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Study of Peak Expiratory Flow Rate in School Children & Its Correlation to Height & Sitting Height

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Abstract:
Background: *Peak expiatory flow rate (PEFR) is a lung function test which is easily measurable and reproducible but the standard reference values of PEFR have not been studied at large scale among children in Maharashtra. This study gives a preliminary local reference value of PEFR for school going children of Mumbai.*
Objectives: *The aim of this study is to (a) To study PEFR values in healthy school children: 5-18 year age group (b) To find out correlation of PEFR with Height, Sitting Height & BMI.*
Methodology: *A prospective cross-sectional study was done at two schools in Mumbai from August 2016 to October 2016 involving 1376 children aged 5-18 years who fulfilled selection criteria. PEFR was measured using peak flow meter and the highest among the three values was taken. PEFR values correlation with Height, Sitting Height & BMI were estimated using linear regression analysis.*
Results: *The coefficient of correlation obtained for all the four variables is significant (p <0.001). The correlation of the PEFR with height is positive and highly significant. Highest association is noted between PEFR and standing height (0.850), more in males (0.864) when compared to females (0.826). The correlation between sitting height & PEFR (0.755) is more when compared to weight (0.689) & BMI (0.359) but lesser than standing height.*
Conclusion: *Our study proved the positive correlation between age, weight, height, sitting height & BMI with PEFR. In our study PEFR has very good correlation with height better than sitting height, weight & BMI. Boys have higher PEFR than girls for any given height. It gives a preliminary local reference value of PEFR for school-going children of Mumbai.*
Key Word: *PEFR; Height; Sitting Height; Weight; BMI.*

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I. Introduction

Peak Expiratory Flow Rate (PEFR) is defined as the maximal expiratory flow rate which can be sustained by a subject for at least 10 milliseconds during forced expiration starting from total lung capacity. It is expressed in liters/min. It is an effort-dependent parameter, emerging from the large airways within about 100-120 msec of the start of forced expiration. It remains at its peak for 10 msec [(1)]. It is an accepted index of pulmonary function. It primarily reflects large airway flow and depends on the voluntary effort and muscular strength of the child. Peak expiratory flow rate (PEFR) correlates with FEF (max) in spirometry. Its measurement does not require body temperature pressure saturated (BTPS) correction [(2)]. It is one such parameter that can be easily measured and is a convenient tool to measure lung functions in the field study [(3)]. PEFR as a measurement of ventilator function was introduced by Hadron in 1942, and was accepted in 1949 as an index in spirometry [(4)].

It is a simple reliable way to follow up children with bronchial asthma and other obstructive lung diseases [(5)]. It is a fairly good indicator of bronchial hyper-responsiveness [(6)]. Bronchial asthma is a common respiratory disease of childhood which is associated with fluctuation in airway calibre and one of the earliest sign of impending attack is fall in PEFR [(7)]. Recent studies have shown that personal best PEFR is a useful concept for asthma self-management plans when determined as the highest PEFR over the previous 2 weeks [(8)]. The response to treatment can be monitored by using serial PEFR measurements [(9)]. PEFR is easily measured using peak expiratory flow meter and can be recorded by the patients at home by themselves and at the clinic to reflect the severity of the out flow obstruction and was shown to anticipate early deterioration of patients conditions before it actual happens[(10,11)]. There is a need for a simple, effective technique such as the PEFR

measurement to screen for and control asthma in the community, particularly when the prevalence of asthma and asthma-related hospital admissions are rising. It is well documented in literature that a wide range of geographical, climatic, anthropometric, nutritional, and socioeconomic conditions of India are associated with regional differences in lung function [(12)]. It is influenced by various factors such as age, sex, height, weight, and body surface area, environmental and ethnic differences. For the purposes of evaluation of an observed reading of PEFR, knowledge of its range in normal subjects of the same sex, age and body size is required [(13)]. Ventilatory function studies in adult population from different parts of India are well documented [(13-17)]. Similar data in children is limited [(7)].

