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Effect of Obesity on Spirometry tests among Healthy Non-smoker Adults of Bangladesh

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ABSTRACT

Obesity is a growing threat to health in countries all over the world because of increasing incidence and its various deleterious effects on different systems of the body including lung function. The present study is planned to assess the effect of obesity on pulmonary function tests in young healthy non-smokerBangladeshi adults as it was not addressed previously.This is a cross sectional comparative study done in Rangpur Medical College Hospital, a northern territory (division) of Bangladesh during the period from August 2013 to March 2014. A total of 80 participants were selected by purposive sampling method and divided into two groups (obese and non-obese as per WPRO criteria for Asian, 2000). Among them 40 male and 40 female and again among the both group 20 were non-obese as control and 20 were obese as case. Both groups were age and physical activity matched. Pulmonary function tests were performed using standard spirometer. The statistical analysis consisting of parametric and non-parametric tests was done depending on the distribution of each variable, considering $p < 0.05$ to be statistically significant. An informed written consent was taken from each of the participants. Age of the participants was ranging from 18 years to 35 years with mean 26.58 ± 3.54SD.We found no significant differences in FEV1 (p value = 0.272), FVC (p value = 0.253), FEV1/FVC Ratio (p value =0.444), $FEF_{25-75\%}$ (p value = 0.491) and PEFR (p value=.355) between the obese and non-obese subjects.Obesity itselfdoes not have significant effect on lung function test among healthy nonsmoker adults though it causes a decline in lung function parameters among the obese.

Keywords: Obesity; Pulmonary function; Spirometry; Healthy non-smoker adults; Bangladesh

INTRODUCTION:

Obesity is the most common metabolic disease in the world (Formiguera et al 2004)and its prevention has become one of the leading priorities for the World Health Organization (WHO) (Lean et al 2006). Obesity is defined as an abnormal or excessive fat accumulation that may impair health (World Health Organization. Obesity and overweight. Fact Sheet No 311, 2006). It is categorized by body mass index (BMI kg/m^2), which is highly correlated with body fat and is therefore a useful measure in clinical assessment and epidemiological studies (Formiguera et al 2004).

The prevalence of obesity has been increasing over several decades(Ogden CL et al 2004) and recent figures estimate that there are over 1.6 billion overweight adults worldwide (BMI >25 kg/m^2). Of these, at least 400 million are obese (World Health Organization. Obesity and overweight. Fact Sheet No 311, 2006). The WHO further predicts that, by 2015, around 2.3 billion adults will be overweight and more than 700 million will be obese(McClean et al 2008.

Besides genetic predisposition, adoption of sedentary life style and inappropriate intake of calorie rich easily available junk food has made the environment conducive to development of obesity (Saxena et al 2008).It is now replacing the most traditional public health concern viz. communicable diseases and undernutrition (Park's Text Book of Preventive and Social Medicine. Jabalpur:2003).

Obesity is not a single disease in itself. It places patient at the risk of many diseaseswith substantial morbidity and increased mortality. Obese adults have an increased prevalence of pulmonary disorders with impairment of pulmonary or ventilatory function (Mahajan et al 2011).

Pulmonary function testing (PFT) is a simple procedure for the assessment and monitoring of respiratory diseases (Kalpana et al 2011).The factors that usually affect the values of pulmonary function tests are age, gender, height, race or ethnic origin and possibly obesity (Al Ghobain 2012).For instance as the individual gets older age, the lung volumes and capacities become smaller and the lung volumesand capacities are larger in males than in females (Harik-Khan et al 2001). Out of the above stated factors affecting pulmonary function values, increase in weight which reflects itself as obesity is considered to be the 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(Rayet al 1983)

Assessment of respiratory function of obese individuals may help to identify and treat the changes at an early stage in order to prevent negative effects on health and quality of life. Therefore, the objective of this study was to compare pulmonary function of obese and non-obese adult men and women with no history of pulmonary disease.

