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RELATION OF PHYSICAL ACTIVITY AND OBESITY WITH LUNG CAPACITY AMONG ADULT FEMALES

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Abstract:

Background: *Obesity and poor respiratory function are associated with morbidity and mortality. Obesity affects lung function, however the effects of all degrees of obesity on lung function should be investigated in different populations and gender.*

Aims and Objectives: *The authors investigated the relationship between BMI, waist circumference, physical activity with lung function among adult females.*

Place and Duration: *In the Pulmonology Department of Fauji Foundation Hospital Rawalpindi for one-year duration from March 2019 to February 2020.*

Material and methods: *The analysis included 359 women aged 18-44, who had not been diagnosed with any serious disease before, and who had a complete anthropometric examination (height, weight and waist circumference) and forced vital capacity (FVC) using simple measurements spirometry and chest. Physical activity was measured using the "International Physical Activity Questionnaire" (IPAQ).*

Results: *Both FVC and predicted FVC along with the chest dilatation measures were linearly and inversely related across the entire range of body mass index (BMI) and waist circumference (WC) and positively associated with physical activity in subjects, even after adjusting for the confirmatory age our hypothesis. However, BMI and exercise accounted for the highest percentage of variance for both FVC and thoracic expansion in regression analysis compared to WC.*

Conclusion: *In the general population of adult women, obesity may play a role in impaired lung function from a BMI ≥ 35 kg / m2, while even moderate physical activity may have a positive effect on lung function.*

Keywords: *body mass index; chest expansion; forced vital capacity; physical activity; waist circumference.*

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INTRODUCTION:

Today, obesity is the most significant contributor to mortality and morbidity worldwide, as it can affect virtually any organ or tissue in the human body. Estimates indicate that in 2008 as many as 1 • 46 billion adults worldwide were overweight, and among them 502 million adults suffered from clinical obesity, thus increasing the world's health burden[1-2]. The Pakistan ratifies global trends following the recent economic and nutritional transformation. A review published in 2011 suggests that as many as two-thirds to three-quarters of Pakistani adult population is overweight or obese[3-4]. The available literature confirms a strong inverse relationship between severe obesity and pulmonary complications, including respiratory diseases such as chronic obstructive pulmonary disease and asthma[5-6]. Although less established than other NCDs, recent research has focused on lung capacity and has a multi-layered link with morbidity and mortality. Except for smoking, there are relatively few studies identifying the major etiological factors responsible for decreased lung capacity and contributing to long-term health and quality of life. Increasingly, studies have also documented that lung function can be positively influenced by other lifestyle factors such as habitual physical activity, exercise capacity and a healthy weight. Obesity can affect lung capacity, causing changes in respiratory mechanics, reducing the strength and endurance of the respiratory muscles, reducing lung gas exchange, reducing breathing control, and reducing lung function tests and exercise capacity[7-8]. Additional fat deposits in the chest wall and abdominal cavity can reduce lung volume and overload the inspiratory muscles by reducing diaphragm displacement, reducing lung and chest wall compliance, and increasing elastic recoil. These changes are aggravated by increases in BMI, and relationships vary across subpopulations. However, the impact of lower obesity and / or fat distribution on lung capacity is limited, making it difficult to draw any conclusions from these studies. The importance of understanding these phenomena is slowly gaining the attention of researchers around the world. Body mass index (BMI) is the most frequently used measure of obesity in most epidemiological studies[9-10]. However, BMI is not a reliable indicator for understanding the distribution of body fat and / or for distinguishing between muscle mass and fat mass, both of which can affect lung function. There are several studies that have investigated the relationship of central indicators of fatness such as waist circumference (WC) and waist-to-hip ratio (WHR) with lung function, but gender stratification has been reported to be conflicting. However, it is difficult to conclude from these studies whether the predicted results apply to all degrees of obesity and to both genders in all racial populations. In addition, most of these studies have not largely investigated any other significant variable in physical activity that affects lung capacity. In connection with the above discussion, we conducted a study to investigate the relationship between lung function and BMI, waist circumference and physical activity in a selected sample of the female population. Based on the literature review, we hypothesized that lung function may be positively associated with physical activity and negatively associated with BMI and WC in women.

