A STUDY OF THE ASSOCIATION OF OVERWEIGHT AND PEAK EXPIRATORY FLOW RATE (PEFR) AMONG CHILDREN

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ABSTRACT

BACKGROUND
The aim of this study was to examine the difference in the measure of Peak Expiratory Flow Rate (PEFR) between overweight, obese and non-obese school going children in the age group of 8-13 years.

MATERIALS AND METHODS
A cross-sectional study was conducted involving 643 healthy school going children aged 8-13 years. The study was conducted in one secondary school selected in the urban area of Puducherry between August and September 2017. After baseline data collection including height and weight, BMI was calculated using the Quetelet index. The PEFR was measured using a mini-Wright Peak flow meter. For the study, the highest of the three measurements were recorded.

RESULTS
The study included 643 healthy students, out of which 391 and 252 were boys and girls respectively. Out of 643 children, 590 were in the ideal weight range while 28 and 25 categorized as obese and overweight respectively. The prevalence of overweight and obesity among children in the age group of 8 to 13 years was 3.9% and 4.4% respectively. The present study showed that PEFR was significantly higher in the obese group (256.07±55.47 L/min), than overweight (252.00±51.24) and non-obese group (224.15±53.74, p<0.001).

CONCLUSION
The present study showed a significant difference in the PEFR rate between obese, overweight and normal groups where higher PEFR has been reported on obese than normal. Excess weight directly and positively affects the PEFR, while further investigations on the underlying mechanism is warranted.

KEYWORDS
Peak Expiratory Flow Rate, Obese, Overweight, Children, BMI, South India, Puducherry.

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BACKGROUND

Obesity in India is rising at an alarming rate, especially among children. According to the recent report, India ranks the second highest number of obese children in the world, with 14.1 million reported cases.[1] Epidemiological studies have consistently identified Body mass index (BMI) as a risk factor for an expanding set of chronic diseases[2,3,4] including respiratory diseases such as Asthma. Growing evidence had clearly and consistently evidenced that obesity as an essential and direct predictor of respiratory function as lung function depends on the size and specific distribution of connective tissue.[5] The main effect of overweight and obesity on decreased lung function is due to the fact that it exerts an additional load upon the respiratory system, changing the pressure balance between the lung's inward recoil and chest outward pressure. However, such action has significant consequences on exhaled nitric oxide, airway hyperresponsiveness, ventilation distribution, expiratory flow limitation, airway closure, airway mechanics and overall lung volume.[6]

Lung function assessed by Spirometry including peak expiratory flow (PEF), forced expiratory flow, and forced vital capacity are not only important objective indicators of overall respiratory health but also an important long-term predictor of all-cause mortality and morbidity in both children and adults.[5] However, the critical differences in the effect of obesity on lung function varied between adults, adolescents and children[5] and this has been documented in the literature. Therefore, studies that have been conducted on

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adults[7] on the relationship between obesity and PEFR cannot be generalized to children and adolescents.

While studies have been conducted in the West and few from Asian countries have demonstrated that increased BMI correlates positively with a reduced PEFR compared to their peers during childhood. Costa Junio[8] demonstrated significantly lower lung function in male children with obesity than normal. Hossain[9] examined PEFR among two hundred students from the schools of Dhaka and results showed that PEFR were significantly higher in non-obese than obese group. Similar results were obtained in the study by Pasic[10] where spirometric findings were lower in the obese group in comparison with normal. Chieh Yao[11] also reported a positive association with PEFR rate with BMI z-score among Taiwanese Children in the age group of 5 to 18 years. In contrast, Liyanage[12] reported no significant difference in any of the spirometer parameters between obese/overweight and normal weight school children in Sri Lanka. Similar findings were reported among Nigerian Children[13] where PEF rates were similar across all the BMI groups among both girls and boys.

There are few studies conducted in India, but these studies reported inconsistency in the relationship between PEFR and obesity. Das et al.[14] compared dynamic lung function parameters of overweight and thin boys with healthy in the age group below 19 years. However, PEFR although showed an increase in value but failed to reach significance between normal, thin and overweight. Saxena et al.[7] also found an insignificant difference between normal and obese participants. To date, not many studies have been conducted in the southern part of India. Sugunya[15] reported a significant difference in the PEFR rate between obese and normal. Yet, the current literature on the effect of obesity and overweight on lung function in children remains controversial.