Moreover the hazardous effects of gaining weight might be reversible and weight loss can improve lung function in obesity (Bottai et al 2002, Morgan et al 2000, Womacket al 2000). It was observed that most of those who reduced their BMI values also improved their lung function. This study can encourage the obese losing their weight to improve the lung function.

Numerous studies have examined the association between body mass index (BMI) or weight change and pulmonary function testing variables, and the associations vary in different subpopulations(Chen et al 1993).

Bangladesh is a developing country with increasing trends towards rapid urbanization. According to demographic and health survey Bangladesh 2004, the prevalence of obesity (BMI ≥ 25) in women was 9% and women living in urban areas were found more than three times obese than rural area women (National Institute of Population Research and Training, Dhaka, Bangladesh. Demographic and health survey Bangladesh 2004).This indicates that obesity is going to be a great problem in our country soon. Due to ethnic diversity of Bangladeshi population, here the relationship between the obesity and lung function parameters might have some difference with other subpopulations which needs to be assessed.

To the best of our knowledge the interaction between obesity and PFT has not been addressed previously among the Bangladeshi population. Therefore, we aim to study the effects of obesity on spirometry tests among healthy non-smoker adults of Bangladesh. Our study is limited to the spirometry part of PFT as it is considered as the initial screening tool for pulmonary diseases.

METHODS:

Selection and Description of Participants:

Across sectional comparative study was conducted at the Department of Medicine, Rangpur Medical College Hospital, Rangpur, Bangladesh during the period from August 2013 to March 2014.In total 80 healthy volunteers who fulfilled the exclusion and inclusion criteria were selected for data collection by consecutive purposive sampling technique.

Inclusion criteria includes: i) adult healthy male and female population aged 18 to 35 years, ii) volunteers or hospital visitors or relatives of patients visiting the hospital, iii) subjects are Bangladeshi lifetime nonsmoker, and iv) weight ranging from 40 kg to 100 kg and height ranging from 140 to 190 cm. Patients unwilling to take part in the study, patient's age less than 18 or more than 35years with any history of smoking, and history of respiratory diseases such as pulmonary tuberculosis or asthma, respiratory tract infection in last 4 weeks and having history of cardiac or thoracic surgery or features suggestive of cardiac or lung disease or evidence of chest deformities or serious medical conditions, and having worked in environments with a high concentration of dust or pollution were excluded from the study.

Ethical Approval:

Before entering the study, all participants signed a written consent form. In addition, they could exit the study at any time they wanted. This study was approved by the Ethical committee of Rangpur Medical College, Rangpur, Bangladesh.

Data collection:

At first the whole procedure was explained to the participant and a written consent was taken. After taking a detailed history, thorough physical examination was done. The particulars of participants were recorded in the data collection sheet and then anthropometric measurement taken.The standing height and body weight of all subjects was recorded. The height was measured in centimeter using a fixed tape measure while participants stood wearing no shoes on a hard surface, with the back to a vertical backboard. Both the heels were placed together, touching the base of the vertical board. The weight was measured to the nearest 0.1 kg with the subjects wearing light clothing and barefoot on a weighting scale. BMI calculated as per Quetelet's index (Anon. Adolphe Quetelet. The Columbia Encyclopedia. 2005). Body mass index (BMI) = Weight (kilogram)/ Height^2 (meter).

WHO has published a non-gender specific BMI criteria (1998) for overweight and obesity, with a BMI of 25.0-29.9 indicating overweight and a BMI of ≥ 30.0 indicating obesity, further classified as class I (BMI 30.0-34.9), Class II (BMI 35.0-39.9) or Class III (BMI>40) obesity(WHO, Obesity: Preventing and Managing the global epidemic 2000). But according to WHO (2000) criteria of BMI in Asians, the cut off for overweight (≥23.0 Kg/m^2) and obesity (≥25.0 Kg/m^2) are lower than WHO criteria (1998) i.e. <18.5 are underweight, BMI between 18.5-22.9 are normal, >23.0 are overweight 23-24.9 are at risk, 25-29.9 are obese-I ≥30 are obese-II] (Regional Office for the Western Pacific (World Health Organization), International Association for the Study of Obesity 2000).Here in this study Asian criterion for obesity has been used.

