Effect of increasing weight on spirometry in young healthy adult female: A study in West Bengal

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ABSTRACT

Introduction and aim: There are conflicting reports on pulmonary function in overweight and obesity. This study was carried out in healthy young adult female Bengali subjects to evaluate the effect of increasing weight on spirometry.

Materials and Methods: A cross-sectional study was conducted in a tertiary care centre in eastern India. Body mass index of the subjects were determined and they were grouped into underweight, normal, overweight and obese. Spirometric parameters included forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/FVC ratio, forced expiratory flow between 25-75% of vital capacity ($FEF_{25-75\%}$) and peak expiratory flow rate (PEFR).

Results: Out of 84 female subjects included in the study, 11 were underweight, 64 normal and 9 overweight. All the subjects were between 18 and 22 yrs. Median height, weight and BMI were 160 cm, 54.1 kg and 21.5 kg/m^2 respectively. Median FVC, FEV1 and PEFR were 2.739 L, 2.351 L and 5.048 L/s respectively. There was no significant difference in any of the respiratory parameters among the underweight, normal and overweight groups. Median FVC, FEV1 and PEFR were lowest in underweight and highest in overweight group. Weight had significant positive correlation with FVC, FEV1 and PEFR while BMI had significant positive correlation with FVC and PEFR.

Conclusion: FVC, FEV1 and PEFR tend to increase with increase in weight in normal and overweight range of BMI.

Keywords: Spirometry; FVC; FEV1; Weight; Female.

INTRODUCTION

Spirometry is used to diagnose various lung diseases and to monitor the efficacy of treatment during the course of a disease. Height, age and gender are the most important predictor of lung volumes (1-3). Ethnic differences in pulmonary parameters are also well-known (4). Previous studies have suggested decrease in lung function at both extremes of weight. The initial increase in pulmonary function with increasing weight is considered to be a "muscularity effect" while the decrease with further increase in weight is due to "obesity effect" (5).

Overweight and obesity has become a world-wide epidemic inflicting developed and developing countries alike. Body mass index (BMI) is a simple tool for classifying individuals into underweight, normal, overweight and obese. There are conflicting reports on pulmonary function in overweight and obesity. While several studies have found abnormal spirometry only in massively obese subjects, others suggest lower lung volume with increasing body fat (6-8). Keeping in mind the ethnic difference in lung function, this study was carried out in healthy young adult female Bengali subjects to evaluate the effect of increasing weight on spirometry in especially those with normal weight and overweight.

MATERIALS AND METHODS

A cross-sectional study was conducted in a tertiary care centre in West bengal after approval from Institutional Ethics Committee. The subjects comprised of adult healthy female Bengali medical or nursing students. Those with pre-existing chronic respiratory diseases, with history of surgery on head, neck or face were excluded. Those with respiratory tract infection underwent spirometry after recovery. After informed consent of the participants, data were recorded in a predesigned format. Height was measured to the nearest centimeter in the standing posture using a graduated wooden rod scaled in centimeter and inch and fitted with an adjustable horizontal bar to fit over the cranial vault. Weight was measured to the nearest 0.1 kg using a spring-type weighing machine from the zero reference point. Body mass index (BMI) was calculated by using Quetlet's index, weight in kilograms divided by the square of the height in meters (9). According to WHO criteria, body mass index (BMI) of less than 18.5 kg/m^2 is considered underweight, 18.5 to 24.9 kg/m^2 is considered normal weight, 25.0-29.9 kg/m^2 is considered overweight and a BMI of 30 kg/m^2 or higher is considered obesity (10).

Spirometric parameters included forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/FVC ratio, forced expiratory flow between 25-75% of vital capacity ($FEF_{25-75\%}$) and peak expiratory flow rate (PEFR). They were obtained from windows based digital spirometer, spirowin version 2.0. Procedure of spirometry was explained and demonstrated to the subjects. They were first asked to take the maximal inspiration and then to blow into the mouthpiece as quickly, forcefully and maximally as possible with nose manually closed by the subjects themselves. American Thoracic Society (ATS) criteria for acceptability and repeatability of spirometry were followed without any compromise (11). Individual spirograms were considered acceptable if there was adequate effort with satisfactory start and satisfactory exhalation. The procedure was repeated thrice or more until the two largest values of FVC were within 0.150 L of each other. Those with unacceptable spirometry and/or inadequate effort had to undergo repeat spirometry on second or even third sitting. Maneuver with largest sum of FVC and forced FEV1 was used (11).