Aims and Objectives

The aim of this study was to examine the difference in the measure of Peak expiratory flow (PEFR) between obese and non-obese school going children in the age group of 8-13 years. The specific objectives of the study were as follows:

1. To examine the difference in the anthropometric parameters stratified by age, height, weight, PEFR rate between obese, overweight and non-obese school going children
2. To assess the relationship between height and the PEFR between obese, overweight and non-obese school going children
3. To evaluate the relationship between weight and the PEFR between obese, overweight and non-obese school going children
4. To correlate the BMI with PEFR between age and gender.

MATERIALS AND METHODS

A cross-sectional study was conducted involving 643 healthy school going children aged 8-13 years. The study was conducted in one secondary school selected in the urban area of Puducherry between August and September 2017.

Inclusion Criteria

The study had stringent inclusion criteria. Firstly, the study had included only healthy children after baseline screening. Secondly, the children in the age group between 8 and 13 years were included in this study.

Exclusion Criteria

The following exclusion criteria were followed during the screening process: Firstly, children those who suffered from asthma and with chronic respiratory disorders were excluded strictly. Secondly, those children who have experienced a respiratory infection in the past two weeks were excluded. Thirdly, with a family history of asthma, low birth weight (<2500 gms.), history of premature birth (<37 weeks) and those had a severe chronic illness were excluded. Finally, children who are not in a condition to perform the test and finally those children and parents who are not willing to participate or sign informed consent were excluded from the study.

Data Collection

Puducherry consists of 10 communes out of which five located in Puducherry district and other five in Karaikal district. Out of five communes in Puducherry district, only one commune was selected using simple random sampling method specifically using random number table,[16] From the selected commune, one school was selected using simple random sampling. Before commencing the study, prior permission was obtained from the school principal with a covering letter stating the importance of the study. Written and oral informed consent was obtained from the parents, teachers and students. The students were explained about the procedure and benefits of participation. Only students in the age group between 8 and 13 years were selected using systematic random sampling method. The lists of students were first obtained from the class teacher and they were listed in the ascending order of their age group and one was picked randomly. From there every third subject was identified and requested to participate in the study after getting informed consent. The baseline questionnaire was administered to record previous history, current illness and their age and sex parameters. A basic physical examination was done to exclude children based on the exclusion criteria. Data were recorded between 9 am and 11 am to remove the circadian effect.

Anthropometric measurements including height and weight of the students were recorded using standard methodology. The Standing height was measured using a stadiometer attached to the wall without footwear, standing erect with a heel to the nearest 0.1 cm. Body weight was determined using a digital weighing scale wearing only school uniform with bare foot to the nearest 0.1 kg. The weighing balance was calibrated before taking measurements while the accuracy of the machine was ±50 g. BMI was calculated using the Quetelet index: weight (kg) divided by the square of height (m^2).

Peak Expiratory Flow Rate (PEFR) was measured using Mini-Wright's peak flow meter (mWPFM) (Clement Clarke International Ltd, U. K) and the accuracy of the flow meters was ±10 L/min with daily calibration. Before commencing the PEFR rate, the manoeuvre was explained and demonstrated to the children. The recording was done in standing position where the mouthpiece of the Mini – Wright's peak flow meter was placed in the child's mouth and the child was asked to take a deep inspiration to total lung capacity. After holding the breath for 1-2 seconds, the child was asked to blow out the Mini-Wright's peak flow meter as hard and fast as possible in a single exhalation. These steps were repeated two maximum inspiration and expiration efforts while the highest value from the three attempts was recorded as the child's PEFR in L/min. If a higher value was obtained on the third manoeuvre, the test was repeated until a value of ≤105 difference was obtained. Disposable mouthpieces were used for each subject. The PEFR was recorded at a fixed time (10.00 am to 1 pm) of the day throughout the study.

Ethical Committee Clearance

Permission was obtained from the Institutional Research and Ethics Committee. Permission was also obtained from the Department of School Education, Puducherry to conduct the study among the school children.

Statistics

The data were analysed using International Business Machines (IBM) SPSS (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was used to determine the distribution of the data. Parametric data such as continuous variables, including age, height, weight and BMI were expressed as means ± standard deviation while for categorical variables, including sex was presented as a percentage in each subgroup. Means for height, weight, age, and forced expiratory volume in 1 second were stratified by sex. To test for differences in measurements between boys and girls, the student t-test was used. To compare the difference across the groups, one-way analysis of variance was used. To examine the relationship between dependent and independent variables and PEFR correlation coefficient were calculated. Multivariate regression was done for the prediction of PEFR taking BMI as a dependent while PEFR as independent variables after controlling for age and sex.A p Value of <0.05 was considered as the level of significance.

