Changes in spirometry parameters with the change in posture from sitting to supine positions in asymptomatic normal weight, overweight and obese young Omani males

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Objectives Worldwide obesity is one of the major problems. Some studies say that in Oman it reaches up to 50% of the adult population. Obesity creates many complications in the body, mainly the respiratory system. Few studies were done to evaluate the effect of obesity on airflow parameters in pulmonary function test. Our study evaluates the effect of obesity on the airflow parameters while changing the posture from sitting to supine position in non-obese, overweight, and obese individuals.

Methods About 30 subjects were divided into three groups according to their BMI. Physical examination was done and questionnaire was given to the subjects prior to the procedure. Forced vital capacity maneuver was done for each subject at least five times spirometry parameters were derived from the flow volume curve obtained after expiratory effort.

Results All the parameters were decreasing from sitting to supine position in all the three BMI groups except PEF in overweight group. There was no statistically significant difference between the three groups while comparing them in sitting or supine position. Also, the comparison between each two groups in mean percentage difference showed no significant difference.

Conclusion The study showed that the difference in airflow parameters with the change in posture from sitting to supine position was not significantly different in obese subjects as compared with non-obese and overweight subjects. This insignificant result may be due to small sample size or because of the fixed age group [19–25 years old]. Females were not included in the study. The study has generated some background information on lung functions of obese but otherwise asymptomatic Omani males which can be used for study of lung function in morbidly obese subjects.

Keywords spirometry, pulmonary function test, obesity, airway

Introduction

Prevalence rate of overweight and obesity in Oman is 50%. Majority of the previous studies have focused on the effect of obesity on cardiovascular and gastrointestinal systems but only a few have looked at the effect of obesity on spirometry parameters. The lung volumes and the diffusion capacity for carbon monoxide decrease in obese children. Luder et al. reported that the children who are obese and overweight tend to have more severe symptoms of asthma. Another study showed that obesity affects the respiratory system by increasing the deposition of the adipose tissue in the upper respiratory tract. The fatty tissue starts to release adipokines, which are inflammatory substances such as interleukin-1 (IL-1), interleukin-6 (IL-6) and tumor necrosis factor alpha (TNF-α). These substances stimulate mucus secretion and cause bronchospasm leading to airway obstruction. A study from Turkey showed that forced vital capacity (FVC), forced expiratory volume 1 (FEV1) second, peak expiratory flow (PEF) and forced expiratory force in the 25–75% of the air blow (FEF25–75%) are inversely proportional to BMI but the (FEV1/FVC ratio) remains normal.

Most of the previous spirometry studies were performed in the erect/sitting posture while attention was not given to the changes that occur while supine. Our study looks at the changes in spirometry parameters such as asymptomatic obese, overweight and non-obese individuals with a change in posture from sitting to supine. We hypothesize that fat deposition around the upper airway of obese subjects is likely to alter the functional anatomy of the neck resulting in reduction in maximal airflows and this may be exaggerated by changing posture from sitting to supine. Even in normal non-obese subjects, diameter of upper airway reduces with a change in posture from sitting to supine. The change may also be associated with the decrease in lung volumes that occur because of the increase in the intrathoracic blood volume and restriction of gravity induced descent of the diaphragm.

Materials and Methods

Selection of subjects

About 30 male subjects from different regions in Oman volunteered for the study after an announcement done in Collage of Medicine and Health Science at Sultan Qaboos University, Sultanate of Oman. Of these, 10 were non-obese (BMI < 25 kg/m²), 10 were overweight (BMI 25–30 kg/m²) and 10 were compared with lean subjects. It also has been shown that FVC and FEV1 are inversely proportional to BMI but the (FEV1/FVC ratio) remains normal. Most of the previous spirometry studies were performed in the erect/sitting posture while attention was not given to the changes that occur while supine. Our study looks at the changes in spirometry parameters such as asymptomatic obese, overweight and non-obese individuals with a change in posture from sitting to supine. We hypothesize that fat deposition around the upper airway of obese subjects is likely to alter the functional anatomy of the neck resulting in reduction in maximal airflows and this may be exaggerated by changing posture from sitting to supine. Even in normal non-obese subjects, diameter of upper airway reduces with a change in posture from sitting to supine. The change may also be associated with the decrease in lung volumes that occur because of the increase in the intrathoracic blood volume and restriction of gravity induced descent of the diaphragm.
obese (BMI > 30 kg/m²). Physical characteristics of the subjects are listed in Table 1.

The participants selected were free from any disease related to cardiovascular or respiratory systems. The subjects completed a questionnaire that we designed and a physical examination for respiratory and cardiovascular systems was done. All smokers were excluded. The procedure and the expected conditions were discussed and explained to the subjects and informed consent was obtained from them. Ethical approval was obtained from the Ethical Committee of the College of Medicine and Health Sciences, SQU, Muscat, Oman.

