fifth leading risks for global deaths, and are linked with various metabolic diseases. The prevalence of obesity is increasing significantly in many regions of the world for example in

United States, almost 33% adults are obese and 65% are overweight.[1] In Pakistan, Jafar et al. has reported that the prevalence of obesity is 10.3% and that of overweight is 25%.[2]

Several methods have been proposed to measure obesity, however, the most commonly used approach is the body mass index (BMI). Normally, BMI ranged from 18.5 to 24.9kg/m^2 and in overweight individuals it is raise to 25-29.9 kg/m^2. When the BMI approaches 30kg/m^2 or above, it is categorized as obese.[3] WHO has recognized that Asians experience health problems at lower BMI than the Caucasians and therefore Asian obesity has been redefined. According to this revised criteria, 18.5-22.9kg/m^2 is the normal BMI and between 23-24.9 kg/m^2 is classified as overweight. BMI greater or equal to 25kg/m^2 is considered obese.[4]

Studies have shown that health of a person is affected not only by the amount of body fat but also by the pattern of its distribution. It is the android obesity or abdominal adiposity, which is considered as more related to the clinical and metabolic abnormalities. Whereas, the gynoid obesity, which has a peripheral fat distribution pattern, has a relatively lower risk of poor health.[5] BMI and body weight are inexpensive and can be easily measured to determine obesity. The drawback in using these methods is that both of these are unable to differentiate between the fat and the muscle mass. Moreover, BMI cannot describe the pattern of fat distribution in the body. For estimation of the distribution pattern, waist circumference (WC) and waist to hip ratio (WHR) are better indicators of abdominal or central obesity and are more closely associated with the pulmonary functions.[6]

Obesity is a chronic disease which involves the accumulation of fat in the body to an extent that it starts damaging the health of the person directly as well as indirectly. It is associated with many clinical conditions such as diabetes, hypertension, vascular dysfunction and metabolic syndrome. The role of obesity in the impairment of pulmonary system is also significant. The respiratory system is affected negatively by the excess deposition of fatty tissue in the body. Fat alters the lung mechanics, decreases the efficiency and strength of respiratory muscles and reduces the compliance. Obesity also affects the distribution of ventilation and perfusion of lungs along with closure of small airways and alveolar collapse thus reducing the lung function tests and exercise capacity.[7] Excess deposition of fat in the abdominal wall and around the viscera tends to push the diaphragm upwards into the chest thus hindering the downward movement of diaphragm during inspiration. Also, during expiration the elastic recoil of diaphragm is increased. Thus lungs are not filled to their full potential resulting in decreased functional residual capacity (FRC), Expiratory reserve volume (ERV), Total lung capacity (TLC), Forced vital capacity (FVC), Forced expiratory volume in first second (FEV_1) and FEV_1/FVC ratio.[8]

Spirometry is the best technique to determine the lung functions and to diagnose and treat different respiratory conditions. This method is used to measure few lung functions such as forced vital capacity (FVC), which is the volume of air forcefully exhaled from the point of maximum inspiration. It also measures (FEV_1), the volume of air expired during the first second of the above-mentioned procedure. The FEV_1/FVC ratio is calculated by computing both measurements. The instrument used in spirometry is called spirometer.[9]

In this study, we investigated the effects of obesity on lung functions and correlation of different adiposity markers such as body mass index, waist circumference, and waist to hip ratio with the dynamic lung volumes FVC, FEV_1 and FEV1/FVC ratio. Finding of this study facilitate the understanding of the relationship of obesity with the respiratory problems in Pakistani population.

Patients and Methods

This cross sectional comparative study was conducted at the Institute of Chest Medicine, King Edward Medical University Lahore, Pakistan. Sample size was one hundred and twenty individuals. Among them 60 were obese (30 males, 30 females) and another 60 were non-obese (30 males, 30 females). Sample size was calculated by taking confidence level=95%, power=90% and mean difference for spirometric parameters for obese and non-obese individuals (obese 3.55 $\pm$ 0.36 L, non-obese 3.75 $\pm$ 0.28 L).[10] It was non-probability purposive sampling.

