Effect of upper body fat distribution on pulmonary functions in medical students

Ashvin Sorani*, Chirag Savalia*, Kirit Sakariya*, Bharat Chavda*, Manish Kakaiya*, Pradeep Pithadia***

*Assistant Professor, **Tutor, Department of Physiology, P.D.U. Govt. Medical College, Rajkot, Gujarat, India.
***Assistant Professor, Department of Community Medicine, Shri M P Shah Govt Medical College, Jamnagar, Gujarat, India

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ABSTRACT

Background: The prevalence of obesity is increasing, and there is evidence that obesity, in particular abdominal obesity as a marker of insulin resistance, is negatively associated with pulmonary function. The mechanism for this association and the best marker of abdominal adiposity in relation to pulmonary function is not known.

Study objectives: We assessed the association between pulmonary function and body mass index (BMI), waist/hip ratio and Body fat percentage as markers of adiposity and body fat distribution. We used Pearson correlation coefficient to analyse the association of pulmonary function (i.e., FEV1 and FVC) [with manoeuvres performed in the sitting position] with overall adiposity markers (i.e., Body fat percentage and BMI) and abdominal adiposity markers (WHR).

Methods: One forty male subjects underwent physical examination, computerised pulmonary function tests (spirometry, lung volumes) and various anthropometric measurements (waist-hip ratio, BMI, skin fold thickness) out of which seventy were case and seventy were control.

Results: Result showed that expiratory reserve volume and FVC were showed negative correlation with WHR in obese group (p<0.001). There was negative correlation observed between BF% and ERV (-0.49), FVC (-0.05), and MVV (-0.11). There was negative correlation observed between BMI and ERV (-0.46) and MVV (-0.17). WHR also showed negative correlation with ERV (-0.14).

Conclusion: ERV and FVC were significantly decreased in subjects with WHR more than 0.93. These results suggest that abdominal adiposity is a better predictor of pulmonary function than Body fat percentage or BMI, and investigators should consider it when investigating the determinants of pulmonary function.

Key Words: Waist Hip Ratio, Body mass index, Body fat percentage, FVC, Abdominal obesity.

INTRODUCTION

An increase in the prevalence of obesity in young adults has been increasingly seen around the world [1]. A variety of anthropometric indices of body distribution have demonstrated that Upper body obesity carries a higher risk of cardiovascular and metabolic disease than does lower body obesity in investigations of severe adiposity [2,3,4]. Although the influence of obesity on pulmonary function tests has been examined [5,6,7], the role of body fat distribution has received limited attention. One widely used measure of determining upper versus lower body fat is the waist-to-hip ratio (WHR), with a WHR of 0.950 or greater indicating upper body obesity and a WHR of less than 0.950 indicating lower body obesity [8]. Preliminary studies of severely obese persons with upper body obesity suggest that they have more severely compromised lung volumes than those with lower body obesity [9,10]. A decrease in lung volume increases respiratory resistance contributing to exercise-induced dyspnoea in obese patients [7]. Abdominal adiposity is a cardiovascular risk factor that is associated with insulin resistance, impaired glucose metabolism, hypertension, and dyslipidemia, all of which are features that are associated with the metabolic syndrome [11,12].

Insulin resistance is recognized as a low-grade inflammatory condition [13,14], and proinflammatory cytokines (i.e. adiponectin, leptin, tumour necrosis factor and interleukin-6) are associated with adiposity [15,19]. Systemic inflammation is also thought to play a role [20,21] in the association between reduced pulmonary function and cardiovascular mortality as well as all-cause mortality [22,23]. However, the exact mechanism for the latter association is not fully understood. Insulin resistance and inflammation
that arise from abdominal adiposity may mediate the relation of pulmonary function and all-cause mortality.

MATERIAL AND METHODS

A Study was performed on 140 healthy, otherwise asymptomatic young individuals in the age group of 18 to 24 years, randomly selected from medical students of P.D.U. Medical College, Rajkot. We have selected 70 students having boy fat distribution of 20% or more. To compare with them, we have selected 70 students having body fat distribution of lower than 20%. Individuals doing regular exercise, having respiratory infections or any other respiratory diseases, smokers, hypertensive, or having any musculoskeletal deformities of chest/vertebral column were excluded from the study. Of the subjects, to be enrolled for the study, were informed about the study and procedure details and an informed consent was obtained. The subjects were all healthy asymptomatic.

All participants provided information on age, family history, personal habits (alcohol intake, tobacco consumption, and level of physical exercise, drug ingestion, known pathological conditions). A detailed physical examination was conducted to exclude cardiac or pulmonary diseases. Our study was reviewed and approved by the Ethics Committee. All the records i.e. anthropometric measurements, skin fold measurements and recording of pulmonary function tests were conducted in one sitting on the same day.

Anthropometric variables like height and weight were obtained. Height was measured to the nearest of 0.1 cm and weight was measured to the nearest of 0.1 kg with minimum of clothes and no shoes. Body mass index was calculated by Quetelet's Index [24].