The spirometry tests were conducted to assess pulmonary function using techniques recommended by the American Thoracic Society (ATS) and the European Respiratory Society (ERS) (Yusuf Set al 2005). Tests were done between 10 AM to 1 PM at room temperature, in the sitting position, wearing a nose clip. Uniformity of spirometry test was assured by using the same device brand for all the subjects(MINATO portable auto spirometer AS-307; Japan). The tests includes measurement of vital capacity, forced vital capacity (FVC), forced expiratory volume in 1st second (FEV_1), peak expiratory flow rate (PEFR) and forced mid-expiratory flow ($FEF_{25-75\%}$). At least three maneuvers were done for each test and the best one was recorded for the study. In addition to these measured parameters, the ratio of FEV_1 to FVC (FEV_1/FVC, expressed as a percentage) was calculated. The subjects were divided into two groups according to their BMI. The first group consisted of non-obese (normal body weight) subjects with BMI of 18.5 to 24.9 kg/m^2 and the second group consisted of obese subjects with BMI of 25 kg/m^2 and above.

Statistical analysis:

After collection of data it was coded and checked manually and then entered into computer. Data analysis was done by doing student's 'T' test. Descriptive statistics was calculated for the total study sample, for males and females and for both groups using means and standard deviations & p value less than 5% was considered statistically significant. Independent samples test was used to compare the spirometry results of obese and non-obese subjects.

RESULTS:

In this study, the total number of participants was 92. Due to inability to perform spirometry perfectly and unwilling to do spirometry 12 were excluded and finally 80 were selected. Out of them 40 (50%) were male and 40 (50%) were female. Sociodemographic pattern of the participants are shown in Table 1.

The baseline characteristics of the participants are shown in Table 2. There was no significant difference in age or BMI between genders, though men tended to be taller and heavier than women.Significantly lower values (P value <0.05) were observed in females than the males in lung function parameters i.e. FEV_1, FVC, FEV_1/FVC (%), VC, PEFR, FEF $_{(25-75\%)}$.

Table3 shows comparison between non-obese and obese group as a whole where 40 were non-obese and 40 were obese. Mean BMI for non-obese and obese is 22.45 and 28.85 kilograms per $meter^2$respectively.Non-obese had a higher values of FEV_1, FVC, VC and PEFR than that of their obese counterpart; though the difference is not significant statistically (p>0.05).FEV_1/FVC (%) and $FEF_{25-75\%}$ were almost equal in both groups.

Table4shows comparison between the non-obese and obese group of male population, where 20 were non-obese and 20 were obese.Mean BMI for non-obese and obese were 22.44 and 28.42 kilograms per $meter^2$respectively.All the respiratory parameters (FEV_1, FVC, FEV_1/FVC (%), VC, PEFR and $FEF_{25-75\%}$ were lower in the obese group though the differences were not statistically significant (P>0.05).

Table5 shows comparison between the non-obese and obese group of female population, where 20 were non-obese and 20 were obese.Mean BMI for non-obese and obese were 22.45 and 29.28 kilograms per $meter^2$ respectively.Non-obese female had a higher VC (2.38 liters) than the obese (2.35 liters) and interestingly all the other spirometric parameters (FEV_1, FVC, FEV_1/FVC (%), PEFR and $FEF_{25-75\%}$) are higher in the obese group though the differences were not statistically significant (P>0.05).

