The Effects of Obesity on Pulmonary Function Tests among Children and Adolescents

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Abstract: Objective: The purpose of this study was to examine the influence of obesity on pulmonary function among a group of children and adolescents in Cairo area. **Introduction:** Increases in childhood overweight and obesity have become an important public health problem all over the world. The interplay between obesity and the respiratory system has implication on lung functions and exercise capacity, sleep disordered breathing and asthma. Among adults abnormalities of the respiratory function among obese have been reported in many studies**.**. Few reports have examined obesity and pulmonary function in childhood and adolescents. **Methods:**40 obese children aged from 6-13Years were enrolled in the study to be compared with 20 non obese child. Anthropometric measures were taken including weight and height for both groups .in addition, waist and hip circumferences, triceps and sub scapular skin fold were measured for the obese group. Lung function was assessed using spirometry. It was performed for all subjects .Forced vital capacity (FVC), forced expired volume in one second (FEV1), FEV1% (FEV1 to FVC ratio;FEV1/FVC), and forced expiratory flow between 25%–75% of vital capacity (FEF25–75) were determined according to the America Thoracic Society. recommendations. **Results:**Obese children has significantly lower percentage of forced vital capacity (FVC) and Forced Expiratory Flow in one Second (FEV1).BMI showed no significant correlation with pulmonary function on the contrary waist circumference is significantly positively correlated with pulmonary function namely FVC. **Conclusions:** The results indicate the pulmonary consequences of obesity in children and adolescents and provide further evidence of the adverse consequences of obesity in Cairo area.
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Key words: BMI = Body mass index, FVC = Forced Expiratory Flow**,** Flow, FEV1 = Forced Expiratory Flow in one Second, FEF25-75 = Forced Expiratory Flow at 25-75% of Expiratory, pulmonary function.

1. Introduction:

Obesity is an ever _ increasing problem in today's society for both children and adults. The interplay between obesity and the respiratory system has implication on lung functions and exercise capacity, sleep disordered breathing and asthma. Obese children have signs and symptoms of obstructive sleep apnea largely related to the effect of obesity on upper airway dimensions. Since obesity can cause respiratory symptoms, many obese people are referred to pulmonary function tests. It is well known that obesity causes decrease in lung volumes, but there has never been a large study showing the correlation between the body mass index and the various lung volumes **(Jones and Nzekwu, 2006).** Obese children have more respiratory symptoms than their normal weight peers and respiratory related pathology increases with increasing weight. A significant number of obese children have signs and symptoms of obstructive sleep apnea largely related to the effect of obesity on upper airway dimensions **(Deane and Thomson2006) .** It seems likely that unless action is taken soon, increasing numbers of children will experience preventable respiratory morbidity as a result of nutritional obesity **(Watson and Pride, 2005; Deane and Thomson**, **2006)..**The aim of this study is to determine the effect of obesity in children and adolescents on pulmonary function tests and to correlate the different anthropometric masures (BMI, waist and hip circumferences, waist/hip ratio, and triceps and sub-scapular skin fold thickness) with different pulmonary function tests.

2. Subjects and Methods

This is across sectional case control study conducted at the **Diabetes Endocrine and Metabolic Pediatric Unit (DEMPU), Cairo University Children's Hospital** between June 2007 and December 2007. The subjects were selected aged 6-13 years .They were 18 males and 22 females. Their mean ages were 9.7±1.9 years. They were compared with 20 healthy children 11 males and 9 females with a mean age 9.7±1.9 years who attended the outpatient clinic for their routine checkups, nutritional assessments. They had normal physical examination and normal weight. In this study an obese subject was defined as one whose BMI ≥95th percentile according to the sex- and age-specific BMI reference range using the **Egyptian Growth charts (2002)**. Children having Syndromatic obesity, chronic cardio- respiratory, neuromuscular problem and those with history of asthma and other atopic diseases were not included in the study.An informed consent was obtained from the subjects and controls and their parents. All included patients were subjected to medical history, anthropometric measurements including height, weight and BMI. For cases only waist circumferece, hip circumference and waist/hip ratio were performed.The height was measured to the nearest 0.1 cm using stadiometer and all patients were assessed by single examiner.The weight was measured to the nearest 0.1 kg using an electronic digital scale. BMI was calculated as weight (kg) divided by the square of height in meters (kg/m^2).The waist circumference was measured as the minimum abdominal circumference between the xiphoid process and the umbilicus. The hip circumference was measured as the maximum circumference over the buttocks. The waist-to-hip ratio (WHR) was calculated as the ratio between these two circumferences.