The waist circumference (cm) was measured at a point midway between the lower rib and iliac crest, in a horizontal plane. The hip circumference (cm) was measured at the widest girth of the hip. The measurements were recorded to the nearest 0.1 cm.

Skin fold thickness was measured at four standard anatomical sites with the help by measuring skin fold thickness at four sites (4SFT-biceps, triceps, subscapular and suprailiac) with the help of Harpenden's caliper. The percentage of body fat was estimated by using the method of Durnin and Womersley [25].

Pulmonary functions were recorded on a computerized portable lung function unit SP-1. The recorded parameters were compared with the inbuilt pulmonary function norms for the Indian population depending upon the age, sex, height, and weight. Recording of static and dynamic pulmonary function tests was conducted on motivated young healthy volunteers in standing position [26].

These tests were recorded at noon before lunch, as expiratory flow rates are highest at noon. For each volunteer three satisfactory efforts were recorded according to the norms given by American Thoracic Society [27]. The essential parameters obtained were, tidal volume (VT), expiratory reserve volume (ERV), inspiratory capacity (IC), forced vital capacity (FVC), timed vital capacity (FEV1), maximum ventilator volume (MVV) and peak expiratory flow rate (PEFR).

RESULTS

Table 1 shows that expiratory reserve volume and maximum voluntary ventilation were significantly decreased in obese group (p<0.001). In this study there was statistically significant difference in body mass index and waist to hip ratio observed in obese subjects.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control (BF&lt;20%) N=70</th>
<th>Obese (BF&gt;20%) N=70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(years)</td>
<td>19.03±0.24</td>
<td>22.14±0.24</td>
</tr>
<tr>
<td>Height(cm)</td>
<td>171.6±0.71</td>
<td>166.3±0.54</td>
</tr>
<tr>
<td>Weight(kg)</td>
<td>64.89±0.036</td>
<td>80.09±0.53</td>
</tr>
<tr>
<td>BMI(kg/m²)</td>
<td>22.07±0.30</td>
<td>29.00±0.20*</td>
</tr>
<tr>
<td>WHR</td>
<td>0.83±0.009</td>
<td>0.93±0.007*</td>
</tr>
<tr>
<td>Skinfold thickness (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BICEPS</td>
<td>7.8±0.31</td>
<td>14.6±0.22*</td>
</tr>
<tr>
<td>TRICEPS</td>
<td>9.8±0.36</td>
<td>18.7±0.42</td>
</tr>
<tr>
<td>SUBSCAPULAR</td>
<td>13.1±0.38</td>
<td>23.14±0.56</td>
</tr>
<tr>
<td>SUPRAILIAC</td>
<td>15.31±0.4</td>
<td>27.04±0.68*</td>
</tr>
<tr>
<td>Pulmonary function tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERV(L)</td>
<td>1.1±0.041</td>
<td>0.71±0.0079*</td>
</tr>
<tr>
<td>IC(L)</td>
<td>3.31±0.018</td>
<td>3.14±0.041</td>
</tr>
<tr>
<td>FVC(L)</td>
<td>4.18±0.047</td>
<td>3.74±0.03</td>
</tr>
<tr>
<td>FEV₁/FVC</td>
<td>0.7904±0.0025</td>
<td>0.79±0.0024</td>
</tr>
<tr>
<td>MVV(L/Min)</td>
<td>127.5±5.56</td>
<td>118.9±1.31*</td>
</tr>
<tr>
<td>PEFR (L/Min)</td>
<td>424.9±10.68</td>
<td>445.5±9.38</td>
</tr>
<tr>
<td>FEF25–75% (L/Sec)</td>
<td>4.913±0.014</td>
<td>4.919±0.011</td>
</tr>
</tbody>
</table>

*P<0.05 unpaired ‘t’ test.
Body Fat % calculated by Durnin and Womersley method

Table 2 and 3 shows Pearson correlation coefficients in normal (BF<20%) and obese (BF>20%). Body fat percentage showed negative correlation with ERV (-0.43), FVC (-0.20), and MVV (-0.15) in obese subjects and these values were statistically significant. Body mass index also showed negative correlation with ERV(-0.3) and FVC(-0.35). Anthropometric parameters like triceps and suprailiac skin fold thickness showed significant negative correlation with pulmonary function in obese group. WHR which is a marker for abdominal obesity showed significant negative correlation with ERV (-0.78) & FVC (-0.57).