Figure 1 showing the relationships between Body Mass Index (BMI) and lung function in Spirometry test. Forced Expiratory Volume in 1st second(FEV_1), Forced Vital Capacity (FVC), Vital Capacity (VC) and Peak Expiratory Flow Rate (PEFR) showed negative relationships with BMI (Fig. 1A, Fig. 1B, Fig. 1D and Fig. 1E, respectively). Whereas, ratio of FEV1 and FVC, and Forced Expiratory Flow during mid-expiratory phase ($FEF_{25-75\%}$) showed absence of relationships with BMI (Fig. 1C and Fig. 1F, respectively).

DISCUSSION:

Main findings of our study is that there is no significant differences between the obese and non-obese subjects as a whole regarding FEV_1, FVC, VC, FEV_1/FVC ratio, PEFR and FEF $_{25-75\%}$; though non obese have higher values except FEV_1/FVC ratio than that of the obese.While comparing separately male non-obese & obese group it is found that all the parameters (FEV_1, FVC, VC, FEV_1/FVC ratio, PEFR and FEF $_{25-75\%}$) are higher in non- obese than the obese group though result is not significant statistically (P>0.05). On the other hand female non obese group when compared with their obese counterpart a reverse picture is found. Except the VC (Vital Capacity) all parameters are higher in the obese group though the result is not significant statistically (p>0.05). To our knowledge, this is the first study to address the relationship between obesity and spirometry tests among the Bangladeshi population. Many studies were conducted in the rest of the world and addressed such relationship showed heterogeneous results. The effects of obesity on spirometric values are not consistent across all studies with some studies showed no effects and some others showed positive effects. This discrepancy between studies can be explained by the wide variations in ethnicity of different population in PFT values or this may be a result of methodological differences in these studies. However all studies that addressed lung volumes and capacities showed that the obesity directly correlated with these values (Al Ghobain et al 2012). Our study was limited to the spirometric values (FEV_1, FVC, VC, FEV_1/FVC%, FEF $_{25-75\%}$ and PEFR) and did not include the lung volumes and capacities.

Our result is supported by the findings of the study done by Mohammed Al Ghobainwhere total subjects were 294 Saudi Arabians with a mean age of 32 years. There were 178 males and 116 females subjects. They found no significant differences in FEV_1, FVC, FEV_1/FVC ratio and FEF $_{25-75\%}$ between the obese and non-obese subjects. However, there was significant difference in PEFR between the two groups (P value < 0.020).(Al Ghobain et al 2012).

A study conducted by Dirceu et al in Brazil addressed the relationship between spirometric tests and obesity produced results similar to those of our study. The author recruited 20 obese young women with a BMI of 35-49.99 kg/m^2 who were sedentary, non-smokers and had no lung disease and 20 non-obese control young women who were also sedentary non-smokers and had no lung diseases with body mass indices between 18.5 and 24.99 kg/m^2. There were no significant differences between the obese group and the non-obese group with respect to the age, vital capacity (VC), tidal volume (TV), FVC, and FEV_1. However, the obese group had a greater inspiratory reserve volume (IRV), a lower expiratory reserve volume (ERV), and lower maximal voluntary ventilation (MVV) than the non-obese group(Dirceu et al 2008).

Mahajan et al in their study, Correlation of Obesity and Spirometric Ventilatory Status of Adult Female Population of North India, compared respiratory parameters between 100 nonobese and 100 obese female of 25-46 years old and found no significant difference between the groups regarding FEV_1, PEFR & FEF $_{25\text{-}75\%}$, though FVC and FEV_1/FVC ratio was highly significant (Mahajan et al 2011).

Our study is also supported by Chen et al. where they concluded that Waist circumference but not the BMI is negatively and consistently associated with pulmonary function in normal-weight, overweight and obese subjects (Chen et al 2007).

