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Influence of Anthropometric Indices on Pulmonary Function Tests in Young Individuals

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Abstract: Pulmonary functions vary in healthy people and are greatly influenced by individual weight, height, age, sex, race, nutrition, body surface area and environmental factors. Most of the epidemiological studies have considered age, sex and height as major predictors of pulmonary functions. The influence of various other anthropometric measurements like body mass index and waist circumference on pulmonary function tests has received less attention, particularly in younger age group. Hence the present study aimed to study the influence of anthropometric indices on pulmonary function tests in young individuals. 100 subjects (50 males and 50 females) in the age group of 18-21 years were recruited for the study. They were divided into subgroups based on their body mass index and waist circumference. Vital capacity (VC), Forced vital capacity (FVC), forced expiratory volume in first second (FEV_1), FEV_1/ FVC ratio (FEV_1 %) and peak expiratory flow rate (PEF) were measured using computerized spirometer. All the respiratory parameters other than FEV_1 % were significantly ($p < 0.001$) lowered in underweight, overweight and obese individuals compared to the individuals with normal body mass index. Similarly individuals with higher waist circumferences showed significantly ($p < 0.001$) lower values of respiratory parameters compared to the individuals with normal waist circumferences. All the respiratory parameters showed a negative correlation with body mass index and waist circumference above normal values. However a positive correlation was observed with waist circumference within normal limits. Hence body mass index and waist circumference do significantly influence the pulmonary function and therefore can be suggested for use in prediction equations for pulmonary functions.

Key words: Body Mass Index・Waist Circumference・Pulmonary Functions

INTRODUCTION

Primary respiratory diseases are responsible for a major burden of morbidity and untimely deaths worldwide and lungs are often affected in multi-system diseases. Respiratory symptoms are the most common cause of presentation to the family practitioner. Pulmonary function tests are used to aid diagnosis, assess functional impairment and monitor treatment or progression of respiratory diseases. They have become part of routine health examinations in respiratory, occupational and sports medicine and also in public health screening. Spirometry is the most frequently performed lung function test. Spirometric lung function parameters can be affected by many sorts of variations, including technical variations, biological variations and clinical variations [1]. Differences in pulmonary function in normal people may be due to ethnic origin, physical activity, environmental conditions, altitude, tobacco smoking, age, height, sex and socioeconomic status [2]. In his historic study, John Hutchinson (the inventor of the spirometer) found that age and height are the most important determinants of lung function [3]. The majority of equations used for the estimation of normal values of pulmonary function consider simple anthropometric parameters such as age, gender and height for prediction. Beyond gender, height and age, there are a lot of other anthropometric measurements that can influence the lung function, such as body mass index (BMI), waist circumference and waist hip ratio. These previously unrecognized factors make it

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difficult to get accurate norms with regression equations, traditionally using sex, height and age as predictors [4]. The consideration of these factors become important with the increasing prevalence of overweight and obesity all over the world. The definition of obesity is generally based on the anthropometric measures like body mass index, waist circumference, waist hip ratio. Obesity is associated with a variety of medical disorders including the lesser known but not less important respiratory complications, the most persistent abnormality being a restrictive respiratory impairment [5]. However the influences of body mass index, waist size, body composition on lung function are underscored. Few studies have suggested that considering these factors for prediction may improve the accuracy and biological relevance of reference equations of lung function [4]. There lies a paucity of data regarding the influence of these anthropometric indices over pulmonary function tests in the younger age group.

Hence the present study was undertaken to study the influence of these anthropometric indices on pulmonary function tests in the young individuals.

MATERIALS AND METHODS

A total of 100 subjects were recruited for the study, which include 50 males and 50 females in the age group of 18 - 21 years. Subjects with known medical illness, history of drug intake were excluded from the study. Informed written consent was obtained from all the study participants. A detailed review of medical history through structured questionnaire and physical examination were performed. The participants were instructed to wear light clothing during their study visits. During anthropometric measurements the participants were instructed to stand erect with abdomen relaxed, arms at their sides and feet together. Weight (in kilograms) was recorded using standard weighing machine. Height (in centimeters) was measured in standing and erect posture using a stadiometer. Body Mass Index (BMI) was calculated as the ratio of weight and square of Height in meters, using Quetelet Index. Waist circumference (in centimeters) was measured at the narrowest circumference between the bottom of the rib cage and top of the iliac crest, following normal expiration.