Graph Pad Prism version 5 (San Diego, California: GraphPad Software Inc., 2007) was used for statistical analysis. The data were analyzed using Kruskal-Wallis test followed by Dunn's multiple comparison test. $p < 0.05$ has been considered as statistically significant. Pearson's correlation analysis was used to determine correlation of weight and BMI with respiratory parameters.

RESULTS

Out of 84 female subjects, 11 were underweight, 64 normal and 9 overweight. There were 2 obese subjects but excluded from analysis. Their baseline and pulmonary parameters have been shown in table 1. All the subjects were between 18 and 22 yrs. Median height, weight and BMI were 160 cm, 54.1 kg and 21.5 kg/m^2 respectively. Median FVC, FEV1 and PEFR were 2.739 L, 2.351 L and 5.048 L/s respectively.

Table 1: Baseline and Pulmonary parameters of subjects

Parameter	Minimum	25th Percentile	Median	75th Percentile	Maximum
Age(yrs)	18	18.25	19	20	22
Height(cm)	146	155	160	163	170
Weight(kg)	37.2	49.5	54.1	59.3	75.3
BMI (kg/m^2)	14.82	19.67	21.50	23.57	29.82
FVC (L)	1.896	2.489	2.739	2.989	3.543
FEV1 (L)	1.607	2.147	2.351	2.599	3.100
FEV1/FVC (%)	76.81	81.67	86.44	89.75	97.53
$FEF_{25-75\%}$ (L/s)	1.397	2.295	2.840	3.282	4.464
PEFR (L/s)	2.371	4.390	5.048	5.619	8.004

Table 2 compares the baseline and pulmonary parameters among three sub-groups on the basis of BMI. These groups were similar in age and height and differed significantly only in weight and BMI. There was no significant difference in any of the respiratory parameters among these groups.

Table 2: Comparison of baseline and respiratory parameters of subjects grouped according to BMI

Parameter	Underweight (n=11)	Normal-weight (n=64)	Overweight (n=9)	p value
Age(yrs)	19 (18-20)	19 (18-20)	20 (19-20.50)	0.18
Height(cm)	160 (158-163)	158 (154-163)	162 (156-164)	0.15
Weight(kg)	45 (41-47)	54.5 (50-59)	69 (66.5-74)	<0.0001
BMI (kg/m^2)	17.26 (16.23-17.75)	21.57 (20.14-23.21)	26.35 (25.72-28.93)	<0.0001
FVC (L)	2.660 (2.331-2.910)	2.739 (2.489-3.042)	2.897 (2.641-3.306)	0.08
FEV1 (L)	2.186 (1.804-2.555)	2.351 (2.147-2.599)	2.568 (2.187-2.706)	0.26
FEV1/FVC (%)	87.80 (80.87-93.78)	86.33 (82.05-89.43)	87.12 (79.84-89.34)	0.70
$FEF_{25-75\%}$ (L/s)	2.846 (2.192-3.448)	2.832 (2.295-3.255)	3.137 (2.364-3.499)	0.77
PEFR (L/s)	5.004 (3.512-5.180)	5.048 (4.412-5.619)	5.443 (4.697-6.585)	0.21

Values are median (inter-quartile range); p value obtained by Kruskal-Walis test.

Correlations of weight and BMI with respiratory parameters have been shown in table 3. Both weight and BMI had significant positive correlation with FVC and PEFR. Correlation of weight with FEV1 was also significant and positive. The scatter plot of different pulmonary parameters with weight and BMI has been depicted in figure 1 and 2.