II. Materials & Methods

Study area: Schools in Mumbai district – IES Manik Vidyamandir, Bandra Reclamation & Kherwadi Municipal School, Kherwadi, Bandra East were included in the study. Informed consent was obtained from concerned authority of the Institution & parents of children included in the study prior to study.

Study population: School going children aged 5-18 years

Study design: A prospective, cross sectional study

Sample size: 1376

SAS 9.2 package was used to calculate sample size based on the correlation coefficient values taken from Manjunath et al [(18)].reference. Total sample size required is 1076. The minimum sample size of boys and girls required was calculated to be 617 & 459 respectively; correlation coefficient for boys and girls 0.76 & 0.88 respectively.

Inclusion criteria – The study includes children, who are -

1. Normal healthy children: 5-18 yeas age group.
2. Both boys and girls.

Exclusion criteria- Children with following will be excluded from the study-

1. History suggestive of cold or any other respiratory disease within the preceding two weeks.
2. Evidence of grossly enlarged tonsils and adenoids.
3. Chronic respiratory diseases like Bronchial asthma, Bronchopulmonary dysplasia.
4. Past history of asthma, allergies or chest injuries.
5. Structural deformity of thoracic cage like: Scoliosis, Kyphosis, Kypho-Scoliosis, Pigeon chest, Tongue tie.
6. History suggestive of Cardiac Disease.
7. Rhonchi/ Wheeze on auscultation/prolonged expiration.
8. Refused to be included in this study.

Data Collection Methods

Approval was obtained from Institutional Research and Ethics Committee. Questionnaire for parents and consent forms were obtained from parents prior to school check up. Anthropometric data i.e. Height (corrected to 0.1cm), sitting height (corrected to 0.1cm) was measured. Body mass index (BMI) was calculated using this formula –

$$BMI = \text{weight in kg} / \text{height in } m^2.$$

All children were thoroughly examined to exclude any cardiac, pulmonary, or systemic diseases. Any abnormal findings encountered during examination were informed to the parents via the school authorities. 23 children were eliminated from study as they were fitting into exclusion criteria based on questionnaire and clinical examination. Use of peak flow meter was demonstrated to all children and was recorded under direct supervision of primary investigator, Dr Mamata Gupta. Peak flow meter of same brand was used for all children. At rest and in standing position, each child was made to blow to get three reproducible PEFR readings times, without a nose clip into a standard peak flow meter. Practical upper limit of maximum number of maneuvers was kept as eight [(19)]. The highest of the three reproducible readings obtained were taken as final PEFR for that child.

III. Results

Sample size was calculated using SAS 9.2 software package. Data were analyzed using SPSS 15.0 (Statistical Package for Social Sciences), Version 15.0. Data were given as Mean ± SD for numerical data and Number (Percentage %) for categorical data. ANOVA (Analysis of Variance F test) was applied to compare more than 2 group means. Analysis of variance and student t test has been used to find the significance of PEFR with age, height, weight, sitting height and BMI. ANOVA test was 2 tailed. Alpha (α) Level of Significance was

taken as P<0.05. Pearson correlation has been used to find the significant relationship between PEFR and anthropometric parameters. Prediction equations by regression analysis are carried out.

Table 1. Anthropometric data of the study group
Data: Mean ± SD (standard deviation)