RESULTS

A total of 643 healthy school children from Puducherry were selected for the present study out of which 391 and 252 boys and girls respectively with a rate of 1.55. Out of 643 children, 590 were in the ideal weight range while 28 and 25 categorized as obese and overweight respectively. The prevalence of overweight and obesity among children in the age group of 8 to 13 y was 3.9% and 4.4% respectively.

The mean of age, height, weight, BMI and PEFR of Group-A, Group-B and Group-C were 10.52 ± 1.75 years, 11.24 ± 1.62 years, 11.43 ± 1.26 years, 138.47 ± 11.99 cms., 145.56 ± 11.05 cms., 146.96 ± 8.09 cms., 31.39 ± 9.09 kgs., 51.60 ± 7.85 kgs., 58.94 ± 8.68 Kgs., 16.08 ± 2.85, 23.87 ± 0.55, 27.17 ± 2.05 and 224.15 ± 53.74 L/min, 252.00 ± 51.24 L/min and 256.07 ± 55.47 L/min respectively. Age, height, weight, BMI and PEFR were significant (p<0.001) across obese, non-obese and overweight. In specific, the obese group had a higher mean compared to overweight and Non-obese (Table 1).

Parameters	Non-Obese (n=590)	Overweight (n=25)	Obese (n=28)	p Value
	Mean±SD			
Age	10.52±1.75	11.24±1.62	11.43±1.26	0.004**
Height (in Cm)	138.47±11.99	145.56±11.05	146.96±8.09	0.000**
Weight (in Kg)	31.39±9.09	51.60±7.85	58.94±8.68	0.000**
Body Mass Index (Kg/m^2)	16.08±2.85	23.87±0.55	27.17±2.05	0.000**
PEFR (Litres/min)	224.15±53.74	252.00±51.24	256.07±55.47	0.000**

Table 1. Distribution of Anthropometry and PEFR by Groups (n=643)

Data were expressed in Mean±SD. Statistical analysis was done by ANOVA, **p<0.001

In relation to different height interval <=140 cm, 141-150 cm, 151-160 cm and >=160 cm, there were no significant differences in PEFR between non-obese overweight and obese with different height intervals (p>0.05) (Table 2).

Height Interval (in Cm)	Non-Obese	Overweight	Obese	p Value
	PEFR (Litres/min)			
	Mean±SD			
<=140	202.73±44.73	225.67±43.67	202.50±83.42	0.438
141-150	243.53±46.12	249.00±53.43	261.67±50.44	0.295
151-160	276.62±48.24	264.29±46.85	270.00±32.66	0.787
>=160	264.67±69.78	300.00±70.71	285.00±35.36	0.754

Table 2. Distribution of Different Height Intervals and PEFR by Groups (n=643)

Data were expressed in Mean±SD. Statistical analysis was done by ANOVA.

In relation to different weight interval 20-29 Kg, 30-39 Kg, 40-49 Kg, 50-59 Kg and >=60 Kg, PEFR in non-obese had higher mean 256.46±53.47 L/min compared to overweight (241.67±40.70 L/min) and obese (176.67 ± 80.21 L/min) respectively. There were no significant differences in PEFR between non-obese, overweight and obese for 20-29 kgs., 30-39 kgs., 50-59 and >=60 kg (p>0.05) except 40-49 years (p<0.05) (Table-3).

Weight (in Kg)	Non-Obese	Overweight	Obese	p Value
	PEFR (Litres/min)			
	Mean±SD			
20-29	205.24±44.55	200.00±0.00	-	0.907
30-39	239.44±51.31	210.00±0.00	-	0.568
40-49	256.46±53.47	241.67±40.70	176.67±80.21	**0.040***
50-59	267.92±52.67	250.00±49.77	254.00±48.96	0.522
>=60	-	313.33±55.08	283.00±34.01	0.259)

Table 3. Distribution of Different Weight Intervals and PEFR by Groups (n=643)

Data were expressed in Mean±SD. Statistical analysis was done by ANOVA, *p<0.05.

PEFR was positively correlated with height in non-obese (r=0.556, p<0.001) overweight r=0.401, p=0.047 <0.05) and obese group (r=0.483, p=0.009) (Table 4). Similarly, weight also correlated significantly with PEFR rates among non-obese (r=0.478, p<0.001), overweight (r=0.449, p=0.024<0.05) and obese group r=0.530, p=0.004) respectively. (Table 5). PEFR was positively correlated with BMI in 11 years (r=0.274, p=0.003) and 13 years (r=0.194, p=0.035<0.05) (Table 6).