The study groups were divided into obese and non-obese groups. Subjects ranging from 20-40 years of age, non-smokers, healthy, mentally fit of both genders were included. BMI values between 18.5 and 22.9 Kg/m^2 were considered non- obese. A BMI greater than or equal to 25 kg/m^2 was considered obese. Subjects with history of asthma, chronic bronchitis, interstitial lung disease, respiratory tract infection or on treatment of any of these conditions and those who were Unable to complete spirometry were excluded from the study.

The data was collected from the medical students, employees of KEMU/Mayo Hospital and the attendants of the patients presented to the hospital. Informed written consent was taken from all subjects. Subject's identity was kept confidential. The demographic information of these subjects like name, age, sex, height, weight, body mass index, waist circumference, and waist to hip ratio were recorded on proforma. Subjects were advised to wear light clothing and keep their feet 25-30 cm apart and straight back. Waist circumference was measured at top of the hip bone at the side of the waist. Bottom edge of the measuring tape was aligned at the top of hip bone. Subjects were asked to take deep breath and on exhalation waist circumference was measured by tightening the tape taking care not to compress the skin fold. Hip circumference was measured at the level of greater trochanter of femur by tailor's measuring tape taking care not to compress the skin fold. Waist to hip ratio was calculated from waist circumference and hip circumference.

Spirometry was performed on Spirolab III. All subjects were asked to come between 10 a.m. to 1.00 PM. with light breakfast and to avoid tight clothing. The procedure was explained to the subjects. Nose clips were used to avoid air leak. Disposable mouthpiece was used for each subject. Subjects were asked to inhale maximally, close the lips tightly around the mouthpiece and immediately blow the air out with full force until no air came out from the lungs. Same procedure was done again and three acceptable and reproducible results were recorded. Results were called acceptable which started at maximum inspiration, without any hesitation at start and expiration completed without any pause. Reproducible results were those in which maximum variation of two best reading of FVC and FEV1 were less than 200 ml. Predicted values were calculated from the subject's data such as sex, age, ethnic group, weight and height. Results were interpreted with predicted values.

Data was analyzed using SPSS software, version 20. Independent 't' test was used to compare the FVC, FEV1 and FEV/FEV1 between obese and non-obese groups. Pearson correlation was used to assess linear correlation between anthropometric variables like BMI, waist circumference, waist hip ratio and lung volumes. The p-value of ≤0.05 was considered statistically significant.

Results

The mean age of all cases in this study was 28.92 ± 6.34 years, while mean age in obese and non- obese cases was 32.18 ± 5.89 years and 25.65 ± 4.98 years. The mean FVC in obese cases was 3.18 ± 0.92 L and in non-obese cases was 3.68 ± 0.93 L with p value of 0.021. The mean value of FEV_1 in obese was 2.83 ± 0.82 L and in non-obese cases was 3.19 ± 0.71 L with p value 0.011 and mean FEV_1/FVC ratio in obese cases was 84.73 ± 11.86 and in non-obese cases it was 90.27 ± 6.89 with p value of 0.002. The mean FVC, FEV_1 and FEV_1/FVC ratio was significantly lower in obese cases when compared to non-obese cases, p-value < 0.05 (Table 1).

Table 1: *Distribution of subjects by pulmonary function tests*

	Obesity	Mean	S.D	Minimum	Maximum	p-value
FVC (Liters)	Obese (n=60)	3.18	0.92	1.07	5.24	0.021*
	Non Obese (n=60)	3.68	0.93	2.04	5.80	
	Total (n=120)	3.43	0.93	1.07	5.80	
FEV1 (liters)	Obese (n=60)	2.83	0.82	1.00	5.21	0.011*
	Non Obese (n=60)	3.19	0.71	1.92	4.50	
	Total (n=120)	3.01	0.79	1.00	5.21	
FEV1/FVC Ratio	Obese (n=60)	84.73	11.86	9.40	97.60	0.002*
	Non Obese (n=60)	90.27	6.89	72.30	100.00	
	Total (n=120)	87.50	10.05	9.40	100.00	

*SD: Standard Deviation; * P Value < 0.05 is Significant*

Pearson correlation equation was used to assess the relationship between different obesity markers like BMI, waist circumference, hip circumference, waist –hip ratio and lung volumes FVC, FEV_1 and FEV_1/FVC ratio.

