ORIGINAL ARTICLE

SPIROMETRIC VALUES IN OBESE CHILDREN OF AMRITSAR AGED 10–15 YEARS

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Background: Pulmonary function tests are getting increased favour not only of industrial physiologists but also of practicing physicians. Obesity is a major health concern facing today's society. This study has looked into a possible role of obesity in the aetiology of mortality, with decreased pulmonary functions resulting in cardiovascular disease. **Methods:** Pulmonary function tests (PFTs) of normal healthy obese children of Amritsar population in age group ranging 10–15 years were performed on a spirometer and compared with normal children of the same age group. All tests were performed at the same time of the day in all subjects. **Results:** There were insignificant changes in FVC, FEV_1 and FEV_1/FVC among obese children when compared to non-obese children of the same age group. There was significant decline in PEF and $FEV_{25–75}$ among obese children compared to non-obese children of the particular age group. **Conclusion:** There are not much significant changes of spirometric values in obesity in FVC, FEV_1 and its ratio. However PEF and $FEV_{25–75}$ showed significant decline in obesity.

Keywords: Obesity, pulmonary function tests, respiration, spirometry, spirometer, children

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INTRODUCTION

Obesity may affect respiratory functions in a number of ways.[1] In obese children, the presence of adipose tissue around the rib cage , abdomen and in the visceral cavity loads the chest wall and reduces pulmonary functions.[2] Body mass is modulated from birth to adulthood by physiological mechanisms such as balancing intake, caloric expenditure and energy reserves. Hypercaloric diets and sedentary lifestyle have resulted in the development of obesity in younger populations.[3] In Brazil, the prevalence of obesity is greater than 30% among children 5–9 years of age and is almost 20% in children 10–19 years of age.[4]

Carbon dioxide production increases as a result of increased body weight. Obese subjects consume approximately 25% more oxygen than non-obese subjects at rest.[5] Severely obese patients are often hypoxemic, especially in the supine position.[6] The increased lung and respiratory system resistance in obesity reduces lung volume.[7–9]

The cause of decline of various respiratory parameters in obesity in adults may be due to decrease in distensibility of chest wall and is also the cause for the alterations in ventilatory volume and flow.[10] This may reflect extrinsic mechanical compression on the lung and thorax and intrinsic changes within the lung in the form of deranged pulmonary function tests, modifying airway smooth muscle function by obesity related changes in lungs, chronic systemic inflammation (including increased serum levels of inflammatory cytokines and chemokines) and adipocyte derived factors including leptin, adiponectin and plasminogen activator inhibitor.[11–13]

Pulmonary function tests provide an assessment of respiratory system in terms of its volumes and flow rates. Pulmonary function tests in health are influenced by a number of factors but obesity is considered to be commonest and worst offender which alters relationship between lungs, chest wall and diaphragm leading to profound alterations in pulmonary function values which can be assessed by spirometry.[14]

Spirometric investigation is seen as a gold standard for diagnosing airway obstruction. Therefore spirometry is a quality standard in general practice.[15,16] The aim of our study was to determine the predominant pulmonary function tests in obese, and normal healthy children of Amritsar aged 10–15 years and to assess the correlation and comparison of pulmonary functions amongst them.

SUBJECTS AND METHODS

The study was approved by the local ethics committee. Informed written consent was obtained from the subjects themselves (if they were older than 12) and from their parents. A total of 150 children aged 10–15 years were included in the study from population of Amritsar by convenience sampling, and were arranged into 3 groups of 50 subjects in each group. Group A comprised of 50 non-obese normal healthy children aged 10–15 years. Group B comprised of 50 obese children aged 10–15 years. Group C comprised of 50 morbidly obese children aged 10–15 years. The ventilatory function tests were done on a computerised spirometer in standing posture. Subjects with history of smoking, chronic cough, recurrent respiratory tract infection, history of chest or spinal deformity, personal history of asthma, chronic obstructive lung diseases were excluded from the study.

Brief history was recorded and physical examination was done. Obesity was assessed from Body Mass Index (BMI). A child with a BMI in the 95th percentile or greater was considered to be obese and greater than 97th percentile was considered morbidly obese.[17,18] The BMI values of the patients in the study were compared with age and sex-specific percentile values from the second National Health and Nutrition Examination Survey (NHANES II)[19,20] values for individuals in the wide age range. The parameters recorded were FVC, FEV_1, FEV_1/FVC, $FEV_{25–75}$, and PEF. The anthropometric measurements were taken on each subject using standard methodology. Statistical analysis was done for all parameters, paired sample *t*-test was used and $p<0.05$ was considered significant. Mean±SD were calculated.

RESULTS

The results are presented in Table-1. Average of basal FVC, FEV_1, FEV_1/FVC, PEF, and $FEF_{25–75}$ values, represented as percent of predicted values, were lower in the study groups B and C compared with control group A. There were no statistically significant changes ($p>0.05$) in FVC, and FEV_1 in group B when compared with group A. FEV_1/FVC ratio showed insignificant changes ($p>0.05$) when group A was compared to group B and C. On the other hand, PEF and $FEV_{25–75}$ showed significant ($p<0.001$) decline in group B and C when compared to group A.

There were no significant differences between group B and C, and between males and females within the same groups.