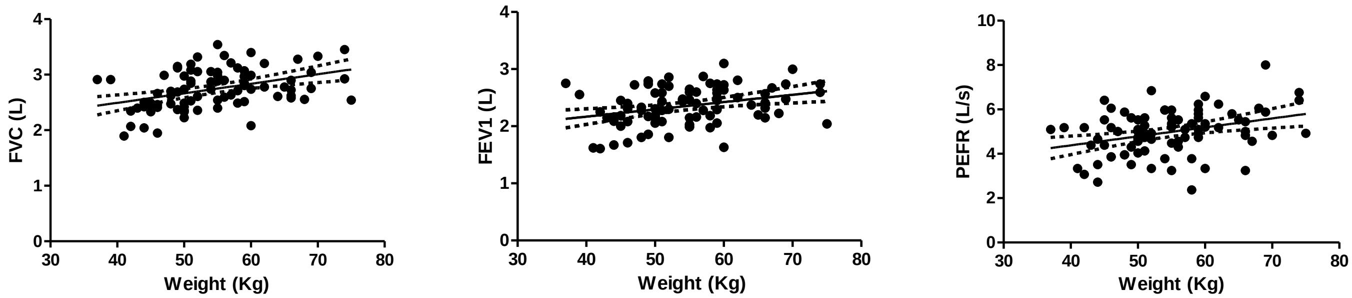

Fig 1: Scatter plot of weight with FVC, FEV1 and PEFR

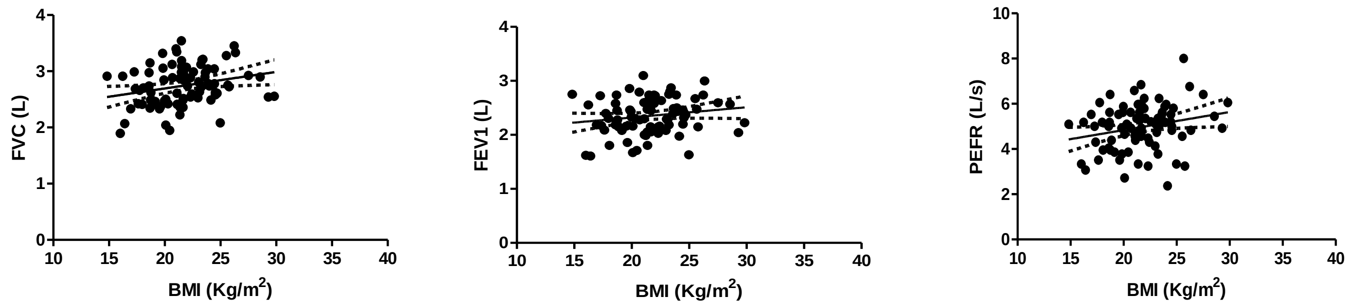

Fig 2: Scatter plot of BMI with FVC, FEV1 and PEFR

Table 3: Correlation of weight and BMI with respiratory parameters

Parameters	Weight		BMI	
	Pearson's r	P value	Pearson's r	P value
FVC (L)	0.4064	0.0001	0.2478	0.0230
FEV1 (L)	0.3260	0.0025	0.1725	0.1167
FEV1/FVC (%)	-0.1065	0.3349	-0.1205	0.2750
$FEF_{25-75\%}$ (L/s)	0.1600	0.1461	0.0587	0.5960
PEFR (L/s)	0.3383	0.0016	0.2378	0.0294

DISCUSSION

This study demonstrated no significant difference in spirometric parameters among underweight, normal and overweight group. However, median FVC, FEV1 and PEFR were lowest in underweight and highest in overweight group. Weight had significant positive correlation with FVC, FEV1 and PEFR while BMI had significant positive correlation with FVC and PEFR.

Our study is in conformity with others who demonstrated no significant change in lung volume with increase in BMI (12-14). Spirometric lung volumes and airflow are usually within normal limits even in mild degree of obesity (7, 8, 15, 16). However, some other studies have found decrease in FVC with increasing adiposity (17, 18). The mechanics of respiration depends on the interaction of the lungs, the chest wall and respiratory muscles. Pulmonary function initially increases as weight increases and then decreases as weight continues to increase (19, 20). It has been suggested that the increase of pulmonary function with weight might be a sign of increasing muscle force, and the decrease with further weight gain may be due to obesity diminishing the mobility of the thoracic cage (5). Low FVC, FEV1 and PEFR in underweight group indicate that an improvement in the nutritional status could help in improving their pulmonary functions. Decreased muscle mass is often associated with a weaker diaphragm and other respiratory muscles and a decreased respiratory strength (21). However, the weight at which pulmonary function starts decreasing after reaching a maximum remains elusive. Our study indicates beneficial effect of increasing weight on pulmonary function in those having BMI up to 30. A study in children found elevated body mass index increases lung volume but reduces airflow (22).

Since all the subjects were healthy young adult with majority having normal BMI, weight had significant positive correlation with FVC, FEV1 and PEFR probably reflecting increased muscle force with increase in weight. However, two prospective studies in men found that weight gain was significantly related to losses in FVC (23, 24). This might be due to difference in ethnicity, effect of increasing age in longitudinal nature of study or combination of healthy and unhealthy, young and old individuals.

The small number of overweight and obese subjects is a limitation of this study. Since the participants were of similar age (18-22 yrs), gender (female) and ethnicity (Bengali), the confounding effects of these variables were eliminated while measuring correlation of weight and BMI with lung parameters. This is strength of this study. However, the findings of this study might not be extrapolated in other populations of different ethnic origin.

CONCLUSION

FVC, FEV1 and PEFR tend to increase with increase in weight in normal and overweight range of BMI. A larger prospective study may be undertaken to elucidate the relation of weight gain and increasing BMI on pulmonary function.

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