Among obese cases we found significant negative correlation of BMI with FVC (r value -0.329, p value 0.010) while FEV_1 also had significant negative correlation with BMI (r value -0.281, p value 0.046). There was significant positive correlation seen between BMI and FEV_1/FVC ratio (r value 0.293, p value 0.023). In non-obese cases there was no significant correlation between BMI and FVC, FEV_1 and FEV_1/FVC ratio (P value >0.05).

There was significant negative correlation seen between waist circumference and FVC (r value -0.381, p value 0.017) and FEV_1 (r value -0.373, p value 0.019) in obese cases. In non obese cases there was no significant correlation between waist circumference and FVC, FEV_1 and FEV_1/FVC ratio (P value >0.05).

No significant correlation was found in hip circumference and FVC, FEV_1 and FEV_1/FVC ratio in both obese and non-obese cases (P value >0.05).

There was significant negative correlation found between waist to hip ratio and FVC (r value -0.520, p value 0.001) and FEV_1 (r value -0.428, p value 0.006) in obese cases while no significant correlation between waist to hip ratio and FVC, FEV_1 and FEV_1/FVC ratio (P value >0.05) (Table 2).

The mean FVC in obese and non-obese male was 3.78 ± 0.65 L and 4.48 ± 0.72 L (p value 0.038) and in obese and non-obese female was 2.48 ± 0.54 L and 2.97 ± 0.47 L (p value 0.042). The mean FEV_1 in obese and non-obese male was 3.21 ± 0.67 L and 3.92 ± 0.57 L (p value 0.031) and in obese and non- obese female was 2.25 ± 0.48 L and 2.67 ± 0.38 L (p value 0.027). The mean FEV_1/ FVC ratio in obese and non-obese male was 82.21 ± 14.78 and 87.25 ± 7.50 (p value <0.001) and in obese and non-obese females was 87.25 ± 7.37 and 93.29 ± 4.62 (p value <0.001). The mean FVC, FEV_1 and FEV_1/FVC were significantly less in both male and females (p< 0.05) and no statistically significant gender difference was seen (Table 3).

Discussion

Breathing is essential for life and any decrease in lung function can affect the quality of life and can impair daily routine activities. To maintain the function of respiration it is important that all structures involved in respiratory system should work in equilibrium. In normal individuals diaphragm contracts and pushes the abdominal contents downward and forward and at the same time external intercostal muscles contracts

Table 2: *Pearson correlation coefficient between obesity and lung function*

	Obesity		FVC (liters)	FEV1 (liters)	FEV1/FVC
Body mass Index(kg/m²)	Obese (n=60)	Pearson Correlation	-0.329	- 0.281	0.293
		p-value	0.010*	0.046*	0.023*
	Non-obese (n=60)	Pearson Correlation	-0.117	-0.120	0.108
		p-value	0.371	0.363	0.411
Waist Circumference (cm)	Obese (n=60)	Pearson Correlation	-0.381	-0.373	0.218
		p-value	0.017*	0.019*	0.095
	Non-obese (n=60)	Pearson Correlation	0.351	0.379	-0.132
		p-value	0.06	0.06	0.317
Hip circumference (cm)	Obese (n=60)	Pearson Correlation	-0.239	-0.166	0.198
		p-value	0.066	0.204	0.129
	Non-obese (n=60)	Pearson Correlation	0.026	-0.021	-0.135
		p-value	0.846	0.873	0.303
Waist-Hip ratio	Obese (n=60)	Pearson Correlation	- 0.520	-0.428	0.082
		p-value	0.001*	0.006*	0.533
	Non-obese (n=60)	Pearson Correlation	0.073	0.126	0.094
		p-value	0.580	0.338	0.477