Contrary to our findings KhwajaNawazuddinSarwari et al. found significant differences between the non-obese and obese group regarding FVC,FEV_1, FEV_3, PEFR, FEF $_{25\text{-}75\%}$ (Sarwari et al 2012. Harik-Khan et al. in their study “The effect of gender on the relationship between body fat distribution and lung function” where 1094 men and 540 women (18–102 years) from the Baltimore Longitudinal Study of Aging (BLSA) were studied for The effect of WHR & BMI on FEV1 and FVC in healthy subjects. WHR appears to be more strongly associated with FVC than with FEV_1. In contrast, BMI had noeffect on FVC in healthy women, and was only marginally significant in men ($p = 0.08$). WHR is a significant predictorof FEV_1 in men only, and appears to have a greater impact on FVC in men than in women (Harik-Khan et al 2001).Another study by Bottai et al. also supports our result by concluding that the magnitude of decreased lung function associated with weight gain tends to be more pronounced in men (Bottai et al 2002).

This difference in lung function due to obesity in the male and female group as evident in our study (Table 2) may be explained by the fact that fat is more peripherally distributed in women and more centrally distributed in men & thus pulmonary function is also affected according to gender, as verified by some authors (Ochs-Balcom et al 2006 and Rebekah et al 2008). Ochs-Balcom stated that abdominal adiposity contributes to impairment of lung function and is even more important than general adiposity markers such as weight and BMI. (Ochs-Balcom et al 2006).

The adverse effect of abdominal obesity on lung function is likely mediated through direct effects on the rib cage or thoracic compliance. It is also possible that compression of the abdominal viscera by local fat redistributes blood to the thoracic compartment, thus reducing vital capacity. This is the explanation that has been given for the fall in vital capacity that occurs in the supine position (Schmidt et al 1989)

While a number of studies have shown that body weight can adversely affect lung function, the relationship is complex.In younger people, increasing BMI may be associated with an increase in lung function (muscularity effect), whereas in older people, increasing BMI is associated with a decrease in lung function (adiposity effect). Consequently, the overall impact of BMI on lung function in cross-sectional analyses is small (Chinn et al 1996).One of our study finding is increased respiratory parameter (except VC) in the obese female when compared with their non-obese peer may be explained by this fact (muscularity effect); as our study population was 18-35 years old and hence free of the adiposity effect.

CONCLUSION

In conclusion, obesity itself does not have significant effect on lung function though it might have some negative impact of spirometry test. This effect is more marked in male which could be due to the pattern of fat deposition rather than generalized obesity. We recommend further study in large scale that includes all pulmonary function test variables (spirometry test and other lung volumes) and measurement of body fatness with fat distribution pattern among Bangladeshi population and elsewhere to establish the relationship among them. Thus the deleterious effects of obesity on lung function can be assessed precisely that would enable us to takeappropriate measures to improve lung function.

Ethical considerations

Ethical issues (including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and / or submission, redundancy, etc.) have been completely observed by the authors.

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Table 1. Socio-demographic pattern of the study populations (n=80)

Variables	Categories	Frequencies	Percentages
Sex	Male	40	50
	Female	40	50
Level of education	Graduate & above	46	57.5
	Undergraduate	32	40
	Illiterate	2	2.5
Occupation	Service	62	77.5
	Farmer	1	1.25
	Day laborer	0	0
	Business	0	0
	Housewife	0	0
	Unemployed	2	2.5
	Others	15	18.75
Socio economic condition	High	5	6.25
	Middle	63	78.75
	Low	12	15

Table 2. The baseline characteristics and spirometry test results of the studied population (n=80)

Characteristics	Total population and their characteristics						
	Male (n=40)		Female (n=40)		*P* value	Total (n=80)	
	Mean	Stdev.	Mean	Stdev.		Mean	Stdev.
Age (Years)	26.6	3.05	26.57	4.15	0.488	26.58	3.54
Height (meters)	1.67	0.07	1.55	0.06	< 0.01	1.61	0.09
Weight (kg)	71.18	11.12	62.17	10.11	< 0.01	66.68	11.50
BMI (kg/m^2)	25.43	3.67	25.87	4.52	0.255	25.65	4.09
FEV_1(L)	3.17	0.49	2.32	0.36	< 0.01	2.74	0.61
FVC(L)	3.66	0.58	2.61	0.40	< 0.01	3.14	0.72
FEV_1/FVC (%)	86.81	4.23	88.98	4.82	0.029	87.90	4.64
VC(L)	3.37	0.63	2.36	0.53	< 0.01	2.87	0.77
PEFR(L/sec)	7.64	1.42	5.32	1.05	< 0.01	6.48	1.70
$FEF_{25-75\%}$(L/sec)	3.87	1.04	3.01	0.74	< 0.01	3.44	1.00