Procedure

Spirometry recording was performed using “MEDGRAFIC – CPFC/D” which uses the software called “BREEZE SUITE”. Each subject was trained to do a successful slow and forced vital capacity maneuver as per standard practice.

On the day of the test, subjects were asked to fast for at least 2 hours before coming to the laboratory. They were abstained from tea or coffee on the day of the test.

The subjects were asked to take 5–6 breaths at tidal volume. After that, they performed the forced expiration maneuver as trained in sitting position first. This procedure was repeated also in supine position for all the subjects. Each subject performed five maneuvers for the FVC in the sitting and the supine postures. Three maneuvers with FVC within 5% of each other were selected for analysis in both situations. The volume and airflow variables were derived from these efforts and the mean of three values was reported.

Statistics

The data of the test were recorded and analyzed by using "SPSS software version 17"; the level of confidence used was 95%.

The data in sitting and supine postures for each group was compared using “paired sample t-test”. Furthermore, intergroup data was used to compare the effect of changing posture between the three groups on lung volumes using “independent sample t-test”. “ANOVA test” was used to compare between lung functions of three different body weight groups.

Results

Table 2 shows the effect of changing posture from sitting to supine on lung volumes in normal, overweight, and obese individuals. The lung volumes reduced significantly in all the three groups when the posture changed to supine. Changes in spirometry parameters with the change in posture from sitting to supine on lung volumes in normal, overweight, and obese individuals are listed in Table 3.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Posture</th>
<th>Mean sitting (SD)</th>
<th>Mean supine (SD)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-obese</td>
<td>PEF (l/min)</td>
<td>645.3 (44.5)</td>
<td>568.5 (53.9)</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FEF25–75%</td>
<td>3.88 (0.6)</td>
<td>2.72 (0.7)</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FEF50%</td>
<td>4.47 (0.7)</td>
<td>3.44 (0.7)</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FEFmax</td>
<td>8.52 (1.6)</td>
<td>7.73 (1.4)</td>
<td>0.034</td>
</tr>
<tr>
<td>Overweight</td>
<td>PEF (l/min)</td>
<td>576.2 (74.7)</td>
<td>559.5 (84.6)</td>
<td>0.564</td>
</tr>
<tr>
<td></td>
<td>FEF25–75%</td>
<td>3.74 (0.8)</td>
<td>2.50 (0.8)</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FEF50%</td>
<td>4.54 (1.0)</td>
<td>3.41 (0.9)</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>FEFmax</td>
<td>8.60 (1.3)</td>
<td>7.85 (1.2)</td>
<td>0.02</td>
</tr>
<tr>
<td>Obese</td>
<td>PEF (l/min)</td>
<td>599.07 (112.5)</td>
<td>535.07 (98.6)</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>FEF25–75%</td>
<td>3.64 (0.9)</td>
<td>2.61 (1.0)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>FEF50%</td>
<td>4.21 (1.0)</td>
<td>3.42 (1.1)</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>FEFmax</td>
<td>8.80 (1.2)</td>
<td>7.33 (1.4)</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Table 1. Physical characteristics of the subjects (statistically compared using ANOVA)

<table>
<thead>
<tr>
<th>Non-obese</th>
<th>Over weight</th>
<th>Obese</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>20.1 (0.9)</td>
<td>20.6 (1.3)</td>
<td>20.6 (1.1)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>172.05 (7.6)</td>
<td>169.9 (3.2)</td>
<td>173.1 (6)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>21.86 (1.6)</td>
<td>27.12 (1.4)</td>
<td>31.8 (1.17)</td>
</tr>
</tbody>
</table>

Changes in spirometry parameters with the change in posture from sitting
A major result of our study is that there is no significant decrease in PEF was significant ($P = 0.002$) and the change was from 599.07 (l/min) in sitting to 535.07 (l/min) in supine. FEF$_{25-75\%}$ also decreased from 3.64 in sitting to 2.61 in supine ($P = 0.001$). FEF$_{50\%}$ also decreased from 4.21 in sitting to 3.42 in supine ($P = 0.007$) and FIF$_{max}$ decreased from 8.80 in sitting to 7.33 in supine ($P = 0.016$).

Table 4 illustrates the mean difference in spirometry parameters from sitting to supine position in all groups. The table shows that the mean percentage of reduction is variable between the groups, and that no major changes happen while comparing the mean change. For example, when comparing the mean percentage difference of FVC, we notice that FVC is 5.82% in non-obese, 6.24% in overweight and 7.19% in obese subjects with $P$-value of 0.657. The mean difference in FEF1 was 10.63% in non-obese vs 9.07% in overweight and 9.39% in obese subjects which is not a statistically significant change ($P = 0.722$).