Table 3: *Comparison of lung functions by gender*

		Obesity	Mean	S.D	Minimum	Maximum	p-value
FVC (liters)	Male	Obese(n=60)	3.78	0.65	2.67	5.24	0.038*
		Non Obese(n=60)	4.48	0.72	2.57	5.80	
		Total (n=120)	4.13	0.70	2.57	5.80	
	Female	Obese (n=60)	2.48	0.54	1.07	3.68	0.042*
		Non Obese(n=60)	2.97	0.47	2.04	3.82	
		Total (n=120)	2.73	0.52	1.07	3.82	
FEV1 (liters)	Male	Obese(n=60)	3.21	0.67	2.44	5.21	0.031*
		Non Obese(n=60)	3.92	0.57	1.92	4.50	
		Total (n=120)	3.56	0.64	1.92	5.21	
	Female	Obese(n=60)	2.25	0.48	1.00	2.79	0.027*
		Non Obese(n=60)	2.67	0.38	2.00	3.19	
		Total (n=120)	2.46	0.48	1.00	3.19	
FEV1/FVC Ratio	Male	Obese(n=60)	82.21	14.78	9.40	96.60	<0.001*
		Non Obese(n=60)	87.25	7.50	72.30	97.60	
		Total (n=120)	84.73	11.90	9.40	97.60	
	Female	Obese(n=60)	87.25	7.37	65.60	97.60	<0.001*
		Non Obese(n=60)	93.29	4.62	81.80	100.00	
		Total (n=120)	90.27	6.82	65.60	100.00	

*SD: Standard Deviation, * P Value < 0.05 is considered significant*

and moves the ribs upward and forward. In obese persons this mechanism is impaired because of excessive adipose tissue present in the abdomen and on the chest wall. Fat deposition in the abdomen leads to increase in intra-abdominal pressure and prevents diaphragmatic contractions. Fat deposition in the thorax prevents effective contractions of external intercostal muscles leading to impaired ventilatory mechanics. An effective way to evaluate the lung functions is by measuring lung volumes. Dynamic lung volumes like FVC, FEV_1, FEV_1/FVC are measured by spirometry and static lung volumes like functional residual capacity, total lung capacity are measured by plethysmography.(11)

In this study we investigated the effects of a number of adiposity markers such as body mass index, waist circumference, and waist to hip ratio on lung functions like FVC, FEV_1 and FEV_1/FVC in normal young adults of Pakistani population. In our study the mean age in obese group was 32.18 ± 5.89 years and in non-obese group was 25.65 ± 4.98 years. As compared with the study of Al-Ghobain(12) the mean age of male subjects was 32.2 ± 10.2 years and mean age of female subjects was 32.2 ± 9.6 years, which is comparable with our study. In our study in obese and in non-obese group there were 50% male and 50% female subjects. As compared with the study of Bankeyet al. (13), there were 50% male and 50% female subjects, which is comparable with our study.

In our study, the mean FVC in obese subjects was 3.18 ± 0.92 L and in non-obese group the mean FVC was 3.68 ± 0.93 L with p value of 0.021. As compared with the study of Bankey et al. (13) the mean FVC in obese subjects was 2.95 ± 0.71 L and in non obese group the mean FVC was 3.58 ± 0.64 L with p value of < 0.05 which is comparable with our study. In this study, the mean FEV_1 in obese subjects was 2.83 ± 0.82 L and in non-obese group the mean FEV_1 was 3.19 ± 0.71 L with p value of 0.011. As compared with the study of Bankey et al. (13) the mean FEV_1 in obese subjects was 2.51 ± 0.64 L and in non obese group the mean FEV_1 was 2.95 ± 0.52 L with p value of <0.05 which is comparable with our study. In present study, the mean FEV_1/FVC ratio of obese group was 84.73 ± 11.86 and in non obese group the mean FEV_1/FVC ratio was 90.27 ± 6.89 with p value of 0.002. As compared with the study of Atta-ur–Rasool et al. (14) the mean FEV_1/FVC ratio of obese subjects was 82.952 ± 6.19 and mean FEV_1/FVC ratio of non obese subjects was 81.86 ± 5.47 which is comparable with our study.