Group		PEFR (Litres/min)
Non-Obese	Height (in Cm)	0.556**
Overweight		0.401*
Obese		0.483**

Table 4. Correlation Between Height and PEFR by Groups (n=643)

**P<0.001

Group		PEFR (Litres/min)
Non-Obese	Weight (in Kg)	0.478**
Overweight		0.449*
Obese		0.530**

Table 5. Correlation Between Weight and PEFR by Groups (n=643)

**P<0.001

Age		PEFR (Litres/min)
8	Body Mass Index (Kg/m2)	.014
9		.003
10		-.054
11		.274**
12		.089
13		.194*

Table 6. Correlation Between BMI and PEFR by Age (n=643)

**P<0.001, *P<0.05

Sex		PEFR (Litres/min)
Boys	Body Mass Index (Kg/m2)	.277**
Girls		.331**

Table 7. Correlation Between BMI and PEFR by Sex (n=643)

**P<0.001

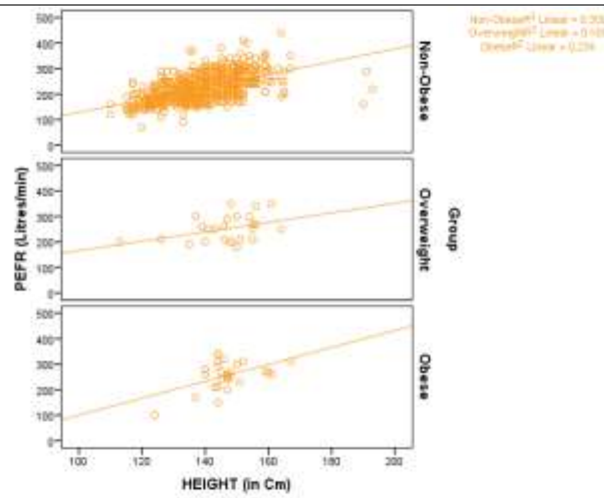

Figure 1. Correlation Between Height and PEFR by Groups (n=643)