Spirometry (Vmax 229, sensor dedics) was performed for all subjects in Chest department- Kasr El Ani Hospital. The subjects underwent the spirometry test in the sitting position, wearing a nose clip. Uniformity of spirometry test was assured by using the same device brand for all the subjects. To perform a ventilatory maneuver, subjects were asked to inhale as far as possible, then blow out through the pyrometer as hard and as far as they could. During the maneuver they were encouraged by the investigator. The total amount of air exhaled was termed the forced vital capacity (FVC). Of that exhaled volume, the amount of air exhaled in the first second was defined as the forced expiratory volume in one second (FEV1). At least three acceptable maneuvers were performed to ensure that a best effort was obtained. Expirations had to last longer than four seconds to be accepted. If individual trial results varied by .5% for eitherFVC or FEV1, the pulmonary function test was repeated until all three trials were within 5% variation. The largest FVC, FEV1, and FEV1% (FEV1 to FVC ratio; FEV1/FVC) for each subject was used for analysis. Forced expiratory flow from 25% to 75% of vital capacity (FEF25–75) was derived from the single best test that produced the largest sum for FVC and FEV1. The FVC is generally considered a good measure of lung volume and is influenced by diseases such as fibrosis and by obesity. The forced expiratory volume in one second (FEV1) and FEF25–75 are estimates of the patency of the airways and are often affected by lung diseases such as emphysema, bronchitis, and asthma.All tests were presented as percentage of predicted value.

Data management and analysis:

The data were analyzed by Statistical Package for Social Science (SPSS) software program version 13. Data were summarized as mean ±SD. T test was used for comparison of tow independent variables (obese & control).Pearson correlation for quantitative data regarding anthropometric measurements and pulmonary function tests were done, P value ≤0.05 was considered statistically significant. Regression models were built and the covariates were tested by the enter and forward approach. Several risk factors such as body weight, body mass index, waist circumference,hip circumference and waist to-hip ratio were included as independent variables

3. Results

Table (1) showed that40 obese subjects with mean age of 9.7years with male to female ratio of 18/22 were enrolled in the study compared with 20 non obese subjects with mean age of 9.7years and male to female ratio of 11/9. No statistical significant differences regarding age and gender character between cases and controls. The mean standard deviation scores SDS of obese cases for weight, height and body mass index BMI were (6.02), (0.84)and (3.79) respectively. The mean standard deviation scores SDS of controls for weight, height and BMI were (.-1.98), (-5.83) and (-0.685) respectively .While the mean standard deviation scores SDS of obese cases for triceps and sub scapular skin fold were (4.40),(7.80) respectively. Tab(2)

Regarding the mean predicted value of pulmonary functions, it was found that ,forced vital capacity FVC was significantly lower among obese children versus controls (85.27%versus 92.3%) and $P_{=}$(0.04).The mean predicted value of forced expiratory volume (FEV1)was significantly lower among obese children versus controls (81.15% 91.35%)and $P_{=}$(0.002).The mean predicted value of the ratio of forced vital capacity /forced expiratory volume ratio (FVC/FEV1) showed no statistical significant difference between obese and controls. The mean predicted value of forced expiratory flow rate $FEFR_{25\text{-}75\%}$ among cases is lower than that among controls (75.65%, versus 81.85%) although not statistically significant (table 5, (figure 1). Table (5) showed the correlative analysis of pulmonary function tests in relation to different anthropometric measures .There was a statistically significant positive correlation between forced vital capacity FVC and waist circumference (P=0.011) Also there were a negative correlation between different pulmonary function tests and waist hip ratio ,triceps and sub scapular skin fold thickness although not significant.

