Original Article

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Physiology Section

Effect of Obesity on Pulmonary Functions among the Adolescent Students of a Private University in Malaysia

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ABSTRACT

Introduction: Obesity is a risk factor for many conditions including respiratory disorders. However, studies investigating pulmonary functions in obese adolescents from Malaysia are few in number.

Aim: To investigate the effect of obesity on pulmonary function variables in the adolescent obese students of a private university in Malaysia.

Materials and Methods: A Cross-sectional comparative study was conducted in a total of 100 (50 obese and 50 non obese control) adolescent students of both sexes aged 16-19 years. Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1), FEV_1 as a percentage of FVC (FEV_1/FVC%), maximum mid expiratory flow rate ($FEF_{25-75\%}$) and peak expiratory flow rate (PEFR) were measured using a computerized spirometer (Spirobank II MIR via Del Maggiolino125, 00155 Roma, Italy). Body weight, height, Waist Circumference (WC) and Hip Circumference (HC) were measured. Student's t-test and Pearson's product moment correlation (r) were used to interpret the data. The p-values less than 0.05 were considered as statistically significant.

Results: There was no significant difference in mean pulmonary function parameters between obese and non-obese control group. However, five obese subjects had mild restriction, whereas no obstructive impairment was detected in any subject of the obese and control groups. In obese group, BMI, WC, HC and Waist Hip Ratio (WHR) had negative significant ($p<0.01$) correlation with FEV1/FVC%, whereas FVC and FEV1 had positive significant ($p<0.05$) correlation with WC and HC. However, in normal weight control group, FVC and FEV_1 had positive significant association with WC and WHR, whereas, rest of the dynamic pulmonary measurements had no significant correlation with measured anthropometric obesity indices.

Conclusion: Our study did not find any significant effect of obesity/overweight on dynamic lung volumes among adolescent students. Significant negative correlation between BMI, WC, HC and WHR with FEV_1/FVC% suggests that obesity decreases FEV_1/FVC% and obese are more prone to obstructive lung diseases.

Keywords: Body mass index, Hip circumference, Pulmonary function test, Waist circumference, Waist hip ratio

INTRODUCTION

The lifestyle of the Malaysian students has changed in the past decades. Nowadays, many of them have adopted unhealthy habits, like lack of exercise, intake of fast food, which may impair their health [1]. Prevalence of obesity and overweight is increasing in adults and children in both developed and developing countries [2,3]. Obesity is a risk factor for many conditions including respiratory disorders such as asthma, increased airway resistance and atopy [4,5]. Therefore, increasing numbers of obese adolescents with respiratory disorders are referred for lung function testing.

Based on the excess body fat distribution, obesity can be categorized as central pattern and peripheral pattern. Body Mass Index (BMI) is a measure of relative adipocity, whereas WC and WHR are considered as measure of central obesity. Central adiposity may be associated with a modest impairment of lung volumes such as FVC, FEV1 and TLC in normal and mildly obese men [6]. Studies have shown that both obesity itself and pattern of body fat distribution have independent effect on ventilatory functions [7]. Most of the previous studies on pulmonary function impairment in relation to obesity have used BMI as obesity indicator [8,9]. However, the abdominal obesity markers such as WC and WHR are better predictor of pulmonary function than BMI [10]. Studies investigating pulmonary functions in relation to obesity among adolescents in Malaysia are few. Hence, the present study was aimed to evaluate the effect of obesity on pulmonary functions, and also to identify the association between WC, HC, BMI and WHR with pulmonary functions among adolescent students of a private university in Malaysia.

MATERIALS AND METHODS

This cross-sectional comparative study was conducted in the Human Physiology Laboratory of a Private University (MSU), Malaysia. Necessary ethical approval has been taken from the university ethical committee (registration No-MSU-HE 124). A total of 100 (50 obese and 50 non obese) non-smoking adolescent students of both sexes aged between 16 to 19 years were randomly selected for the study. Written consent was obtained from each participant. The study was conducted during the period from June to December 2017.