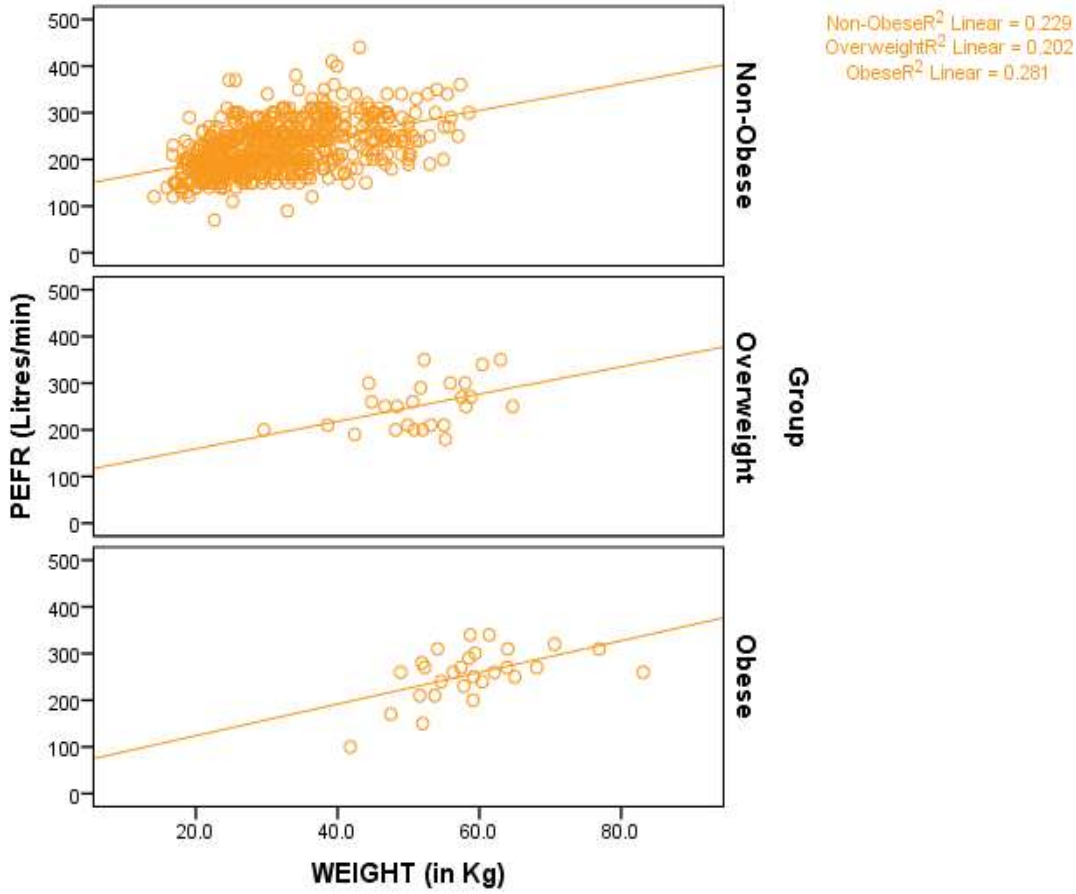

Figure 2. Correlation Between Weight and PEFR by Groups (n=643)

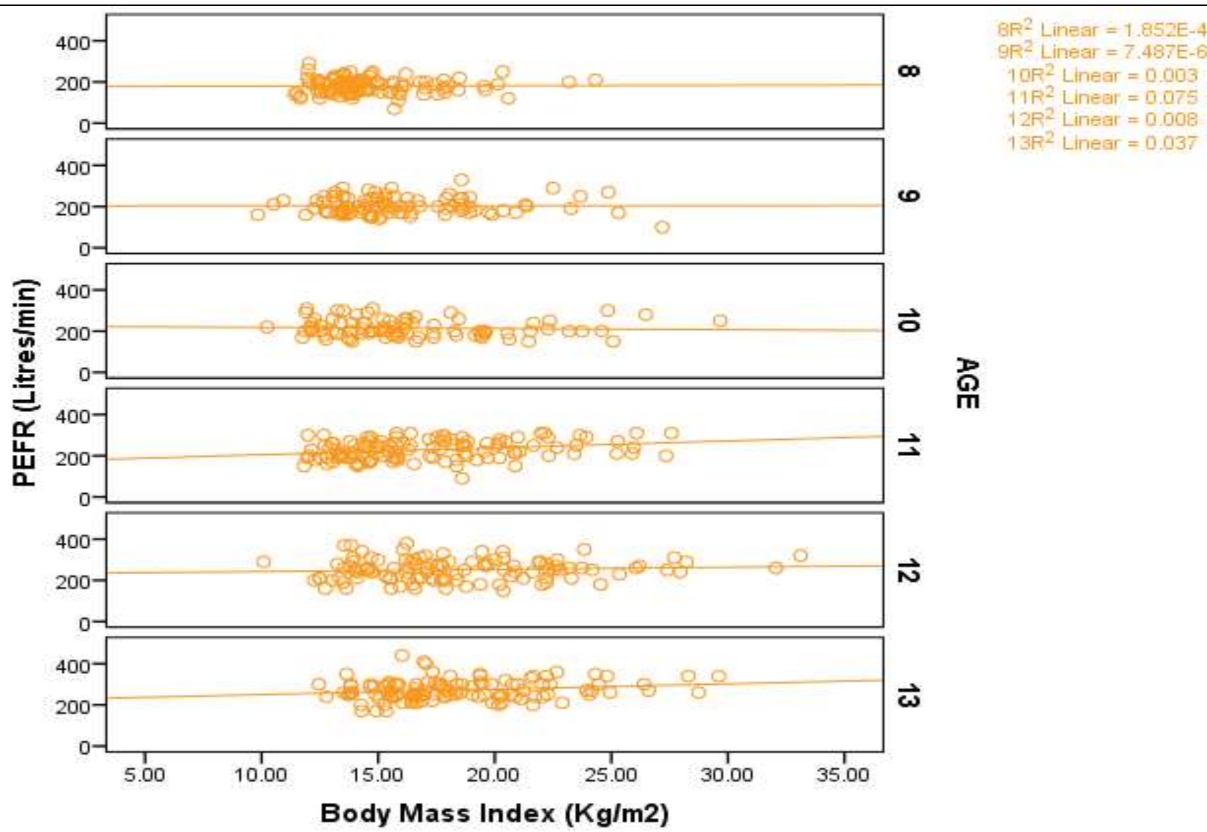

Figure 3. Correlation Between BMI and PEFR by Age (n=643)