Table-1: Pulmonary function tests of control, obese and morbidly obese children (Mean±SD, % of Predicted)

Parameters	Group A (n=50)	Group B (n=50)	Group C (n=50)	*t*	*p*
FVC	92.1±13.4	91.4±10.5	91.9±12.4	1.402	0.211
FEV_1	100.2±10.8	96.7±9.8	95.6±11.3	2.699	0.051
FEV_1/FVC	101.8±10.9	96.4±10.2	99.7±9.5	2.199	0.082
PEF	84.1±12	72.9±12.6	74.8±10.5	9.594	<0.001
$FEV_{25–75}$	119.1±22.3	97.4±21.8	99.9±20.6	8.234	<0.001

DISCUSSION

Many studies have demonstrated an association between obesity and ventilatory dysfunctions in adults. However, investigations into this issue in childhood are limited.[21] We selected the age range 10–15 years because in Amritsar, this age group people have careless food habits and are fond of inappropriate intake of rich caloric junk food along with automated working profile and sedentary lifestyle, and hence are more prone to obesity.

Chaussain *et al*[22], in their study of 39 obese children, reported that vital capacity which reflects lung compliance and resistance, and residual volume were similar to those of the control group. Bosisio *et al*[23] in their study of 23 obese children also found lung volumes to be within the normal range. Our results revealed that FEV_1, FVC and FEV_1/FVC% were similar to those of the control group. Similar studies in children report reduced functional residual capacity and static lung volumes. Inselman *et al*[12] and Mallory *et al*[24] found reduction in diffusing lung capacity to be common among the obese children they studied. They suggested that reductions in diffusing lung capacity seen in children may influence structural changes in the lung resulting in decreased alveolar surface area. It is also possible that conventional respiratory function tests are only affected in extreme cases and mildly affected in obese. It may depend upon different levels of obesity. Ray *et al*[25] stressed that total lung capacity and vital capacity may be reduced only in morbidly obese individuals.

Changes in FEV_1, FVC and FEV_1/FVC in pulmonary function tests reflect obstructive disease. Although in the present study, FEV_1, FVC, and FEV_1/FVC values were lower in obese and morbidly obese subjects, the difference were not statistically significant. It was also found that the obese and morbidly obese children had no obstructive impairment compared to controls.

The $FEV_{25–75}$ and PEF values in our study were found to be reduced in obese and morbidly obese children compared to controls which is similar to the study by Torun *et al*.[26] This could be explained by limited airflow related to decreased inspiratory pressure and flow as well as reduced respiratory strength of muscle. The extrinsic mechanical compression on the lung and thorax might also be the leading mechanism of a decreased $FEV_{25–75}$ in our study.

Because the PEF is limited by force-velocity characteristics of expiratory muscles instead of mechanical properties of the lung and airways, insufficient force would lead to flow limitation. In studies conducted on adults, a change in body mass of 1 Kg was on an average associated with a mean converse change of 21.1 ml in FVC.[27] Similarly in the adults, the spirometric parameters revealed a variable reduction with the increased degree of obesity. Weight loss appeared to be capable of reducing the decline of lung functions linked to obesity.[28] Inselman *et al*[12] found a reduced diffusion capacity and ventilatory muscle endurance among obese children. Marcus *et al*[29] found both restrictive and obstructive abnormalities on pulmonary function tests in obese children. Mallory *et* al[24] reported that obstructive abnormalities were the main problem in obese children. Li *et al*[30] found that reduction in the functional residual capacity and a diffusion impairment in obese adolescents correlated to the degree of obesity. Paralikar *et al*[31] reported a strongly negative correlation between the FEV_1/FVC, maximum voluntary ventilation, and FEF_{25-75} with body weight, BMI, waist circumference, hip circumference, and waist-to-hip ratio in obese and non-obese boys. The observations by Sri Nageswari *et al*[32] were similar in a group of obese children of mixed socioeconomic backgrounds. They believed that obesity is characterised by a decrease in chest wall compliance due to an increased amount of adipose tissue around the chest and abdomen, which decreases the pulmonary functions in these children. In our study, there are not much significant changes in spirometric values (FVC, FEV, and its ratio) in obesity. However PEF and FEV_{25-75} showed significant decline. FVC decrease with weight gain was observed in a six year follow-up study by Chinn *et al*.[33] In a study by Chen *et al*[34], significant directly proportional relationship between BMI and vital capacity was also noted. The significant decrease in FVC may be due to elevated diaphragm, mediastinal fat deposition, interfering with the movements of the chest, decreased compliance and marked thoracic kyphosis. In another study[35], 10 Kg increase in weight induced an additional 51 ml fall in FEV_1 in adult women.

Although spirometric values are usually normal in patients who are obese, there may be a mild reduction in vital capacity and a proportionate reduction in FEV_1, depending upon the age, type of body fat distribution (with central fat distribution having a relatively greater effect), and severity of obesity. According to a study by Joshi *et al*[36], in children percentage of body fat showed negative correlation with FVC and FEV_1. These results indicate that increase in percentage of body fat and central pattern of fat distribution may affect the pulmonary function tests. According to Singh *et al*[37] overweight and obese children showed 13–44% reduction in FVC and 20–46% reduction in FEV_1 depending upon their degree of obesity.

The FEV_1/FVC ratio is usually well preserved or increased even in morbid obesity indicating that both FEV_1 and FVC are affected to the same extent. This finding implies that the major effect of obesity is on lung volumes, with no direct effect on airway obstruction.[2] The decrease in various lung function parameters in obesity have been described by various scientists through different mechanisms. The accumulation of fat may mechanically affect the expansion of the diaphragm.[38] Low FEV_1 and FVC values suggest restrictive lung pattern among obese persons.[39] Fat deposits between the muscles and the ribs may also decrease chest wall compliance thereby increasing the metabolic demands and workload of breathing in the obese individuals even at rest.[40]

CONCLUSION

Obesity significantly affects the pulmonary functions in both adults and children. The cause of decline of various respiratory functions in obesity may be due to limited expansion of thoracic cavity which causes reduced ventilatory volume and total lung capacity. These hazardous effects of obesity might be reversible and weight loss could improve lung functions.

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