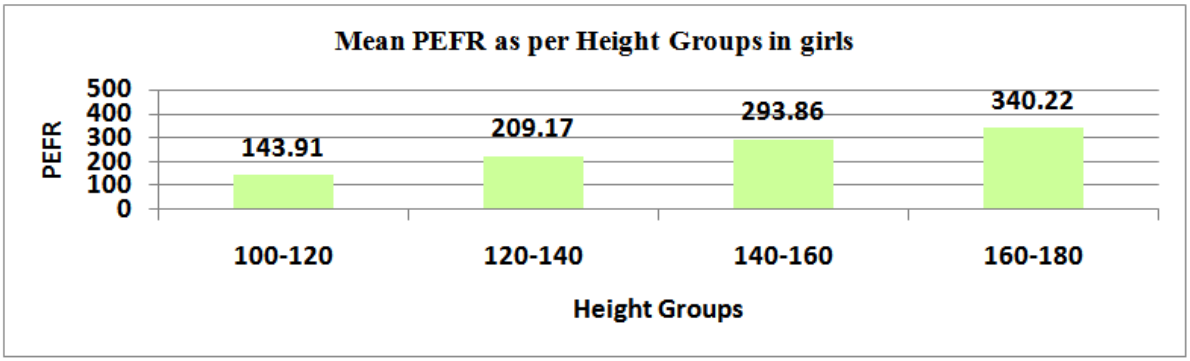
Study group	Number	Age	Weight	Height	Sitting Height	BMI
Girls	568	12.12 ±3.05	39.08 ± 12.26	144.32 ± 13.28	72.15 ±7.50	18.32 ±3.65
Boys	785	11.36 ±3.25	40.03 ± 15.08	146.02 ± 17.20	71.23 ±4.06	18.12 ±4.06
Combined	1353	11.68 ±3.19	39.63 ± 13.97	145.31 ± 15.69	72.91 ±8.20	18.20 ±3.89

The mean height of all girls and boys was 144.32 cm with a SD of 13.28 and 146.2 cm with a SD of 17.20 respectively. The mean sitting height of all girls and boys was 72.15 cm and SD of 7.50 and 71.23 cm and SD of 4.06 respectively. The mean BMI and standard deviation of all girls and boys was 18.32 kg/m^2 & 3.65 and 18.12 kg/m^2 & SD of 4.06.

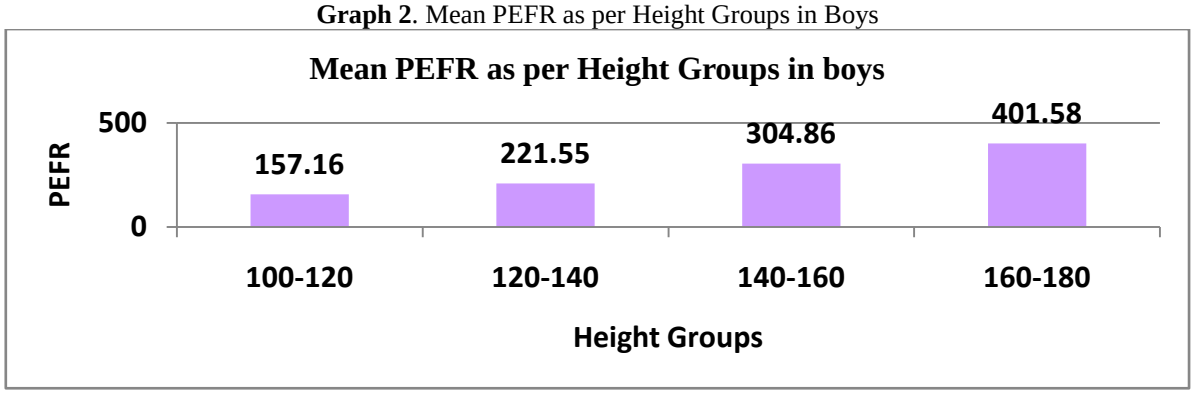
Table 2 : Comparison of Mean and SD of PEFR in Study Subjects According to Height Intervals

Group no	Height (cm)	Girls		Boys	
		No of subjects	Mean ± SD of PEFR (in lpm)	No of subjects	Mean ± SD of PEFR (in lpm)
I	100-120	46	143.91 ± 27.61	67	157.16 ± 31.66
II	120-140	116	209.17 ± 40.65	205	221.55 ± 38.62
III	140-160	360	293.86 ± 39.08	311	304.86 ± 58.57
IV	160-180	46	340.22 ± 50.84	202	401.58 ± 64.00