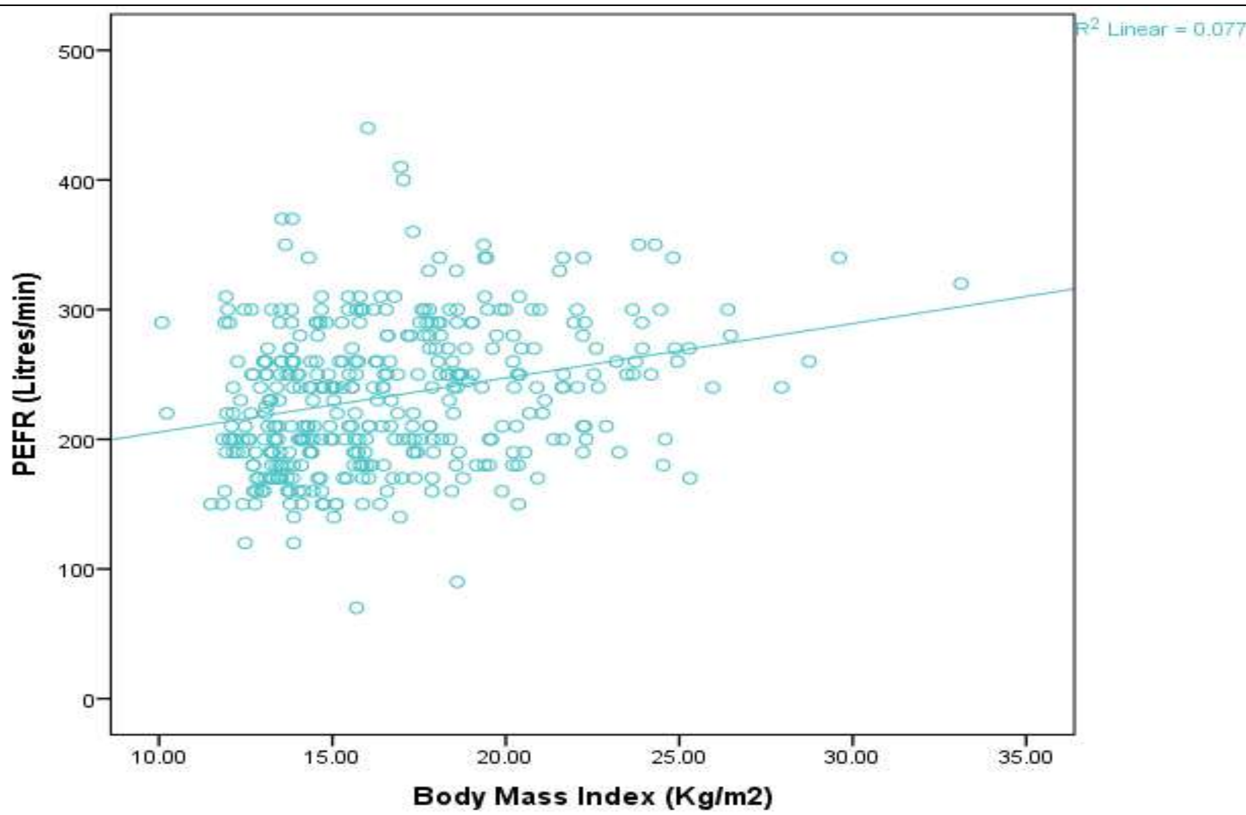

Figure 4. Correlation Between BMI and PEFR for BOYS (n=391)

