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# ABDOMINAL OBESITY AND PULMONARY FUNCTIONS IN YOUNG INDIAN ADULTS : A PROSPECTIVE STUDY

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**Abstract :** Obesity is a global health hazard and has been linked to numerous metabolic complications such as dyslipidemia, type II diabetes, & cardio vascular diseases and is negatively associated to the pulmonary function. The mechanism for this association is still debated and the best marker of adiposity in relation to dynamic pulmonary function is still not clear. We assessed the association of respiratory parameters and body mass index (BMI), waist circumference (WC) and Waist Hip ratio (WHR) as the markers of relative and abdominal obesity adiposity respectively. Step wise linear regression analysis was used to find out the association of FVC and FEV1 (performed in standing) with over all and adiposity markers stratified by gender and adjusted to height and age. A random sample of volunteers (n=80) from general population in and around Dehradun, India of age group 20-40 years. In women the WC shows a higher negative association to respiratory parameters FVC and FEV1 {B (P value), $R^2$ as – 0.381(0.017), 0.122 and – 0.373(0.019), 0.139} while all the adiposity markers showed a negative significant association. In men WC showed highly significant negative association with FVC and FEV1 {Beta (P value), $R^2$ as – 0.502(0.001), 0.232 and – 0.428(0.006), 0.184} with higher $R^2$ values as compared to other adiposity parameters. The result suggested that the abdominal obesity marker is an important and better predictor of pulmonary function than BMI and the investigators suggest the inclusion of it as a potential confounding factor when investigating the determinants of pulmonary function.

**Key words :** body mass index; waist circumference; obesity; indices waist hip ratio; pulmonary function tests; forced vital capacity

## INTRODUCTION

It is globally accepted that obesity is a health hazard because of its strong association with numerous metabolic complications like dyslipidemia, diabetes

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mellitus, hypertension, cardio vascular accidents (1). Several studies have established obesity as being associated with respiratory complications such as obstructive sleep apnoea (2) and obesity hypoventilation syndrome (3), asthma both in child and adults (4, 5) and is believed to reduce lung volumes. Poor respiratory function predicts over all mortality as well as death due to pulmonary diseases (7, 8) cardio vascular diseases (9) and stroke (10). This relation could simply reflect the effect of smoking (11), but obesity is also associated with morbidity and mortality (12).

A number of studies have reported an inverse relation between various indices of obesity or fat distribution and respiratory function. These indices include measures of overall adiposity, such as weight or body mass index (weight (kg)/height ($m^2$) (13–17), and measures of fat distribution, such as waist circumference (WC) (15), percentage of fat mass (18), and skin fold thickness (18, 19). Differential fat distribution among males and females tends to affect the pulmonary functions (20, 21). Asians having increased tendency to abdominal adiposity may show different pattern of regional variability. Most previous reports have used body mass index (BMI) or one of its variations as the measure of overall obesity. This well-known index has much to recommend it (22**)** for epidemiologic purposes, unfortunately, it gives no indication of fat distribution. Also the height and weight which are surrogate measure of Body size are also predictors of pulmonary function test measurements. Gender difference in the accumulation of fat “apple vs pear” shaped may also affect the relation of the adiposity markers with pulmonary functions. A unit of body weight and BMI is likely to have less fat mass for under weight persons and for men than for overweight persons and for women.

Abdominal adiposity markers like Waist Hip Ratio (WHR) and WC may influence pulmonary function through a mechanism that may restrict the descent of the diaphragm and limit lung expansion, compared to overall adiposity, which may compress the chest wall. (11) Clinical studies have evaluated the relation of WHR (23) and WC (24–28), to poor respiratory functions in both mildly obese (19) and morbidly obese (11) persons.

Physicians are often perplexed by remarkable heterogeneity of disease pattern in obese patients. Therefore defining obesity at which disease outcome is more likely to occur is relevant to patient care and treatment.

Investigators have proposed that abdominal adiposity is a better indicator of visceral fat (the metabolically active fat depot) which has been implicated for various metabolic syndromes (28–30). In this study, we investigate the predictability of total body adiposity and abdominal adiposity with FEV1 and FVC in non obese and obese young adults of region of Dehardun. Uttrakhand, India. In particular, we hypothesized that a greater accumulation of abdominal fat is associated with lower levels of FEV1 and FVC, and that abdominal fatness is a better predictor of reduced pulmonary function than total body adiposity.