The study subjects in both the genders were divided into subgroups, based on their body mass index and waist circumferences as follows:

Group I: Based on their body mass index (BMI), they were subdivided into 4 subgroups

Group I_A – BMI < 18.5 (underweight)
Group I_B – BMI – 18.5 – 24.9 (Normal)
Group I_C – BMI – 25.0 – 29.9 (Overweight)
Group I_D – BMI $\geq$ 30 (Obese)

Group II: Based on their Waist circumference (WC)

In males, Group II_A – WC < 94 cm
Group II_B – WC $\geq$ 94 cm
In females Group II_A – WC < 80 cm
Group II_B – WC $\geq$ 80 cm [6]

Pulmonary function tests were measured in all the study participants using the Computerized Spirometer, “Super Spiro”. The subject were made to sit in the upright posture and made comfortable. The subjects were explained in detail about the test and the importance of their involvement for best results. The following parameters were noted.

- Vital capacity – VC
- Forced vital capacity – FVC
- Forced expiratory volume in one second – FEV_1
- FEV_1/ FVC ratio (FEV_1 %)
- Peak Expiratory Flow – PEF

At least three tests of acceptable effort were performed to ensure reproducibility. The best trial was selected from the three reproducible trials for reporting.

Statistical Analysis: Mean and standard deviation were calculated. One way analysis of variance was used for the intra group comparison within the various anthropometric groups in both the genders. Pearson’s correlation test was used to correlate between the anthropometric indices and the respiratory parameters. Student unpaired ‘t’ test was used to test the significance of mean between males and females. Statistical software namely SPSS 16 version was used for the analysis of the data.

RESULTS

Table 1 showed the comparison between baseline characteristics of the male and the female study participants. The anthropometric indices other than body mass index and respiratory parameters other than FEV_1% were significantly ($p < 0.001$) lower in females compared to males.

Table 2 showed the comparison of pulmonary function parameters within various subgroups of group I (body mass index) in males. VC, FEV_1, FVC and PEF were

Table 1: Baseline Characteristics Of Male And Female Subjects

Variable	Male	Female
n	50	50
Height	167 ± 9.72	164.72 ± 9.86*
BMI	23.48 ± 3.65	23.42 ± 3.68
Waist circumference	83.7 ± 11.17	79.37 ± 11.27*
VC	3.42 ± 0.84	3.14 ± 0.80*
FEV_1	3.30 ± 0.80	3.03 ± 0.77*
FVC	3.41 ± 0.80	3.14 ± 0.79*
FEV_1 %	96.52 ± 3.47	96.38 ± 3.58
PEF	6.92 ± 1.72	6.04 ± 1.67*

* $P < 0.001$

BMI – Body Mass Index, VC– Vital Capacity, FVC – Forced Vital Capacity, FEV_1 – Forced Expiratory Volume In First Second, FEV % - FEV_1/ FVC Ratio, PEF – Peak Expiratory Flow Rate

Table 2: Comparison Of Pulmonary Function Parameters Within Group I (BMI) In Males

Parameters	I_A < 18.5 n = 5	I_B 18. 5 – 24.9 n = 23	I_C 25 – 29.9 n = 19	I_D ≥ 30 n = 3
VC	2.51±0.36*	4.12±0.49	3.03±0.52$^{\#\ddagger}$	2.03±0.08†
FEV_1	2.42±0.39*	3.95±0.50	2.94±0.50$^{\#\ddagger}$	2.01±0.07†
FVC	2.47±0.35*	4.05±0.48	3.09±0.52$^{\#\ddagger}$	2.04±0.07†
FEV_1%	97.60±2.88	97.48±2.69	94.74±3.98	98.67±2.31
PEF	5.41±0.48*	8.27±1.08	6.16±1.23$^{\#\ddagger}$	3.95±0.11†