BMI of each subject was calculated as per the following formula:

$$BMI=weight\ (kilograms)/height^2\ (meter^2).$$

Subjects having BMI greater than the 95th percentile for age were classified as obese [11]. A total of 50 such obese boys were identified. An identical number of age-matched non-obese with BMI=18.50-24.99 kg/m^2 were taken as controls. Subject with symptoms of illness like fever, cough, abdominal pain, any history of pulmonary diseases, anxious, apprehensive, and uncooperative ones were excluded from the study. All subjects were explained about the procedures to be undertaken. The following measurements/tests were performed.

Anthropometric Measurements

The body weight of the studied participants were measured by using balanced beam scale to an accuracy of ±0.1 kg with the subject wearing minimum clothing while body height was measured with the measuring rod attached to the balanced beam with an accuracy of ±0.50 cm. Waist circumference was recorded by measuring the smallest circumference between the ribs and the iliac crest to the nearest 0.1 cm, while the participant was standing with the abdomen relaxed, at the end of normal expiration. Hip circumference was recorded by measuring the maximum circumference between the iliac crest and the upper border of pubic symphysis. WHR was calculated by dividing waist circumference by hip circumference.

Pulmonary Function Testing

The dynamic pulmonary functions were recorded on a computerized spirometer (Spirobank II MIR, Del Maggiolino125, 00155 Roma, Italy). The parameters measured were FEV_1, FVC, FEV_1/FVC ratio, PEFR, $FEF_{25-75\%}$. The spirometer was calibrated daily using calibration syringe of 3 Lt. All the measurements were taken in standing posture with nose clipped according to the guidelines given by the American Thoracic Society and European Respiratory Society [12]. The system was calibrated at source to read all measures at Body Temperature and Pressure Saturated with vapour (BTPS). All anthropometric measurements and pulmonary function measurements were conducted in one sitting on the same day for each subject.

STATISTICAL ANALYSIS

The pulmonary function parameters of the obese and control groups were compared using Student's t-test. Pearson's product moment correlation co-efficient was calculated to determine the relationship between various measures of obesity (BMI, waist circumference, hip circumference, waist-to-hip ratio) and pulmonary function parameters. All the statistical analysis were performed using MS-Excel 2010 data analysis tool pack. The p-values less than 0.05 were considered as statistically significant.

RESULTS

Among 100 non-smoking healthy adolescent participants studied, 57 were female (23 obese, 34 non obese) and 43 were male (27 obese, 16 non obese). The general characteristics and anthropometric variables of the obese and control groups have been depicted in [Table/Fig-1].

Weight, waist circumference, hip circumference and BMI were found to be significantly higher in obese groups compared to control group. The comparison of observed pulmonary function parameters of the obese and control groups has been shown in [Table/Fig-2]. Mean FVC, FEV_1 and PEFR were marginally higher in obese group compared to non-obese control group, while mean FEV_1/FVC%, $FEF_{25-75\%}$ were marginally lower in obese subjects than age matched non obese control group. There was no significant difference in mean pulmonary function parameters between obese and non-obese control group. However, five obese subjects had mild restriction, whereas no obstructive impairment was detected in any subject of the obese and control group.

	Obese (n=50)	Control (n=50)	p-values
	Mean (SD)	Mean (SD)	
Age (years)	18.05 (1.35)	18.16 (1.59)	0.79
Height (cm)	166.14 (10.60)	161.44 (8.68)	0.14
Weight (kg)	84.50 (21.07)	55.01 (9.04)	0.0002***
Waist Circumference (cm)	92.43 (18.52)	74.43 (7.16)	0.002**
Hip Circumference (cm)	111.39 (15.11)	91.84 (7.27)	0.0002**
Waist hip ratio	0.82 (0.06)	0.81 (0.08)	0.49
Body mass index (kg/m²)	30.26 (5.27)	21.00 (2.12)	0.00015***

[Table/Fig-1]: Characteristics of the obese/overweight and control groups.
Student's t-test was used to compare the significance of difference between means *p<0.05, **p<0.01, ***p<0.001