## MATERIALS AND METHODS

80 healthy volunteers from both the sexes of the age group of 20 -40 years were studied. The study group was randomly selected from the employees of Himalayan Institute of Medical Sciences and Community

dwellers from the surrounding area of Bhaniyawala, Dehradun. Considering the objective of the study the selection was done observing the following inclusion criteria :

- Age between 20 - 40years.
- Physically and mentally fit.
- Cooperative and capable of understanding the procedure.
- Not suffering from any known respiratory and medical problems.
- No acute respiratory illness at the point of entry.
- Non-smoker.

Following approval of the ethical committee and due consent of the volunteers, the subjects were interrogated for the inclusion criteria following strict detailed history including the detailed medical, family and personal history along with assessment of resting pulse rate and blood pressure recording as per the subject proforma.

The volunteers were asked to avoid beverages like tea, coffee and other stimulants and to report with light breakfast at the department of physiology, HIMS, in the forenoon to avoid diurnal variations. They were briefed and familiarized with the procedure and self demonstration of the required tests was done to help them get conversant with the procedure.

**Study protocol**

*1. Anthropometry:*

The subjects were enquired for any acute respiratory problem and subjected to anthropometry at the point of entry using the standard procedures and instruments.

- Age was recorded from birthday by calendar to the nearest of year (<6 months and >6 months).
- Standing height was recorded without shoes and with light cloths on a wall mounted measuring tape to the nearest of centimeters (<5 mm and >5 mm).
- Weight was recorded without shoes and with light cloths on a Krups weighing machine with a least count of 100 grams.
- Body mass index was calculated by the formula of weight (in Kg) and height (in meters). BMI = Weight (Kg)/(height in $m^2$) (29).
- Waist circumference measurement is done with minimal, adequate clothing (light cloths) with feet 25–30 cm apart and weight equally balanced with a tailor's measuring tape in a plane perpendicular to the long body axis at the level of umbilicus without compression of the skin with nearest to 0.1 cm (WC>/=90 cm in men and >/=80 cm in women) were defined as abdominal obesity using WHO Asia Pacific prospective guidelines (30).
- Hip circumference measurement is done with minimal, adequate clothing (light cloths) across the greater trochanter with legs and feet together by a measuring tape without compressing the skin fold.
- Waist-hip ratio is the ratio of WC and HC is calculated and is the measure of central pattern of fat distribution. (>0.9 for male and >0.8 for females) (30).

*2. Respiratory Parameters :*

Pulmonary function tests were done by a computerized spirometer (Spiro lab II). After rest for 5–10 min and briefing to the technique FVC (maximum inhalation followed by maximum exhalation & to be sustained until asked to inhale again), the test was carried out in a private and quiet room, in a standing position with the nose clip held in position on the nose. The flow, volume/ timed graphs were taken out in accordance to the criteria based on the American Thoracic Society (31) and best of the three acceptable curves was selected as the recording. Spirometeric parameters recorded for analysis were :

- FVC : Forced Vital capacity (L/sec)
- FEV1 : Forced expiratory volume in 1st sec (L/sec)

**Statistical analysis**

Statistical analysis was performed using the windows SPDD 10 version. Test and control groups were made according to the WHO criteria for relative obesity parameter BMI with an obese subjects (BMI of >/= 30) to non-obese subjects (BMI<30) among both the males and females. Trends of the respiratory parameters were also analyzed by stratifying the data by WC and WHR. Initial analysis was done by preparing a Pearson correlation matrix to assess the relationship between the indices of obesity and the selected respiratory markers. Partial correlation between the significantly related variables was than examined controlling for the age, height which themselves may influence pulmonary function measurements. Regression model was created with the most predictable parameter of obesity using step wise analysis. We defined a stronger association as one that yielded a lower P value based on the measurement properties (i.e. less variability and or/higher coefficients) of the variables.