Tab(1) Baseline characteristics of the studied sample .

Variables	Obese (n=40)	Non obese (n=20)	P value
Age(Mean ±SD)	9.7 ±1.9	9.7± 1.7	0.17
Male/female ratio	18/22	11/9	0.74

Table (2): Anthropometric measurements of obese children.

Variables	Wt SDS	Ht SDS	BMI SDS	Triceps SDS	Subscap-ular SDS	Waist Circum.	Hip Circm	W/H Ratio
Mean	6.02	0.84	3.79	4.40	7.80	93.7	98.5	0.95
±SD	3.09	1.97	2.01	1.45	2.35	12.85	10.98	0.14
Max.	14.6	9.6	5.5	7.50	13.50	120.0	123.0	1.50
Min.	0.4	-4.1	0.73	1.90	3.50	58	80	0.66

*SDS=standard deviation score

Table (3): Anthropometric measurements of controls.

Variables	Wt SDS	Ht SDS	BMI SDS
Mean	-1.981	-5.835	-0.685
±SD	3.980	7.18	1.939
Maximum	5.0	6.9	5.1
Minimum	-8.6	-15.5	-3.8

Table (4): Percentage predicted value of pulmonary functions of children enrolled in the obese and control groups.

Pulmonary function tests		Mean	Std. D	min	max	
FVC%	Cases	85.27	13.10	47	116	0.049*
	Controls	92.30	12.04	65	111	
FEV1%	Cases	81.15	10.92	50	107	0.002*
	Controls	91.35	11.83	69	115	
FVC/FEV1%	Cases	86.67	7.41	65	99	0.685
	Controls	87.55	8.64	71	100	
$FEFR_{25\%-75\%}$%	Cases	75.65	19.54	39	127	0.255
	Controls	81.85	20.03	60	115	

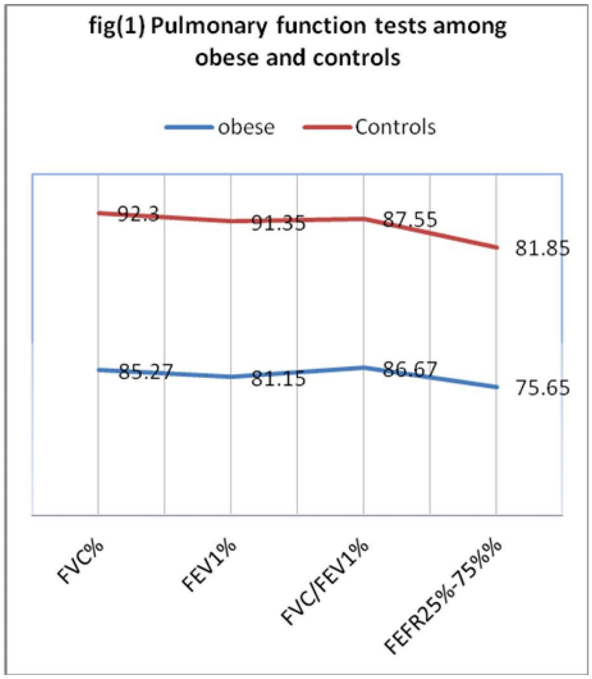
FVC = percentage predicted forced vital capacity

FEV1 = percentage predicted forced expiratory volume in 1 second

$FEFR_{25\%-75\%}$= forced expiratory flow rate interquartile range (1st and 3rd interquartile ranges)

Table (5): Correlation between anthropometric measurements and pulmonary function tests