*$^{\#\dagger}$ $P < 0.001$ - Between I_B And I_A, I_C And I_D Respectively, ‡ $P < 0.01$ - Between I_C And I_D

Table 3: Comparison Of Pulmonary Function Parameters Within Group I (BMI) In Females

Parameters	I_A < 18.5 n = 6	I_B 18. 5 – 24.9 n = 24	I_C 25 – 29.9 n = 17	I_D ≥ 30 n = 3
VC	2.22± 0.23*	3.40 ± 0.31	2.49±0.47$^{\#\ddagger}$	1.96±0.24†
FEV_1	2.10±0.27*	3.28 ± 0.33	2.49±0.47$^{\#\ddagger}$	1.75±0.11†
FVC	2.15±0.25*	3.41 ± 0.35	2.52±0.49$^{\#\ddagger}$	1.79±0.80†
FEV_1%	97.17±3.06	95.66 ± 3.49	96.53±4.23	97.33±2.30
PEF	4.71±0.97*	5.57 ± 1.01	4.95±0.92$^{\#\ddagger}$	3.99±1.45†

* $^{\#\dagger}$ $P < 0.001$ - Between I_B And I_A, I_C And I_D Respectively, ‡ $P < 0.05$ - Between I_C And I_D

Table 4: Comparison Of Pulmonary Function Parameters In Males And Females Within Group II (Waist Circumference)

	Males		Females	
Parameters	II_A WC < 94 n = 28	II_B WC ≥ 94 n = 22	II_A WC < 80 n = 30	II_B WC ≥ 80 n = 20
VC	3.82±0.76	2.95±0.69*	3.20±0.55	2.37±0.41*
FEV_1	3.67±0.74	2.86±0.64*	3.09±0.58	2.27±0.38*
FVC	3.75±0.76	3.01±0.67*	3.20±0.61	2.35±0.40*
FEV_1%	97.89±2.17	94.91±4.03	96.20±3.44	96.30±3.96
PEF	7.82±1.49	5.87±1.34*	5.53±0.96	4.61±1.01*

*$P < 0.001$, WC – Waist Circumference

Table 5: Correlation Between Anthropometric Indices And Pulmonary Function Parameters In Males And Females

	Respiratory Parameters	
Anthropometric Indices	VC, FEV_1, FVC, PEF	FEV_1%
BMI	Negative*	Negative
WC < 94 (Males)	Positive*	Positive
WC ≥ 94 (Males)	Negative*	Negative
WC < 80 (Females)	Positive*	Positive
WC ≥ 80 (Females)	Negative*	Negative

* $P < 0.01$, BMI – Body Mass Index, WC-Waist Circumference

significantly ($p < 0.001$) lowered in groups I_A, I_C, I_D (underweight, overweight and obese respectively) compared to group I_B (normal body mass index). Group I_D (obese) individuals had significantly lower mean values ($p < 0.001$) than other groups. No significant difference was observed between group I_A (underweight) and I_C (overweight) subjects. Similar results were observed in females, which are shown in Table 3. However there was no significant difference in FEV_1% between the groups in both the genders.

Table 4 showed the comparison of respiratory parameters within the subgroups of group II (Waist Circumference- WC) in males and females. VC, FEV_1, FVC and PEF were significantly ($p<0.001$) lower in group II_B (WC ≥ 94 – males, WC ≥ 80 - females)compared to group II_A (WC < 94 – males, WC < 80 - females) in both the genders. There was no significant difference in FEV_1 % between the groups in both the genders.

Table 5 showed the correlation of the respiratory parameters with the anthropometric indices. All the respiratory parameters other than FEV_1 % showed a significant ($p < 0.01$) correlation with the measured anthropometric indices. Body mass index had a significant negative correlation with the respiratory parameters. Waist circumference within normal range showed a significant positive correlation with the respiratory parameters in both the genders, whereas higher waist circumference showed a significant negative correlation with the lung functions.