## RESULTS

Table I illustrates the anthropomorphic parameters in males and females with both the genders showing no significant differences between obese and non obese subjects when age and height were compared suggesting that the population studied is homogenous in nature. As expected the weight and adiposity parameters like BMI, WC and WHR were significantly different among control and obese groups.

Table II shows the trend of the pulmonary functions by the adiposity markers BMI, WC & WHR both in men and women. There were significant lower FVC and FEV1 measurements in obese females as compared to the male .In males an inverse trend in the pulmonary parameters was observed and the trend was significant except when stratified with BMI. The WC showed a

TABLE I : Anthropometric data, body mass index, waist circumference, & waist-hip ratio in obese and non-obese volunteers (n=80).

| *Variable* | *Males (n=40)* | | | *Females (n=40)* | | |
|---|---|---|---|---|---|---|
| | *Non-obese* | *obese* | *P Value* | *Non obese* | *Obese* | *P value* |
| Age (year) | 30.80±6.19 | 29.4±6.50 | N S | 28.05±5.59 | 29.65±6.63 | N S |
| Height (m) | 1.66±0.09 | 1.70±6.97 | N S | 1.55±0.04 | 1.54±0.03 | N S |
| Weight (kg) | 68.05±10.04 | 96.35±6.97* | <0.05 | 54.10±8.18 | 78.65±7.08* | <0.05 |
| BMI (Kg/m$^2$) | 24.48±1.98 | 33.28±3.39* | <0.05 | 22.58±3.38 | 33.15±2.73* | <0.05 |
| WHR | 0.93±0.07 | 1±0.09* | <0.05 | 71.16±13.41 | 104.74±10.23* | <0.05 |
| WC (cm) | 96.92±14.17 | 115.93±11.63* | <0.05 | 0.81±0.06 | 0.90±0.06* | <0.05 |

BMI: body mass index; WC: waist circumference; WHR: waist hip ratio; NS: not significant; Values expressed are mean±SD.

highly significant decreased in the FVC and FEV1 values among obese females. However the WHR showing the highest difference between the pulmonary parameters among non obese and obese subjects among males.

Pearson's partial correlation matrix composed of multiple measures of adiposity markers showed a significant inverse relationship with both the FVC and FEV1 in males and females. WHR and BMI although showed a less than significant correlation with FEV1. Table III and IV show partial correlation coefficient among obesity

TABLE II: Trends of spirometric values FVC and $FEV_1$ by adiposity markers.

| *Males (n=40)* | *Adiposity Markers* | *Non obese* | *Obese* | *P Value* |
|---|---|---|---|---|
| FVC (L/s) | BMI (Kg/m$^2$) | 3.75±0.28 | 3.55±0.36 | NS |
| | WC (cm) | 3.84±0.11 | 3.59±0.34 | 0.022 |
| | WHR | 3.75±0.30 | 3.154±0.30 | 0.009 |
| FEV1(L/s) | BMI (Kg/m$^2$) | 3.37±0.25 | 3.80±0.35 | NS |
| | WC (cm) | 3.42±0.092 | 3.23±0.33 | 0.058 |
| | WHR | 3.35±0.272 | 3.171±0.32 | 0.030 |
| Females(n=40) | | | | |
| FVC(L/s) | BMI (Kg/m$^2$) | 3.19±0.26 | 2.89±0.29 | <0.05 |
| | WC (cm) | 3.18±0.26 | 2.93±0.28 | 0.004 |
| | WHR | 3.26±0.27 | 2.97±0.28 | 0.0048 |
| FEV1(L/s) | BMI (Kg/m$^2$) | 2.88±0.25 | 2.59±0.25 | <0.05 |
| | WC (cm) | 2.85±0.26 | 2.64±0.26 | 0.008 |
| | WHR | 3.26±0.25 | 2.67±0.27 | 0.010 |

FVC: Forced Vital Capacity, FEV1: Forced Expiratory Volume in 1st sec; NS: not significant; * p < 0.05; Values expressed are mean±SD.

