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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%.[1] 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.[2] Luder et al.[3] 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.[4] 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 25–7% of the air blow ($FEF_{25-75\%}$), which is a marker of small airway diseases are lower in obese children in comparison to the control group who were non-obese.[2]

A study showed that loss in weight increased $FEF_{25-75\%}$ indicating a widening of small airway diameter.[5] Another study showed that obesity will alter the respiratory muscles and decrease the lung volumes and will affect respiratory mechanics adversely.[6] Patients with mild obesity (BMI 30–35 kg/m^2) have lower FVC, total lung volume and residual volume (RV) as compared with lean subjects.[7] It also has been shown that FVC and FEV_1 are inversely proportional to BMI but the (FEV_1/FVC ratio) remains normal.[8]

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.[5] 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.[3]

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/m^2), 10 were overweight (BMI 25–30 kg/m^2) and 10 were obese (BMI > 30 kg/m^2).[9] 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 (P ranging from <0.0001 to <0.033). What is interesting is the fact that the RV reduction significance ($P < 0.0001$) was much greater in non-obese group than seen in the overweight and obese groups.

Table 3 shows that changing posture from sitting to supine in each group resulted in a significant reduction in all the spirometry flow rates. In non-obese subjects the mean PEF decreased from 645.3 (l/min) in sitting to 568.5 (l/min) in supine position. $FEF_{25-75\%}$ decreased from 3.88 in sitting position to 2.72 in supine position and $FEF_{50\%}$ decreased from 4.47 in sitting to 3.44 in supine position ($P = 0.0001$ for all). However, forced inspiratory $flow_{max}$ (FIF_{max}) decreased from 8.52 to 7.73 ($P = 0.034$). In overweight individuals the decrease in PEF was not statistically significant [sitting: 576.2 (l/min) vs. supine: 559.5 (l/min); ($P = 0.564$)]. The decrease in $FEF_{25-75\%}$, $FEF_{50\%}$ and FIF_{max} was statistically significant ($P < 0.0001$, $P < 0.0001$ and $P = 0.020$ respectively). In obese individuals the

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

	Non-obese	Over weight	Obese	*P*
	Mean (SD)	Mean (SD)	Mean (SD)	
Age (years)	20.1 (0.9)	20.6 (1.3)	20.6 (1.1)	0.501
Height (cm)	172.05 (7.6)	169.9 (3.2)	173.1 (6)	0.471
BMI (kg/m^2)	21.86 (1.6)	27.12 (1.4)	31.8 (1.17)	0.0001

Table 2. **The mean and SD values for various spirometry parameters. Lung volumes. FVC and FEV1 are standardized to a height of 172 cm**

	Posture		*P*- value
	Mean sitting (SD)	Mean supine (SD)	
Non-obese			
FVC (L)	4.92 (0.4)	4.63 (0.4)	0.0001
FEV1 (L)	4.07 (0.3)	3.64 (0.3)	0.0001
FEV1/FVC%	82.85% (4.7)	78.62% (5.1)	0.0001
ERV (L)	1.72 (0.4)	1.31 (0.3)	0.0001
Overweight			
FVC (L)	4.94 (0.4)	4.63 (0.5)	0.0001
FEV1 (L)	3.95 (0.2)	3.60 (0.3)	0.0001
FEV1/FVC%	80.33% (6.0)	76.49% (5.8)	0.019
ERV (L)	1.96 (0.4)	1.36 (0.6)	0.029
Obese			
FVC (L)	4.61 (0.8)	4.29 (0.7)	0.0001
FEV1 (L)	3.70 (0.4)	3.37 (0.5)	0.0001
FEV1/FVC%	81.18% (8.3)	79.09% (7.4)	0.033
ERV (L)	1.37 (0.5)	0.89 (0.4)	0.013

Table 3. **The mean and the standard deviation of the airflow parameters in both position (*t*-test)**

Parameter	Posture		*P*-value
	Mean sitting (SD)	Mean supine (SD)	
Non-obese			
PEF (l/min)	645.3 (44.5)	568.5 (53.9)	0.0001
$FEF_{25-75\%}$	3.88 (0.6)	2.72 (0.7)	0.0001
$FEF_{50\%}$	4.47 (0.7)	3.44 (0.7)	0.0001
FIF_{Max}	8.52 (1.6)	7.73 (1.4)	0.034
Overweight			
PEF (l/min)	576.2 (74.7)	559.5 (84.6)	0.564
$FEF_{25-75\%}$	3.74 (0.8)	2.50 (0.8)	0.0001
$FEF_{50\%}$	4.54 (1.0)	3.41 (0.9)	0.0001
FIF_{max}	8.60 (1.3)	7.85 (1.2)	0.02
Obese			
PEF (l/min)	599.07 (112.5)	535.07 (98.6)	0.002
$FEF_{25-75\%}$	3.64 (0.9)	2.61 (1.0)	0.001
$FEF_{50\%}$	4.21 (1.0)	3.42 (1.1)	0.007
FIF_{max}	8.80 (1.2)	7.33 (1.4)	0.016