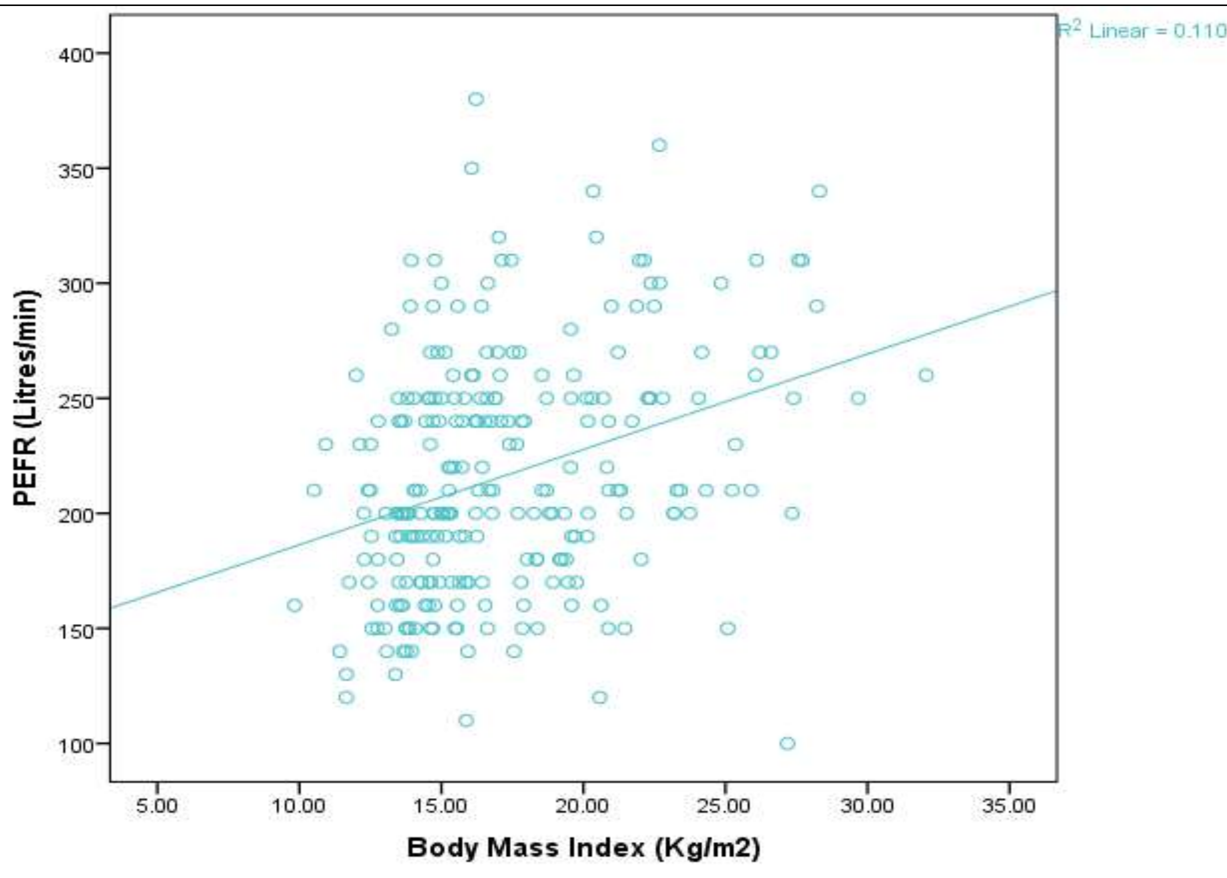

Figure 5. Correlation Between BMI and PEFR for Girls (n=252)