This study showed that when the BMI increases, the lung functions like FVC (r value -0.329, p value 0.010), FEV_1 (r value -0.281, p value 0.046) significantly decreases. These results are consistent with the study of Rehman et al. [15] conducted on medical students showed that subjects with BMI <23% had better FEV_1 and FVC (p values 0.025 and 0.026) as compared to overweight and obese individuals.

A study by Bankeyet al. [13] performed on 120 subjects showed that increase in BMI is associated with deterioration in lung functions, FVC and FEV_1. Another study by Al-Badr et al. [16] reported that obese individuals have significant inverse relationship between BMI and lung functions, FVC and FEV_1 while study of Al-Ghobain [12] showed no statistically significant correlation in BMI and lung functions.

Increase in waist circumference causes mechanical effects by the deposition of fat in the abdomen and around the chest wall leading to impaired ventilation. Our results showed waist circumference was negatively associated with lung functions FVC (r value -0.381, p value 0.017) and FEV_1 (r value -0.373, p value 0.019) in obese cases. These results are comparable with the study by Chen et al. [17] which reported that waist circumference was inversely associated with FVC and FEV_1 (p value <0.001) but not with FEV_1/FVC (p value 0.268). They showed an average 1cm increase in waist circumference was associated with 13 ml reduction in FVC and 11 ml reduction in FEV1.

Study by Rehmanet al. [15] has showed a negative correlation of waist circumference with FEV_1 and FVC in both sexes, which were comparable with our results. Waist to hip ratio reflects both increase in abdominal fat and decrease in muscle mass as quantified by hip circumference and both components affect lung functions. Results of our study showed that WHR is inversely related to FVC (r value -0.520, p value 0.001) and FEV_1 (r value -0.428, p value 0.006) in obese cases while no significant association was seen in non-obese patients. Study by Al-Badr et al. [16] showed that as the waist to hip ratio increases FVC and FEV_1 decreases while FEV_1/FVC remains same. These results are comparable with our study.

Study conducted by Bankey et al. [13] has showed that waist to hip ratio, a marker of abdominal adiposity, is inversely associated with FVC and FEV_1 and these associations although modest but remained statistically significant even after adjustments for potential confounders like age, sex and physical activity.

Another study by Santana et al. [18] reported that waist circumference, and waist to hip ratio, markers of central adiposity were negatively associated with lung functions in elderly subjects, while amount of muscle mass was positively associated with lung functions. Study by Saxena et al. [19] investigated the relation of body mass index, waist circumference, and waist to hip ratio with dynamic lung volumes, FEV_1 and FVC in a population based cross sectional study. They reported an inverse association of body mass index, waist circumference, and waist to hip ratio with lung functions in both male and females these results are comparable with our results.

In this study we found negative association of adiposity markers like body mass index, waist circumference, and waist to hip ratio with dynamic lung volumes, FVC and FEV_1 in men and women of adult Pakistani population. The Strength of our study is the recruitment of subjects who were healthy without co-morbidity. Another strength of this study is that we used multiple markers of adiposity like body mass index, waist circumference, and waist to hip ratio while previously only body mass index and waist circumference were used in Pakistani population. Our study had the limitation of using only dynamic lung volumes and static lung volumes like functional residual capacity and total lung capacity were not assessed which are also significantly decreased in obesity.

Our study showed that obesity has negative effects on lung functions in both genders. In our country prevalence of obesity is increasing so it is very important that our population should be aware of the harmful effects of obesity on lung functions. Obesity can be controlled with regular exercise and dietary modifications and harmful effects of obesity can be prevented. This study will help us in educating the general population about the harmful effects of obesity on lungs and will motivate the general population to keep their weight in check.

We recommend conducting larger studies including both dynamic and static lung volumes to better understand the effects of obesity on lung functions.

Conclusion

Based on these finding, it is plausible to conclude that obese individuals in this cohort carried a significant decline in FVC and FEV1. BMI, waist circumference and waist to hip ratio, were negatively associated with FVC and FEV1.

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