Parameters		Obese (n=50)	Control (n=50)	
		Mean (SD)	Mean (SD)	p-value
FVC (L)	(O)	3.20 (0.97)	2.96 (0.79)	0.39
	(P)	85.84 (17.66)	85.23 (14.55)	0.92
FEV1 (L)	(O)	3.01 (0.85)	2.83 (0.73)	0.49
	(P)	90.07 (15.91)	86.87 (14.68)	0.86
FEV_1/FVC (%)	(O)	94.37 (4.28)	95.93 (3.81)	0.22
	(P)	105.21 (4.5)	106.28 (4.48)	0.43
$FEF_{25-75\%}$(L/s)	(O)	4.36 (1.06)	4.52 (1.20)	0.62
	(P)	107.07 (27.03)	114.84 (0.64)	0.33
PEFR (L/s)	(O)	7.72 (1.43)	6.68 (2.16)	0.08
	(P)	98.42 (16.11)	91.03 (21.84)	0.16

[Table/Fig-2]: Comparison of dynamic lung volumes among obese and normal weight control group.
Student's t-test was used to compare the significance of difference between means; Significant p<0.05
O: Observed value; P: % Predicted; FVC: Forced vital capacity; FEV1: Forced expiratory volume in 1 second; FEV1/FVC: FEV1 as percentage of FVC; FEF25-75%: Maximum mid expiratory flow rate; PEFR: Peak expiratory flow rate

[Table/Fig-3] presents the correlation matrix between various anthropometric obesity markers and pulmonary function parameters in studied obese subjects.

In studied obese subjects, FEV1/FVC% exhibited significant (p<0.01) inverse correlation with all measured anthropometric obesity markers. FVC and FEV1 had positive significant (p<0.05) correlation with WC and HC, whereas maximum mid expiratory flow rate ($FEF_{25-75\%}$) exhibited negative significant correlation with BMI and WHR. [Table/Fig-4] depicts the correlation matrix between various anthropometric obesity markers and pulmonary function parameters in studied normal weight control group.

In normal weight studied subjects, FVC and FEV1 had positive significant association with WC and WHR; however rest of the dynamic pulmonary measurements had no significant correlation with measured anthropometric obesity indices.

DISCUSSION

The present study was aimed to evaluate the effect of obesity on different dynamic pulmonary functions among Malaysian adolescent university students by comparing lung function of the obese adolescent to their age matching normal weight control group. Some studies have shown a significant reduction in spirometry parameters with obesity while others have not shown any effect [13,14]. Torun E et al., have shown in a

	BMI (kg/m2)		WC (cm)		HC (cm)		WHR	
	r values	p-values	r values	p-values	r values	p-values	r values	p-values
FVC (L)	0.19!	0.186	0.38*	0.006	0.49#	0.000	0.15!	0.298
FEV1 (L)	0.12!	0.406	0.32*	0.023	0.45**	0.001	0.11!	0.446
FEV1/FVC (%)	-0.60#	0.000	-0.57#	0.000	-0.52#	0.000	-0.44**	0.001
$FEF_{25-75\%}$ (L/s)	-0.36*	0.010	-0.18!	0.210!	-0.03!	0.836	-0.32*	0.023
PEFR (L/s)	-0.01!	0.945	0.09!	0.534!	0.09!	0.534	0.07!	0.629

[Table/Fig-3]: Correlation of anthropometric obesity indices with pulmonary function measurements in obese studied subjects (n=50).
#Strongly significant p<0.000; **moderately significant p<0.01; *mild significant p<0.05; !=Not significant; r: Correlation coefficient

	BMI (kg/m²)		WC (cm)		HC (cm)		WHR	
	r values	p-values	r values	p-values	r values	p-values	r values	p-values
FVC (L)	0.19!	0.19	0.39*	0.01	0.10!	0.49	0.28*	0.04
FEV1 (L)	0.15!	0.30	0.37*	0.01	0.06!	0.67	0.30*	0.03
FEV1/FVC (%)	-0.24!	0.09	-0.16!	0.27	-0.20!	0.16	0.03!	0.84
$FEF_{25-75\%}$ (L/s)	0.18!	0.21	0.22!	0.12	0.08!	0.58	0.16!	0.27
PEFR (L/s)	0.23!	0.11	0.26!	0.06	0.03!	0.84	0.25!	0.08