Anthropometric measure	FVC (Pvalue)	FEV_1 (Pvalue)	FVC/FEV1 (Pvalue)	$FEFR_{25-75\%-}$ (Pvalue)
BMI	0.259 (0.107)	0.82 (0.615)	-0.235 (0.144)	-0.233 (0.148)
WC	O.397 (0.011)*	0.001 (0.996)	-0.191 (0.239)	0.170 (0.295)
W/H ratio	-0.144 (0.375)	-0.129 (0.427)	-0.049 (0.764)	-0.118 (0.469)
Triceps Skinfold	-0.175 (0.281)	-0.154 (0.344)	-0.058 (0.722)	-0.035 (0.829)
Subsca. Skinfold	-0.221 (0.170)	-0.107 (0.512)	-0.147 (0.367)	-0.218 (0.176)



4. Discussion:

Many studies have demonstrated an association between obesity and ventilatory abnormalities in adults **(De Lorenzo et al., 2001 and Ferretti et al., 2001).** However, studies in children conducted to date have yielded conflicting results. Many have focused on extreme levels of obesity, or have used a small sample size **Bosisio et al., (1984)** in their study of 23 obese children, found that lung volumes to be within the normal range. The study of **Boran et al., (2007)** of 80 obese children revealed that FEV1 %, FVC % and FEV1%/FVC% were similar to those of the control group on the contrary our main findings of this study show decreased lung function in obese children, which supports findings from previous studies **of Lazurus et al(1997)and Schoenberg et al(1978) .** In Australian children and adolescents, Lazurus et al found that increasing percent body fat was inversely related to height- and weight-adjusted FVC and FEV1. Other reports of small samples of obese children or adolescents have found either lower lung volumes **(Inselma et al 1993), (Broussard et al 1991) (Mallory et al 1989)** or ''normal'' lung volumes and capacities **(Marcus et al 1996)**. The study of **Eisenmann et al (2007)** showed **a** decrease in pulmonary function of obese children. Significant differences among groups existed for FEV1% and FEF25-75 in boys and FVC and FEV1 in girls. Recent work has also shown that childhood obesity may be related to the development of asthma (Epstein et al 2000) (von Mutius et al 2001).The decreased pulmonary function in obese children could be due to several mechanisms including respiratory or chest wall mechanics (work of breathing, compliance, elastic recoil), resistance within the respiratory system, respiratory muscle function, and airway structure or function **Babb TG (1999)** Obesity may change airway function by increasing bronchial hyper responsiveness. **Koenig SM (2001)** An alternative explanation may be related to the inflammatory response shown in obese individuals. As suggested by **Gilliland et al(2003),** adipose tissue is a source of pro inflammatory cytokines and chemokines, and their increase in the obese state may have the potential to enhance pulmonary inflammation.On the contrary the study of **Bosisio et al., (1984)** in their study of 23 obese children, also found lung volumes to be within the normal range. The study of **Boran et al., (2007)** of 80 obese children revealed that FEV1 %, FVC % and FEV1%/FVC% were similar to those of the control group. **Ülger et al., (2006)** found that there were strong negative correlations between body mass index (BMI), relative weight, skin fold thickness, waist/hip circumference ratio and basal forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and peak expiratory flow (PEF) values. Strong negative correlations between FVC, FEV1 and skin fold thickness. **Boran et al (2007)** revealed that anthropometric measurements are not correlated with spirometric measurements in children as they are in adults. Although the waist-to-hip ratio was significantly higher in the obese group, it may not be sufficiently high to exert any effect on pulmonary function.

Conclusion:

The mean predicted value of pulmonary function test parameters namely percentage predicted forced vital capacity FVC% and percentage predicted forced expiratory volume in 1 second FEV1 of the obese children are significantly lower than normal weight children. Waist circumference has positive linear regression effect with spirometric measurements namely forced vital capacity FVC.

Recommendations

- Anthropometric measurements especially WC can be used as indicators to affected pulmonary functions.
- Longitudinal studies including physiological tests are needed to explore the effects of different levels of obesity on pulmonary function in children.
- Exersise-test and provocation test should be done to determine the incidence of airway hyperresponsiveness and exercise-induced bronchospasm in obese children. The diagnosis and management of exercise-induced bronchospasm may improve exercise performance and physical activity, assist with weight loss, and break the vicious circle.

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