MATERIALS AND METHODS:

This cross-sectional study was conducted in the Pulmonology Department of Fauji Foundation Hospital Rawalpindi for one-year duration from March 2019 to February 2020. Patients with acute or chronic lung disease, neuromuscular disorders, heart failure, severe or poorly controlled hypertension, chronic kidney disease, diabetes, and systemic corticosteroid use were excluded from the study. A total of 359 eligible women participated in this study after signing the informed consent form. We measured height, weight, BMI, WC, physical activity, chest expansion and forced vital ability of the subjects to explore the study objectives. The Hail University Research Committee approved the study. Anthropometric variables included in the study included body weight, height, BMI, and WC. Body weight was measured without shoes and with minimal clothing, accurate to the nearest 100 g, using a calibrated scale. Height was measured to an accuracy of 1 cm when the patient was in a full standing position without shoes using a calibrated stadiometer attached to the body weight. WC has recently been found to be the best simple measure of fat distribution as it is least influenced by gender, race and overall obesity. WC was measured horizontally with a non-stretch tape measure at the navel level and at the end of a gentle exhalation. During the WC measurement, the tape adhered well, but did not press against the skin. BMI was calculated as the ratio of weight in kg squared of height in meters. We used adult WHO cutoffs for BMI.16 Chest expansion (CE) was measured by tape measure at intercostal space 4. The subjects were asked to be as inspired as much as possible through their nose with their mouths closed to fill their lungs with air. This is done a minimum of twice and the greater convexity is recorded. Participants were asked to "take a deep breath as far as possible, hold back, and then breathe out as far as possible." Physical activity is the movement of the body produced by skeletal muscles that causes an energy expenditure above the resting value. Due to its complexity, physical activity is difficult to accurately assess in free living conditions. However, the intensity, duration and frequency of physical activity can be measured using either subjective or objective methods. The "International Physical Activity Questionnaire" (IPAQ) is one such tool for obtaining data on health-related physical activity that is internationally comparable. Previously, IPAQ had been shown to have high reliability and acceptable validity. The questionnaire looked at the frequency and duration of physical activity levels (PAL), including vigorous, moderate exercise, walking and sitting in the previous week. PAL has been classified into three levels: High: PAL: severe activity ≥3 days a week that makes one breath much more difficult than normal or any cumulative PAL; seven days a week any combination of walking and moderate to vigorous exercise. Moderate: PAL: ≥3 days / week and ≥20 minutes / day, moderate exercise or walking: ≥5 days / week and ≥30 minutes / day; Low when the appropriate PAL level is not reached to be in the moderate or high category. A simple spirometer (12, 1710 Base line Spirometer-China) was used to measure forced vital capacity (FVC). The participants sat comfortably. Before the measurement, the purpose of the test was explained to the participants by well-trained students. Before starting the readings, participants had a few practice exercises to become familiar with the measuring spirometer. Participants were encouraged to blow air continuously for maximum exhalation. The total number of trials was limited (exercises and recordings) to eight or less per session. A clean, disposable, unidirectional mouthpiece is attached to the spirometer. A fresh mouthpiece was used for each participant. Participants were asked to breathe in as deeply as possible and hold their breath long enough to close their mouths. Participants were asked to exhale by force, as hard and as fast as possible, until there was nothing left to expel. The FVC measurement was recorded with the spirometer after the maximum reading was reached. The procedure was repeated three times to obtain an accurate measurement.

Statistical analysis:

The dataset has been wiped and edited for inconsistencies. The missing data has not been statistically calculated. The Social Package for Social Sciences (SPSS) version 16.0 (SPSS Inc, Chicago, IL, USA) was used for data analysis. Descriptive statistics such as means and standard deviations for continuous variables and frequencies for qualitative data were calculated. Analysis of variance (ANOVA), Student's t-test and linear regression analysis were used to investigate differences in variables. Results are expressed as mean ± SD. All P values reported were two-tailed and differences were considered statistically significant at $P < 0.05$.

RESULTS:

Table 1 presents the baseline characteristics of the study population of 359 women. About 75 percent of the study population was in the 18-24 age group (median 24 years). There were no underweight people in the sample. Only about 42 percent of the test subjects had a normal BMI, and about 58 percent of the test population had a waist circumference ≤ 80 cm.

Table 1: Baseline Characteristics of subjects (N=359)

		F	**%**
Age (yrs.)	18-24	269	74.9
	25 - 44	90	25.1
BMI (kg/m^2)	Normal (18.5-24.99)	149	41.5
	Overweight (25-29.99)	45	12.5
	Obesity I (30-34.99)	107	29.8
	Obesity 2 (35 - 39.99)	44	12.3
	Morbid Obesity (≥40)	14	3.9
WC (cm)	≤ 80 cm	207	57.7
	≥ 80.1 cm	152	42.3
Physical Activity Level	Low	244	68.0
	Moderate	115	32.0

Table 2 presents the mean age and the variables of anthropometric and spirometry tests of the respondents. The mean age was 23.60 ± 5.61 years, and the average height and weight of the subjects was 158.17 ± 5.44 cm and 71.52 ± 16.78 kg, respectively. Participants' BMI ranged from 19.14 to 51.95 kg / m2 with an average of 28.29 ± 6.38 kg / m2.