Stdev. = Standard deviation

Table 3. Independent sample test comparing age, BMI &spirometric variables between non-obese and obese (n=80)

Characteristics	Total population and their characteristics				
	Non Obese (n=40)		Obese (n=40)		*P* value
	Mean	Stdev.	Mean	Stdev.	
Age (Years)	26.30	3.56	26.87	3.70	0.254
Height (meters)	1.61	0.08	1.60	0.09	0.248
Weight (kg)	58.82	7.26	74.53	9.40	< 0.01
BMI (kg/m^2)	22.45	1.81	28.85	3.10	< 0.01
FEV_1(L)	2.78	0.63	2.72	0.58	0.272
FVC(L)	3.17	0.77	3.10	0.68	0.253
FEV_1/FVC (%)	87.83	4.83	87.97	4.49	0.444
VC(L)	2.89	0.78	2.84	0.76	0.333
PEFR(L/sec)	6.54	1.70	6.43	1.72	0.355
$FEF_{25-75\%}$(L/sec)	3.44	0.97	3.44	1.03	0.491

Stdev. = Standard deviation

Table 4. Independent sample test comparing age, BMI &spirometric variables between non-obese and obese male (n=40)

Characteristics	Only male population and their characteristics				
	Non Obese (n=20)		Obese (n=20)		*P* value
	Mean	Stdev.	Mean	Stdev.	
Age (Years)	25.85	2.83	27.35	3.15	0.090
Height (meters)	1.67	0.08	1.67	0.06	0.438
Weight (kg)	62.75	7.59	79.63	6.83	< 0.01
BMI (kg/m^2)	22.44	1.89	28.42	2.28	< 0.01
FEVI(L)	3.25	0.52	3.10	0.46	0.173
FVC(L)	3.75	0.63	3.58	0.52	0.185
FEV_1/FVC (%)	86.95	5.02	86.67	3.40	0.421
VC(L)	3.41	0.69	3.33	0.57	0.342
PEFR(L/sec)	7.77	1.23	7.52	1.60	0.300
$FEF_{25-75\%}$(L/sec)	3.93	1.00	3.81	1.10	0.372

Stdev. = Standard deviation

Table 5. Independent sample test comparing age, BMI &spirometric variables between non-obese and obese female (n=40)

Characteristics	Only female population and their characteristics				
	Non Obese (n=20)		Obese (n=20)		*P* value
	Mean	Stdev.	Mean	Stdev.	
Age (Years)	26.75	4.19	26.4	4.21	0.398
Height (meters)	1.56	0.04	1.54	0.06	0.112
Weight (kg)	54.9	4.26	69.45	8.96	< 0.01
BMI (kg/m^2)	22.45	1.79	29.28	3.76	< 0.01
FEV_1(L)	2.31	0.32	2.34	0.40	0.419
FVC(L)	2.61	0.38	2.62	0.43	0.474
FEV_1/FVC (%)	88.70	4.59	89.27	5.14	0.359
VC(L)	2.38	0.46	2.35	0.59	0.426
PEFR(L/sec)	5.31	1.12	5.34	1.01	0.463
$FEF_{25-75\%}$(L/sec)	2.95	0.65	3.07	0.83	0.302

Stdev. = Standard deviation

Fig. 1. Relationships between Body Mass Index (BMI) and lung function in Spirometry test.