TABLE III: Correlation coefficient among obesity and spirometric values adjusted for age and height in males (n=40).

| | *Weight (kg)* | *BMI (Kg/m$^2$)* | *WC (cm)* | *WHR* | *FVC (L/s)* | *FEV1 (L/s)* |
|---|---|---|---|---|---|---|
| Weight (Kg) | 1 | 0.997^ | 0.845^ | 0.483*** | −0.475*** | −0.417** |
| BMI (Kg/m$^2$) | | 1 | 0.825*** | 0.446** | −0.455** | −0.401** |
| WC (cm) | | | 1 | 0.655*** | −0.543*** | −0.432** |
| WHR | | | | 1 | −0.389** | −0.296* |
| FVC (L/s) | | | | | 1 | 0.944*** |
| FEV1 (L/s) | | | | | | 1 |

^P<0.000, ***P<0.001, **P<0.01, *P< 0.05.

TABLE IV: Correlation coefficient among obesity and spirometric values adjusted for age and height in females (n=40).

| | *Weight (kg)* | *BMI (Kg/m$^2$)* | *WC (cm)* | *WHR* | *FVC (L/s)* | *FEV1 (L/s)* |
|---|---|---|---|---|---|---|
| Weight (Kg) | 1 | 0.999^ | 0.854^ | 0.484*** | −0.343** | −0.328* |
| BMI( Kg/m$^2$) | | 1 | 0.856^ | 0.486*** | −0.351** | −0.337* |
| WC(cm) | | | 1 | 0.619^ | −0.281* | −0.272* |
| WHR | | | | 1 | −0.3* | −0.234 |
| FVC (L/s) | | | | | 1 | 0.925** |
| FEV1(L/s) | | | | | | 1 |

^P<.000, ***P<0.001, **P<0.01, *P<0.05.

TABLE V : Regression coefficient for adiposity marker with spirometry values FEV1, & FVC, for all subjects (n=80).

| *Variables* | *FVC(L/s)* | | *FEV1(L/s)* | |
|---|---|---|---|---|
| **Women (n=40)** | **Beta (P value)** | **R2** | **Beta (P value)** | **R2** |
| WC | –0.381 (0.017) | 0.122 | –0.373 (0.019) | 0.139 |
| **Males (n=40)** | | | | |
| WC | –0.502 (0.001) | 0.232 | –0.428 (0.006) | 0.184 |

parameters and Spirometric variables adjusted to age and height showed strong association in males and females. Pearson's correlation with multiple measures of adiposity markers WC and WHR showed a significant inverse relationship with both the FVC and FEV1, in both the males and females. WHR and the BMI showed an inverse less than significant correlation with FEV1. WC showed the strongest correlation with both the dynamic parameters FVC and FEV1compared to other parameters.

In all the WC showed the strongest correlation with both the dynamic respiratory parameters. The most sensitive indicator was analyzed for general population by step-wise regression analysis. The model showed only WC as linearly correlated without other covariates. Table V shows the Beta coefficient and significance and $R^2$ values for the parameter which are more significant in case of male (higher P value and $R^2$) than in females.

## DISCUSSION

We investigated the relation of a number of adiposity markers with pulmonary function in a population-based cross sectional study. The measured mean values of the dynamic pulmonary parameters were lower in obese (BMI>/=30kg/m$^2$) in both the genders. An inverse association of BMI, WHR and waist circumference with pulmonary function was found in both men and women. The relationship of pulmonary function and overall weight is a more complex issue. The inverse association found with adiposity markers may be partially explained by changes in the age and height. Trends of pulmonary function stratified with abdominal adiposity markers as well as the association of abdominal adiposity and pulmonary function adjusted for age and height, suggests that abdominal adiposity markers are strongly negative associated with FEV1 and FVC, and support the hypothesis that abdominal adiposity markers (ie, WHR and waist circumference) have better explanatory power than total body adiposity measured as BMI according to the p value significance and the coefficient values (28). The results of this study are particularly noteworthy in that WC, which is a specific marker for visceral adiposity, explained the greatest amount of variance in pulmonary function among all of the adiposity markers.