### Discussion

Earlier studies have shown that there is an inverse relation between obesity and lung function parameters. A major result of our study is that there is no significant change in lung volumes between different body weight groups in sitting posture except in ERV. Different studies have shown that the most common abnormality induced by obesity on spirometry is the reduction of ERV. This may be attributable to alteration of chest wall mechanism which also leads to decreased total respiratory compliance. Another study showed that FVC, total lung capacity (TLC), and residual volume (RV) decline linearly as the BMI increases. In our study we found that there was no difference between the FVC and FEF1 (corrected to a height of 172 cm$^3$) in our young Omani males whether normal, overweight or obese. On the other hand, ERV and FRC decline exponentially when the BMI increases. Our obese subjects had a significantly lower ERV as compared with the other two groups and in this aspect our findings are consistent with those reported in literature though we did not find a linear decline in this variable.

Our results of FVC and FVE1 are different from the results of several studies. Patients with mild obesity (BMI 30–35 kg/m$^2$) have significantly lower FVC than lean subjects. Different studies showed that FVC, FEV1, FEV1/FVC ratio reduce significantly in obese subjects. The difference between our results and several previous studies results could be a result of subject selection. The age range of our subjects is lower [mean age around 20 years as compared with other studies where the subjects are older (around 40–50 years)]. Also, the level of overall physical fitness of our groups could have been better than subjects of other studies.

These interesting findings lead us to say that mild obesity has no significant effects on people who aged between 19–25 years because in young people their body built (more muscles) is sufficient to help them to compensate for the effects of obesity. Another possible explanation of our results is that most of the subjects had subcutaneous obesity which is well known to have less effect on body systems including respiratory system as compared with central obesity. Also, these differences in results can be related to the sample size. We expect that if we increase the sample size, the slight decrease in lung volumes of obese subjects will be significant compared to normal weight subjects.

The lung volumes reduce with changing posture and this matches with what has been already found in several previous studies. One explanation of the results is that when posture is changed from sitting to supine the intra-abdominal pressure increases. This increase in the pressure prevents descent of the diaphragm which in turn reduces generation of negative pressure in the pleural cavity thus limiting lung expansion. Elliot et al. gave another explanation for that, in which he said that in supine posture the effect of gravity on blood distribution in the body is canceled, therefore, the intra-thoracic blood volume increases which results in reduction of lung volumes.

Other finding was that all the airflow parameters decreased from sitting to supine position. This shows that abdominal content and intra-abdominal pressure have some effect on the ventilation process while changing the posture. PEF in overweight individuals did not have significant decrease. The same finding was found by Saxena et al. that noted that there is no any significant association between BMI and PEF. They also showed that there was no significant association between adiposity markers [IL-1, IL-6 and TNF-a] and PEF. These markers were not estimated in the present study.

FIF$_{25-75\%}$ in sitting position which indicates airflow in the small airways showed a decreasing trend. This may be due to the inflammatory cytokines and the inflammatory response in these small airways, the cytokines was not estimated in our study. FEF$_{50\%}$ also a measure of small airways airflow demonstrated mixed effects. It showed increasing trend from non-obese to overweight subjects, and declining trend from overweight to obese individuals. This trend could also mean that the elastic recoil in the overweight group is much better than the elastic recoil in non-obese and obese individuals as the FEF$_{50\%}$ mostly dependent on the elastic recoil property of the lung.

FIF$_{max}$ that indicates the strength in inspiratory muscles, shows an increasing trend from non-obese to overweight then to obese. This may indicate that the more the BMI the more the FIF$_{max}$ is due to increase in muscle mass and fat content in overweight and obese individuals. We however did not estimate the muscle vs fat content of our subjects.

Our study has some limitations. First, our subjects were young active males. A similar study in an older population may bring out better the effects of obesity of lung function parameters. Secondly, we selected just male subjects and this may be the major limitation of our study as female is also a part from our community and we need to establish their data. Also, the levels of cytokines were not measured in this study.
and this is important because we need to know the relation between the level of cytokines in the airways and BMI. Lastly, morbidly obese individuals could not be included in the study because of their reluctance to participate.

**Conclusion**

In conclusion, our study showed that there is change in the airflow parameters while changing posture from sitting position to supine position in all the three groups except in PEF in overweight subjects because there is no association between the inflammatory markers and PEF. Our study also showed that FEF25–75% and FEF50% have very similar trend which means that there is no need to report both of the values and FEF50% is enough to report for small airway obstruction and inflammation.

Also, this study concluded that mildly obese individuals are not largely affected by the fat distribution in the airways and the main effect would be in the morbid obese individuals as we did not measure the cytokines level and could not recruit morbidly obese subjects.

**Acknowledgments**

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**Conflict of interest**

No funding was needed for the study and no conflict of interest to disclose.

**References**


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