**Table 2: Pearson correlation coefficients in control group** (BF < 20%)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>ERV(L)</th>
<th>FVC(L)</th>
<th>FEV1/FVC</th>
<th>MVV(L/Mi)</th>
<th>FEF 25-75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF%</td>
<td>0.138</td>
<td>-0.037</td>
<td>0.043</td>
<td>0.019</td>
<td>0.004</td>
</tr>
<tr>
<td>BMI (Kg/m²)</td>
<td>-0.334</td>
<td>-0.183</td>
<td>0.128</td>
<td>0.013</td>
<td>0.071</td>
</tr>
<tr>
<td>WHR</td>
<td>0.116</td>
<td>-0.097</td>
<td>0.003</td>
<td>0.024</td>
<td>0.056</td>
</tr>
<tr>
<td>Biceps (mm)</td>
<td>-0.148</td>
<td>-0.085</td>
<td>0.009</td>
<td>0.134</td>
<td>0.092</td>
</tr>
<tr>
<td>Triceps (mm)</td>
<td>-0.148</td>
<td>-0.085</td>
<td>0.009</td>
<td>0.134</td>
<td>0.092</td>
</tr>
<tr>
<td>Subscapular (mm)</td>
<td>-0.480</td>
<td>-0.350</td>
<td>0.001</td>
<td>0.185</td>
<td>-0.09</td>
</tr>
<tr>
<td>Suprailiac (mm)</td>
<td>-0.398</td>
<td>-0.281</td>
<td>-0.026</td>
<td>0.038</td>
<td>0.097</td>
</tr>
</tbody>
</table>

(*P<0.05) **n=70

**Table 3: Pearson correlation coefficients in obese subjects** (BF>20%)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>ERV(L)</th>
<th>FVC(L)</th>
<th>FEV1/FVC</th>
<th>MVV(L/Mi)</th>
<th>FEF 25-75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF%</td>
<td>-0.437</td>
<td>-0.206</td>
<td>0.206</td>
<td>-0.155</td>
<td>0.053</td>
</tr>
<tr>
<td>BMI (Kg/m²)</td>
<td>-0.307</td>
<td>-0.356</td>
<td>0.167</td>
<td>0.121</td>
<td>0.194</td>
</tr>
<tr>
<td>WHR</td>
<td>-0.782</td>
<td>-0.566</td>
<td>0.224</td>
<td>-0.367</td>
<td>0.19</td>
</tr>
<tr>
<td>Biceps (mm)</td>
<td>-0.072</td>
<td>-0.216</td>
<td>0.281</td>
<td>-0.055</td>
<td>0.096</td>
</tr>
<tr>
<td>Triceps (mm)</td>
<td>-0.173</td>
<td>-0.244</td>
<td>0.337</td>
<td>-0.186</td>
<td>0.116</td>
</tr>
<tr>
<td>Subscapular (mm)</td>
<td>-0.193</td>
<td>-0.137</td>
<td>0.105</td>
<td>0.038</td>
<td>0.035</td>
</tr>
<tr>
<td>Suprailiac (mm)</td>
<td>-0.202</td>
<td>-0.053</td>
<td>0.093</td>
<td>0.048</td>
<td>0.043</td>
</tr>
</tbody>
</table>

(*P<0.05) **n=70

**DISCUSSION**

Abdominal and thoracic fat are likely to have direct effects on the downward movement of diaphragm and on chest wall properties while fat on hips and thighs would be unlikely to have any direct mechanical effect on lungs [28].

In terms of anthropometry, respiratory functions are significantly related to the power of abdominal muscles and upper body fat percentage. In the previous studies, it was shown that pulmonary functions are under the influence of muscularity and fat distribution rather than body weight [29]. Bilgin et al also noted negative correlation between fat% and FVC, MVV, FEV1, and PEF [30].

Sutherland et al observed that FVC was negatively associated with both waist circumference and WHR. FVC and the lung volume parameters (excluding residual volume) were found to have a significant negative association with each of the DXA-derived variables. Strongest correlation was found with FVC [31].

Cheryl et al also observed that abdominal fat (measured by waist circumference, waist to hip ratio and thoracic or upper body fat measured by subscapular skinfold thickness or biceps skin fold thickness) is associated with reduction in lung volumes [28].

Lazarus et al observed that increasing proportions of body fat are associated with decreasing FVC. Wannamethee et al also observed inverse correlation of body fat% with FVC and FEV1 [32]. Lynell c. Collins et al also observed that FVC, FEV1, TLC were significantly decreased in upper body fat distribution (WHR<0.93). They also observed that obesity has inverse relationship with FVC [33]. Joshi et al also observed that central fat
distribution is associated with decreased ERV, FVC and MVV [34].

In present study it was observed that subjects with upper body fat accumulation (WHR>0.93) had significantly decreased ERV and FVC, these findings seem to be in perfect tune with previous studies.

CONCLUSION

Significant negative correlation of FVC with body fat percentage has been observed. The observed values of decreased FVC suggested displacement of air by fat within thorax and abdomen.

Waist to hip ratio is highly correlated with abdominal fat mass and is therefore often used as a surrogate marker for abdominal or upper body obesity. In present study central pattern of fat distribution was observed. ERV and FVC were significantly decreased in subjects with WHR more than 0.93. Obese persons with central body fat distribution have more reduced FVC than those with lower body obesity. The intra-abdominal adipose pressing upward on the diaphragm prevents full downward excursion during deep inspiration could be responsible for the results.

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Corresponding Author:
Dr. Chirag V. Savalia
Department of Physiology
P.D.U. Govt. Medical College
Rajkot –360001
Gujarat, India
E mail: chiragsavalia2001@gmail.com
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