Visceral adipose tissue influences circulating concentrations of interleukin-(32) and cytokines that may act via systemic inflammation to negatively affect pulmonary function. (33, 34) WC may therefore negatively impact pulmonary function via the action of insulin resistance. Other Investigators have reported an inverse association of serum leptin concentration with FEV1 as well as with higher levels of C-reactive protein, leukocytes, and fibrinogens, which are other markers of systemic inflammation (35). Another possible mechanism for the association of abdominal adiposity and pulmonary function is a mechanical limitation of chest expansion during the FVC maneuver. Increased abdominal mass may impede the descent of the diaphragm and increase thoracic pressure (36). Abdominal adiposity is likely to reduce expiratory reserve volume via compressing the lungs and diaphragm (17, 37), that will result in lower FVC measurements, which we indeed observed via the strong inverse association of every adiposity marker with FVC in men and women.

The finding of slightly higher pulmonary function in the lowest WC compared to WHR and BMI supports the notion that having a lower WC may be a better indicator in males, of overall health especially compared to having a low BMI, since individuals with a low BMI may have varying levels of abdominal adiposity, depending on gender. This supports our hypothesis that abdominal adiposity may negatively influence pulmonary function even when individuals are classified as being non-obese using standard measures of obesity (ie, BMI, <30 $kg/m^2$).

The results are consistent with finding of Scottish cross-sectional survey of men and women aged 25–64 y, by Chen et al (21) where WC was inversely associated with FVC and $FEV_1$ in both men and women. In a British cohort study of 9674 men and 11876 women aged 45–79 y, Canoy et al (24) analyzed the association of WHR with FVC and $FEV_1$ in both men and women and found a significant inverse association. The associations persisted after adjustment for potential confounding factors like age and height and BMI. The current study also showed a tendency toward a stronger association between WC and $FEV_1$ after adjusting with BMI only in case of females. Our findings are similar to findings of Canoy et al on association of waist/hip ratio and pulmonary function however WC showed an inverse association that remained significant after adjustment for BMI only in females. Harik-Khan et al (26) investigated the association of fat distribution and pulmonary function using waist/ hip ratio & reported an inverse association of FEV1 and waist/hip ratio in men only, which is seen in both the gender in our finding. Koziel et al in their study on 40–50 years of volunteers found no association of WHR with FVC & FEV1 in females however in males FVC was negatively associated with WHR & positively with BMI and FEV1was positively associated with BMI & WHR (20).

In contrast to our finding Lazarus et al found no inverse associations of waist circumference and waist/hip ratio with FVC in women (18). These authors also reported an inverse association of abdominal girth/hip breadth ratio with pulmonary function after adjustment for BMI in men over a narrow age range in the Normative Aging Study. Collins et al examined 42 normal to mildly obese firefighters and found decreased pulmonary function in men with a waist/hip ratio of > 0.95 (19). The finding of an inverse association of BMI and waist circumference and the stronger association of abdominal adiposity and pulmonary function in men points to the importance of what has been called “apple vs pear-shaped” body types. As with other chronic conditions, increased abdominal adiposity or having an “apple-shape” may be an important indicator of lung health. Our result indicate abdominal adiposity markers WC showed consistent predictability for pulmonary function in both FVC and FEV1 in males. A recent study has also found WC as a better indicator than

BMI(38). Canoy et al found WHR in men and WC in females were associated with bigger reduction in pulmonary function than BMI.

The major strength of our study lies in the availability of multiple standardized anthropometric measurements, and spirometry. We were able to analyze the contribution of overall and abdominal adiposity markers to variation in pulmonary function. Our study is a random sample of individuals from the general population, so we were able to investigate this association in non obese individuals. The cross-sectional nature of this study is a limitation, as it does not provide information about a temporal sequence. However longitudinal studies of longer duration are needed to further investigate how abdominal adiposity and changes in abdominal adiposity influence pulmonary function. The findings should be interpreted with caution due the moderate participation rate. In addition, we cannot generalize these findings to children. A study of abdominal adiposity and pulmonary function in subjects in these age groups would be of interest because these individuals may not have yet attained maximal pulmonary function, which may influence pulmonary function decline and mortality risk.

We found negative associations of abdominal adiposity and pulmonary function in men and women from the general populations that are not limited to severely obese persons. Abdominal adiposity is an important determinant of impaired pulmonary function, and it is of greater importance than overall adiposity markers such as weight and BMI. We suggest that investigators consider the inclusion of markers of abdominal adiposity as a potential confounding factor when investigating the determinants of pulmonary function.

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