	Mean±SD	95% CI for mean		Minimum	Maximum
		Lower bound	Upper bound		
Age (yrs)	23.60±5.61	23.02	24.19	18	44
Height (cm)	159.16±5.44	158.32	160.01	145	170
Weight (kg)	71.97±16.78	69.36	74.58	45	133
BMI (kg/m^2)	28.29±6.38	27.63	28.95	19.14	51.95
WC(cm)	80.43±13.57	79.02	81.84	57	127
CE (cm)	2.63±0.83	2.55	2.72	1	5
FVC (L)	2.05±0.59	1.99	2.11	0.5	3.8
% FVC Predicted	61.38±1.76	59.55	63.21	14.97	113.77

The predicted values for WC, CE, FVC, and% FVC were between 57 and 127 cm; 1 to 5 cm; 0.5 to 3.8 and 14.97 to 113.77, respectively.

Table 3 ANOVA for age, WC, CE, FVC and % FVC predicted with stratified BMI groups

BMI Groups#	Frequency	Mean±SD				
		Age	WC	CE	FVC	% FVC
Normal (18.5-24.99)	149	21.86±3.22	71.28±8.22	3.06±0.83	2.17±0.55	65.02±16.56
Overweight (25-29.99)	**45**	22.64±3.41	78.02±12.89	2.72±0.63	2.16±0.49	64.80±14.78
Obesity I (30-34.99)	107	25.11±6.51	85.87±10.50	2.32±0.67	1.99±0.62	59.80±18.54
Obesity II (35 – 39.99)	44	25.30±7.81	93.65±10.92	2.09±0.60	1.81±0.59	54.11±17.85

Obesity III (40 and above)	14	28.36±8.43	102.50±10.33	1.89±0.56	1.56±0.52	46.62±15.48
BMI vs. Variables	**F Value**	10.345**	75.794**	27.666**	6.967**	6.967**
**p significant at 0.0001						
# WHO adults' cut-off points for BMI were used to create BMI groups [16].						

Table 3 shows the ANOVA for age, WC, CE, FVC and% FVC with stratified BMI groups. All examined variables differed significantly in mean values for the BMI groups. A post-hoc Tukey HSD analysis for the stratified BMI groups (results not shown) showed that: a) age in the normal and overweight groups was significantly lower than in all obese groups; b) WC measurements and chest expansion were significantly different in the groups with normal BMI compared to the overweight and obese groups; c) FVC and% FVC predicted for the normal and overweight groups were significantly higher than for obesity groups II and III. The T test for the WC groups also indicated that all the studied variables differed significantly (Table 4).

Table 4 T-Test for age, WC, CE, FVC and % FVC predicted with stratified WC groups

WC Groups	**Frequency**	**Mean± SD**				
		Age	**BMI**	**CE**	**FVC**	**% FVC**
≤ 79 cm	207	22.11±3.50	24.69±4.45	2.89±0.83	2.14±0.58	64.09±17.25
≥ 80 cm	152	25.64±7.12	33.19±5.26	2.29±0.69	1.93±0.59	57.69±17.59
WC vs Variables	**T Value**	-6.190**	-16.534**	7.228**	3.438**	3.438**

Both thoracic expansion and FVC were significantly higher in the WC group with ≤ 79 cm, which is considered to be the normal cut-off values for Asian populations 20. However, for the PAL groups, significant mean differences were found only for the variables CE, FVC and% predicted (tab. 5). In this study, none of the subjects reported "high PAL". The results suggest that probably BMI and WC do not necessarily have an impact on the participants' current level of activity, unlike the lung capacity indicators tested. age appropriate models. Overall, there were negative associations of each obesity marker with the% predicted FEV and CE, but these were not statistically significant for WC. PAL was significantly positively associated with both predicted% FEV and CE.

Table 5 T-Test for age, BMI, WC, CE, FVC and % FVC predicted with stratified PAL groups

PAL Groups	**Frequency**	**Mean± SD**					
		Age	**BMI**	**WC**	**CE**	**FVC**	**% FVC**
Low PAL	244	23.53±5.60	28.02±6.39	80.20±13.72	2.50±0.82	1.94±0.54	58.24±16.29
Moderate PAL	115	23.76±5.65	28.84±6.36	80.91±13.29	2.91±0.77	2.27±0.62	68.05±18.63
PAL vs Variables	**T Value**	-0.355	-1.128	-0.461	-4.409**	-5.082**	-5.082**

DISCUSSION:

The available data from normative pulmonary function tests for the population of the Pakistan are relatively sparse and are most often limited to people in coastal areas. Lung function may vary with gender, age, height, ethnicity, and geographic factors such as altitude, dry and humid climate, and is therefore important in studying lung function test data and factors from different regions. This study is conducted at the Lahore. To the best of our knowledge, there are no studies describing the values of lung capacity tests in Pakistan. In the present study, we assessed the correlation of BMI, waist circumference, and physical activity with lung capacity in 359 women (ages 18 to 44) who did not smoke and had no history of lung disease or serious illnesses. Two well-known, simple methods were used to estimate lung capacity; 1) a measure of chest enlargement as an indicator of lung capacity and 2) FVC spirometer readings as an accurate measurement of lung capacity. Our average FVC readings were lower compared to other studies that looked at women from Pakistan and other parts of the world. As far as we know, we could not find any benchmarks for chest enlargement with KSA that emphasized the need for more such studies from the region11. We found inverse associations between BMI and WC and lung capacity, while physical activity was positively correlated even after adjusting for age, which supports our hypothesis. However, BMI and exercise accounted for the highest percentage of variance for both FVC and thoracic expansion in regression analysis compared to WC. Proper expansion of the lungs and chest is very important for sufficient ventilation. Any interference with the free flow of air in the respiratory system may result in relative insufficiency of ventilation or fatigue of the respiratory muscles. Recent literature increasingly focuses on conceptualizing the etiology of disease in the course of life. Saudi Arabia reportedly has very high obesity rates 3 and a low culture of physical activity among its citizens, which can affect lung capacity. Poor lifestyle factors such as obesity can cause restrictive conditions in the chest wall and can cause lung volume reductions such as FVC or forced expiratory volume in one second (FEV1) without obstructing airflow or the ratio between FVC and FEV1. In contrast, regular exercise can promote normal lung function development and may even limit its worsening with age. Therefore, it is interesting to investigate how these contrasting lifestyle factors affect lung function. In this study, none of the respondents reported vigorous physical activity12-13. However, our results indicate that even moderate activity can have a positive effect on both spirometry and chest expansion tests. Previous studies have shown that physical activity is positively correlated with changes in FVC over the long term. A possible beneficial role of physical activity could be to counteract or slow down the loss of lung elastic recoil and / or the tendency to stiffen the chest wall which are associated with the aging process. Physical activity can also increase the endurance of the inspiratory muscles. Given that our current research results support the beneficial effects of even moderate activity, and other studies have strongly suggested that higher physical activity slows lung deterioration, there is a clear need for an activity-friendly environment across Pakistan. We also examined the relationship of obesity as defined by BMI and WC indices with lung function14-15. There were no underweight people and we could not analyze its relationship to lung function. However, comparisons between normal, overweight, and obesity categories I, II, and III strongly supported other studies that found obesity to be inversely related to lung function. One earlier study investigated the progressive effects of obesity on lung function by combining normal and overweight BMI groups into one group and comparing them with obesity classes I, II, III (BMI 40 to 44.9 kg / m2; BMI 45 to 50.9 kg / m2 and BMI ≥ 51 kg / m2), changes in lung function were found to be more pronounced when BMI is ≥ 45 kg / m2, and even more pronounced when BMI is> 50.9 kg / m2. In this study, a group of overweight and obese people with normal BMI I, II and III (BMI ≥ 40 kg / m2) was compared. We couldn't further divide Obesity III into further classifications due to the smaller number of items in that category (we only had 14 items). However, our study, contrary to the study mentioned above, found that FVC and% FVC predicted for the healthy and overweight groups were significantly better even than a BMI ≥ 35 kg / m². However, our research samples were only women, while the aforementioned research sample included both men and women, and both the absolute mean and relative FVC values were higher compared to this study. However, our study failed to establish a very strong negative relationship between WC and lung capacity. Two epidemiological studies involving both sexes suggested strong negative associations between WC index and waist hip, even after considering potential confounding factors. However, one recent meta-analysis showed that the influence of WC on lung function in men is as much greater than in women because of differences in body composition (apple vs pear shape). The current research sample included significantly younger women (18 to 44 years old) and the majority were under 25 years of age. This may possibly be the reason why a stronger relationship between WC and lung capacity was not found. This study had several limitations. Due to the lack of a digital spirometer, we only recorded forced vital capacity with a simple spirometer. Another limitation was the use of the questionnaire method to collect data on physical activity and sedentary lifestyle. Including both genders in the sample box could provide a better understanding of the results. A significant limitation of this study is possibly the clinical value of these results, which are rather limited to limited populations and less generalizable to other populations or ethnic groups. However, the data makes a decisive contribution to global research that tries to understand regional effects on lung function.

CONCLUSIONS:

Obesity and exercise are important determinants of lung function, and it is more important to remain physically active throughout your life for more than one health reason. It is also important that future research to determine the determinants of lung function consider the inclusion of physical activity as a covariate along with various indicators of obesity, which may be potential confounding factors.

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