[Table/Fig-4]: Correlation of anthropometric obesity indices with pulmonary function measurements in non-obese control (n=50).
*mild significant p<0.05; !: Not significant; r: Correlation coefficient

comparative study on obese and non-obese that although there was no statistically significant difference in FEV_1, FVC, or FEV_1/FVC, a significant reduction in PEFR and $FEF_{25-75\%}$ was found in overweight and obese individuals [14]. The present study did not find any significant effect of obesity or overweight on dynamic lung volumes measured by spirometer, however the mean FVC was high in obese compared to non-obese control group which may be due to higher body surface area of the subjects in obese group. The mean values of FVC and FEV_1 in obese and non obese were lower than the previously reported values among Malaysians [15,16]. Similar study conducted among obese adolescent boys from a school in Baroda city, Gujarat showed that FEV_1 and FEV_1/FVC were significantly low in the obese group [17]. However, in our present study among Malaysians, adolescents showed that FVC, FEV_1 and PEFR were higher in obese subjects whereas FEV_1/FVC ratio, $FEF_{25-75\%}$ were lower in obese compared to age matched non obese control group, however, the difference was not statistically significant. This is supported by a study conducted on Saudi population by Al Ghobain M where he showed that there were no significant differences between the obese and non-obese subjects in FEV1, FVC, FEV1/FVC ratio and $FEF_{25-75\%}$ [18].

The present study was also aimed to evaluate correlation between various anthropometric obesity marker such as BMI, WC, HC, WHR and pulmonary function parameters. The present study revealed that in obese adolescent FEV1/FVC% exhibited significant inverse correlation with all measured anthropometric obesity markers, suggesting that both relative obesity and central obesity causes significant decrease in FEV1/FVC% and obese are more susceptible to obstructive pulmonary diseases. Similar negative correlation has been observed by Banerjee J et al., [9]. On the other hand, in normal weight studied subjects, FVC and FEV1 positively associated with WC and WHR; however rest of the dynamic pulmonary measurements had no significant correlation with measured anthropometric obesity indices.

Some recent studies have observed that pulmonary function shows an inverse relationship with various anthropometric markers of obesity in children and adolescent [17,19,20]. BMI, WC, HC and WHR are considered as anthropometric markers of both general and central obesity, which may influence pulmonary function in children and adolescents [21,22]. The mechanical effect of fat in restricting normal breathing is more evident if central obesity is considered instead of overall or peripheral fat [23]. The excess of fat in the abdomen and thoracic region may lead to a decrease in the compliance and resistance of respiratory system, increasing work of breathing [24]. Obesity has effects on lung function that may exaggerate the effects of existing airway disease [25]. There is no difference in the effect of obesity on the respiratory system when different abdominal obesity indicators are used, such as WC and waist-to-hip ratio, and thoracic fat indicators [25], suggesting an interdependency of these measures with respect to pulmonary function parameters.

Some studies reported that variables like ethnicity, age, weight, and height, are the prime predictors of lung function in different groups of population [26,27]. In contrast, our present study showed that in obese subjects BMI, WC, HC and WHR had inverse significant association with FEV_1/FVC%, suggesting that obese are more susceptible to obstructive pulmonary diseases. A number of hypotheses have been proposed to explain the negative correlation between pulmonary function parameters and measures of visceral adiposity. One possible mechanism is a mechanical limitation of chest expansion during the FVC maneuver. Increased abdominal mass may impede the descent of the diaphragm and increase the thoracic pressure [28]. Also, abdominal adiposity is likely to reduce expiratory reserve volume via compressing the lungs and diaphragm [29,30].

LIMITATION

There are few limitations in the present study. A bigger sample size would have given more concrete evidence. In the present study we have only investigated the dynamic lung volumes since we did not have facilities to examine static lung volumes.

CONCLUSION

Our study concludes that there was no significant effect of obesity on dynamic pulmonary functions among non-smoker healthy adolescent students of both sexes. BMI, WC, HC and WHR exhibited inverse significant correlation with FEV1/FVC ratio, suggesting that obesity decrease FEV1/FVC ratio and obese are more prone to obstructive lung diseases.

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