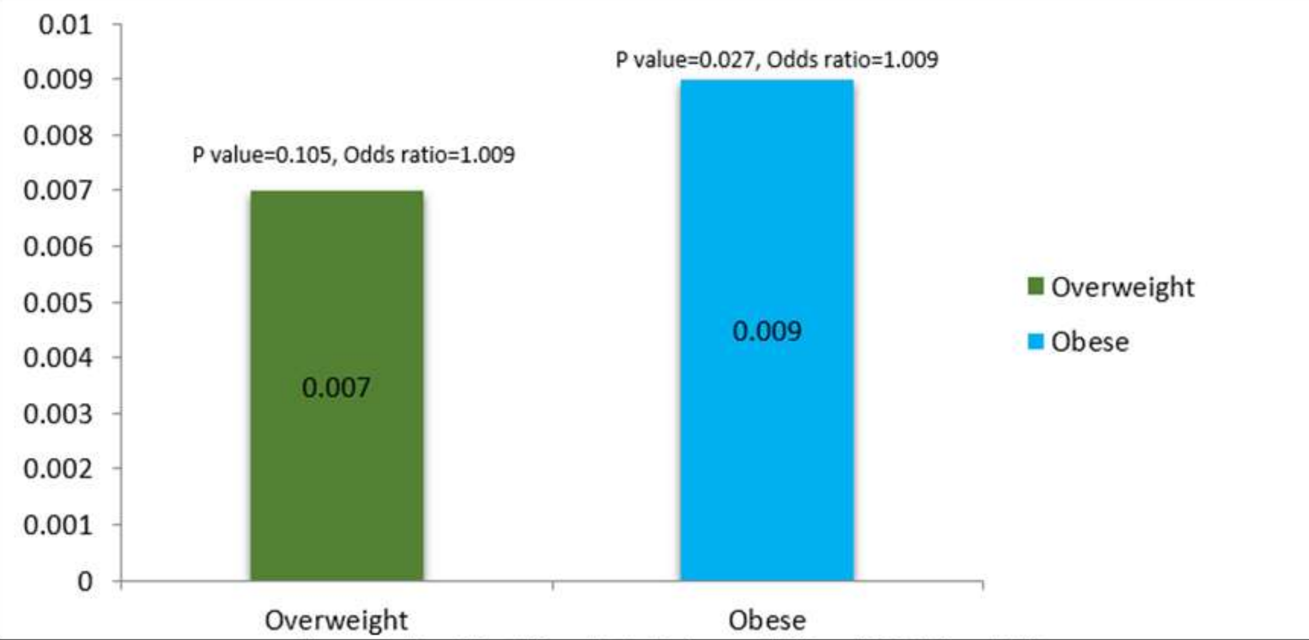

Figure 6. Bar Chart for a Beta Between BMI and PEFR (n=643)

DISCUSSION

Obesity is a global health concern among children while effective treatment for childhood obesity remains largely ineffective. Lung function was significantly influenced by body composition especially BMI. In view of the above, the study has been conducted in Puducherry, given that to our knowledge that none who had previously attempted created nomograms in a healthier population.

In contrast to the previous study findings, the present study showed that PEFR was significantly higher in the obese group (256.07±55.47 L/min), than over weight (252.00±51.24) and non-obese group (224.15±53.74, p<0.001). Our study findings are similar to the findings reported by Chandra Selvi et al.[17] in children and Ashraf et al in medical students.[18] However, this finding is contradictory to the previous findings which demonstrated that increased BMI correlates positively with a reduced PEFR rate compared to their peers during childhood, young children who are overweight or obese.[8,9] The study by Philominal SS et al[15] reported a significant difference in the PEFR rate between obese and normal. Other studies by Liyanage[12] and the study conducted in Nigerian children did not find any differences in the BMI groups among both girls and boys. Saxena et al.[7] Also found an insignificant difference between normal and obese participants. Given that the current literature on the effect of obesity and overweight on lung function in children remains controversial, our study did find increased BMI with an increased PEFER rate.

Previous literature reported many contradictory findings of spirometric variables and obesity in children. The discrepancy could be due to methodological differences such as measurement of fat mass, usage of different tool, sample size, distribution of body fat in the different population, and many factors. However, BMI is a measure of obesity but cannot be distinguished between lean body mass and fat and such relationship between body composition and nutritional status is also controversial. Further accuracy of skin fold measurement is also poor in obese children, but measurement of waist is found to have a direct effect on the chest wall properties.[19] The effect of obesity could be caused by the change of function in respiratory tract, due to the fact that obesity is correlated with the increased bronchial hyperactivity among children with asthma than without asthma. This cumulative effect of inflammatory and increased bronchial sensitivity in obese people could be the start of an asthma attack. Yet understanding such a relationship would be an important step for understanding asthma aetiology in childhood.

Previous studies had used different measurements to assess the lung function. Therefore, our study findings cannot be comparable with the studies conducted elsewhere due to methodological differences. Our study measured Peak expiratory flow rate to measure the lung function. The study had several limitations. The information obtained from this study was self-reported from Children while height and weight were recorded objectively and therefore future study should administer a questionnaire to parents specially to examine the previous medical history. Although this study attempted to distribute the questionnaire to parents via students due to poor response rate, it was dropped in the middle. Secondly, the study is limited to one single school from Puducherry, but future studies should attempt to include more schools that should represent Puducherry and also Karaikal. Thirdly, beside BMI other factors also influence PEFR among children, such as food, air pollution and therefore future studies should account these factors using multivariate or hierarchical regression as confounders to remove these effects on the relationship between BMI and PEFR rate. Finally, the sample size in this study was comparatively small. Therefore further studies need to include larger sample size and region wise comparison including socioeconomic and genetic factors. However, despite these limitations, this is the first study that attempted to capture the peak expiratory flow rate to measure airway obstruction by examining obese, overweight and normal school going children in Puducherry. This research has proved that overweight and obese children had significantly higher PEFR compared to normal.

CONCLUSION

This study provided contradictory evidence showing that excess weight increases lung function which is reflected by higher PEFR. The present study showed a significant correlation between BMI with PEFR across age and sex among 11 and 13 years of healthy school children. There is a significant difference in the PEFR between obese, overweight and normal groups where higher PEFR has been reported in obese than normal. Excess weight directly and positively affects the PEFR, while further investigation on the underlying mechanism is warranted.

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