DISCUSSION

The study showed that the pulmonary functions are significantly influenced by anthropometric indices like body mass index and waist circumference. On analyzing the impact of body mass index (BMI) on lung volumes, the underweight subjects with BMI < 18.5 had lower values compared to the normal and overweight individuals. This can be contributed to the poor respiratory muscle strength due to poor resources of body proteins causing wasting of skeletal muscles including respiratory muscles in the underweight individuals [7].

Individuals with BMI 18.5 – 24.9 had better lung functions compared to adjacent subgroups. It is evident from the previous studies that in individuals with a normal BMI the pulmonary function increases in parallel with weight gain, due to related increase in muscle strength. Individuals with BMI 25-29.9 had significantly higher values than the underweight and obese individuals but the parameters were significantly lower than the normal BMI group. This is very much in contrast to the previous studies where no significant difference was observed between overweight and normal BMI individuals [5, 8, 9]. However this coincides with the results of Joshi AR *et al.*, who observed lowered FVC and expiratory reserve volume (ERV) in the overweight individuals. They correlated the fall in FVC in the overweight individuals to the fall in ERV, as ERV forms a component of FVC. The reduction was also attributed to the increase in body fat % with increasing BMI, particularly in overweight individuals [10]. In the present study, these unmeasured parameters like fat mass and total body fat % might also have contributed to the reduction in the lung function parameters.

Obese individuals with the BMI of $\geq$ 30 had lower VC, FEV_1, FVC & PEF compared to the adjacent sub groups. The reduction can be explained by the mechanical restraint to the movement of thorax and abdomen, reduced chest wall compliance and peripheral airway size. As FEV_1 % did not show any change, it indicates a restrictive impairment in individuals with higher BMI. Reduction in PEF suggests the presence of peripheral airflow limitation and increased airway resistance in obese individuals. These results are comparable to earlier work [5, 8, 9, 11].

Waist circumference showed significant inverse relation with the lung function. The observed means for VC, FVC and FEV_1 and PEF were significantly lower in the subjects with a higher than normal waist circumference in both the genders on comparison with the individuals with normal waist circumference. This signifies the impact of central adiposity on pulmonary functions and is consistent with the results of other population studies [12-17]. Abdominal adiposity (central fat distribution) may restrict the descent of the diaphragm, limit lung expansion and increase the thoracic pressure, leading to restrictive respiratory impairment.

A significant negative correlation was observed between BMI and all the measured parameters. Similar results were observed by Y. Saxena *et al.* and J. Dayanand [5, 18]. Waist circumference in the normal range had a positive correlation with the respiratory parameters. Higher waist circumference was negatively correlated to the lung functions. FEV_1 % did not have a significant correlation with the anthropometric indices. Similar results were observed by Shaheen AA and his colleagues [19]. The mechanical effects of the intra abdominal pressure on the diaphragm are likely to be the main reason for the association of central obesity with compromised lung function [15-17]. Hence weight reduction may improve the ventilatory function by reducing the mechanical constraints [20-23]. Al- jiffri O. *et al*., observed a significant improvement in ventilatory functions in obese asthmatic children after weight reduction [24].

Considering the gender differences, males and females were significantly different in all the parameters studied, with males presenting with higher values. VC, FEV_1, FVC and PEF were significantly reduced in females in all the divided categories. This can be explained by the greater respiratory muscle strength and greater compliance in males compared with females [5, 22].

CONCLUSION

Age and height are commonly used in the prediction equations for lung functions. The isolated effects of higher body mass index and waist circumference, unassociated with other diseases must be identified and the analysis of those effects should be stratified. This aspect is extremely important due to the currently elevated prevalence of overweight, obesity and respiratory diseases in our society. This awareness of increased body mass index and waist circumference on lung function testing will result in better interpretation of the results and hopefully avert unnecessary pulmonary workup. Hence body mass index and waist circumference could be suggested for use in the prediction equations of lung functions, thereby improving the accuracy of the equations.

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