Table 4. **Comparison between the mean percentage difference. Mean% = (Sitting-Supine/Sitting)* 100**

Parameters	Non-obese	Over weight	Obese	*P*-value
	Mean%*	Mean%	Mean%	
FVC	5.82	6.24	7.19	0.657
FEV1	10.63	9.07	9.39	0.722
FEV1/FVC ratio	5.12	3.02	2.42	0.078
PEF	11.88	2.013	10.47	0.105
$FEF_{25-75\%}$	30.56	34.72	28.37	0.621
$FEF_{50\%}$	22.96	24.97	18.74	0.572
FIF_{max}	8.76	8.22	15.75	0.374
ERV	33.91	28.39	32.45	0.915

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. $FEF_{25-75\%}$ 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 all 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 FEV1 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.[2,10,11]

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.[2,8,12] 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 FEV1 (corrected to a height of 172 cm[13]) in our young Omani males whether normal, overweight or obese. On the other hand, ERV and FRC decline exponentially when the BMI increases.[14] 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.[5,9,14] Patients with mild obesity (BMI 30–35 kg/m^2) have significantly lower FVC than lean subjects.[14] Different studies showed that FVC, FEV1, FEV1/FVC ratio reduce significantly in obese subjects.[6,14] 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.[14] 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 compare 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 of generation of negative pressure in the pleural cavity thus limiting lung expansion. Elliot et al[15] 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[16] 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-α] and PEF. These markers were not estimated in the present study.

$FEF_{25-75\%}$ 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,[4] 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 and 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 $FEF_{25–75\%}$ and $FEF_{50\%}$ have very similar trend which means that there is no need to report both of the values and $FEF_{50\%}$ 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.

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Conflict of interest

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

References

1. Al-Moosa S, Allin S, Jemiai N, Al-Lawati J, Mossialos E. Diabetes and urbanization in the Omani population: an analysis of national survey data. Popul Health Metr. 2006;4:5.
2. Ulger Z, Demir E, Tanaç R, Gökşen D, Gülen F, Darcan S, et al. The effect of childhood obesity on respiratory function tests and airway hyper-responsiveness. Turk J Pediatr. 2006;48:43–50.
3. Luder E, Melnik TA, DiMaio M. Association of being overweight with greater asthma symptoms in inner city black and Hispanic children. J Pediatr. 1998;132:699–703.
4. Redinger RN. The pathophysiology of obesity and its clinical manifestations. Gastroenterol Hepatolk. 2007;3:856–863.
5. Hakala K, Stenius-Aarniala B, Sovijärvi A. Effects of weight loss on peak flow variability, airways obstruction, and lung volumes in obese patients with asthma. Chest. 2000;118:1315–1321.
6. Sin DD, Jones RL, Man SF. Obesity is a risk factor for dyspnea but not for airflow obstruction. Arch Intern Med. 2002;162:1477–1481.
7. Powers MA. The obesity hypoventilation syndrome. Respiratory Care. 2008;53:1723–1730.
8. Deane S, Thomson A. Obesity and the pulmonologist. Arch Dis Child. 2006;91:188–191.
9. Colledge NR, Walker BR, Ralston SH. *Obesity in Davidson's Principles & Practice of Medicine.* 21st ed., London, 2010, pp. 116–121.
10. Freedman DS. Center of Disease Control and Prevention (CDC). Obesity - United States, 1988–2008. MMWR Suppl. 2011;60:73–77.
11. Sales-Peres SH, Goya S, Sant'Anna RM, Silva HM, Sales-Peres Ade C, Silva RP, et al. [Prevalence of overweight and obesity, and associated factors in adolescents, at the central west area of the state São Paulo (SP, Brazil)]. Cien Saude Colet. 2010;15:3175–3184.
12. McCoy EK, Thomas JL, Sowell RS, George C, Finch CK, Tolley EA, et al. An evaluation of peak expiratory flow monitoring: a comparison of sitting versus. standing measurements. J Am Board Fam Med. 2010;23:166–170.
13. Suratt PM, Wilhoit SC, Hsiao HS, Atkinson RL, Rochester DF. Compliance of chest wall in obese subjects. J Appl Physiol Respir Environ Exerc Physiol. 1984;57:403–407.
14. Inselma LS, Milanese A, Deurloo A. Effect of obesity on pulmonary function in children. Pediatr Pulmonol. 1993;16:130–137.
15. Elliott AR, Prisk GK, Guy HJ, Kosonen JM, West JB. Forced expirations and maximum expiratory flow-volume curves during sustained microgravity on SLS-1. J Appl Physiol. 1996;81:33–43.
16. Saxena Y, Purwar B, Upmanyu R. Adiposity: determinant of peak expiratory flow rate in young Indian adults male. Indian J Chest Dis Allied Sci. 2011;53:29–33.