Graph 1: Mean PEFR as per Height Groups in Girls



Graph 2. Mean PEFR as per Height Groups in Boys

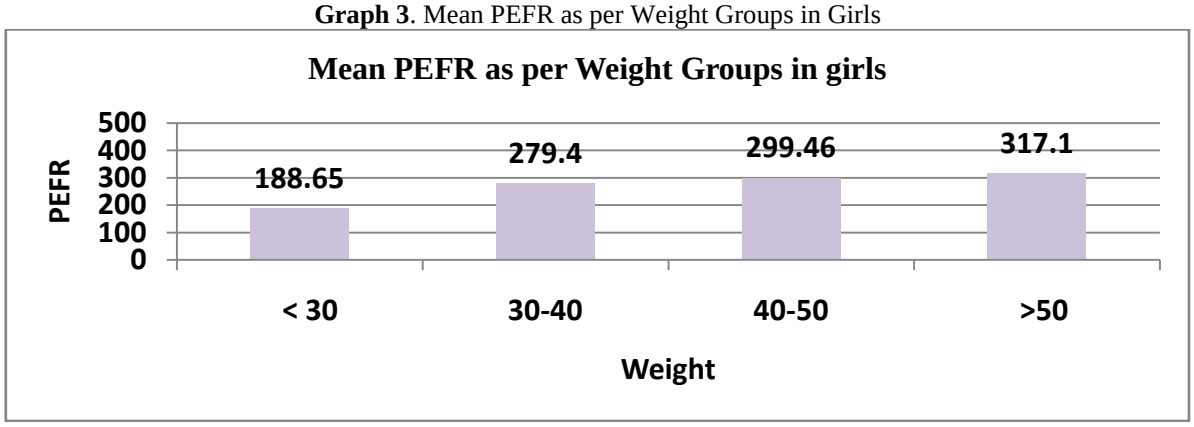


Mean PEFR increases as the height increases in both boys and girls. Boys have a higher value of mean PEFR than girls at the given height as shown in graph 1 & 2.

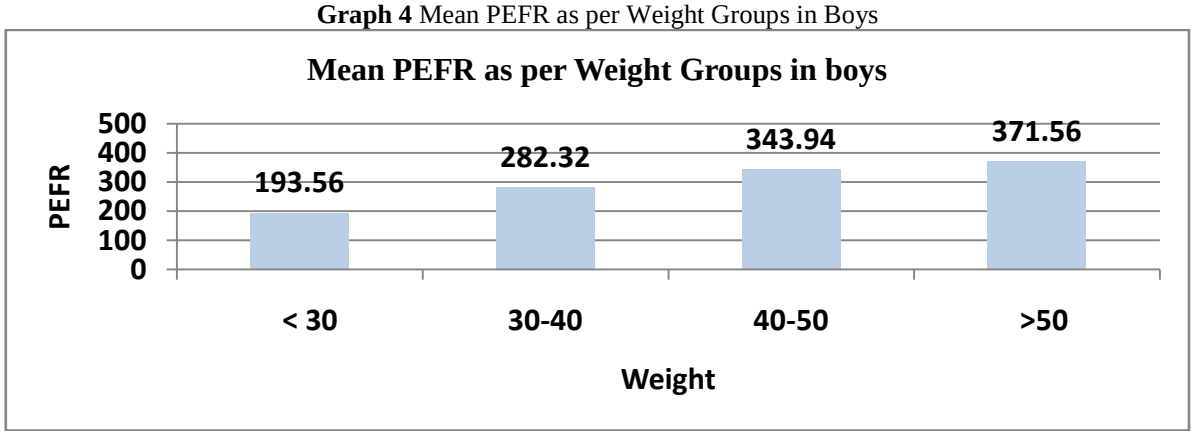
Table 3. Comparison of Mean and SD of PEFR in Study Subjects According to Weight Groups

Group no	Weight (in kg)	Girls		Boys	
		No.of subjects	Mean and SD of PEFR (in lpm)	No. of subjects	Mean and SD of PEFR (in lpm)
I	< 30	126	188.65 ± 48.02	225	193.56 ± 48.20
II	30-40	200	279.40 ± 40.38	194	282.32 ± 61.75
III	40-50	149	299.46 ± 41.62	180	343.94 ± 82.30
IV	>50	93	317.10 ± 52.08	186	371.56 ±75.75

Graph 3. Mean PEFR as per Weight Groups in Girls



Graph 4 Mean PEFR as per Weight Groups in Boys

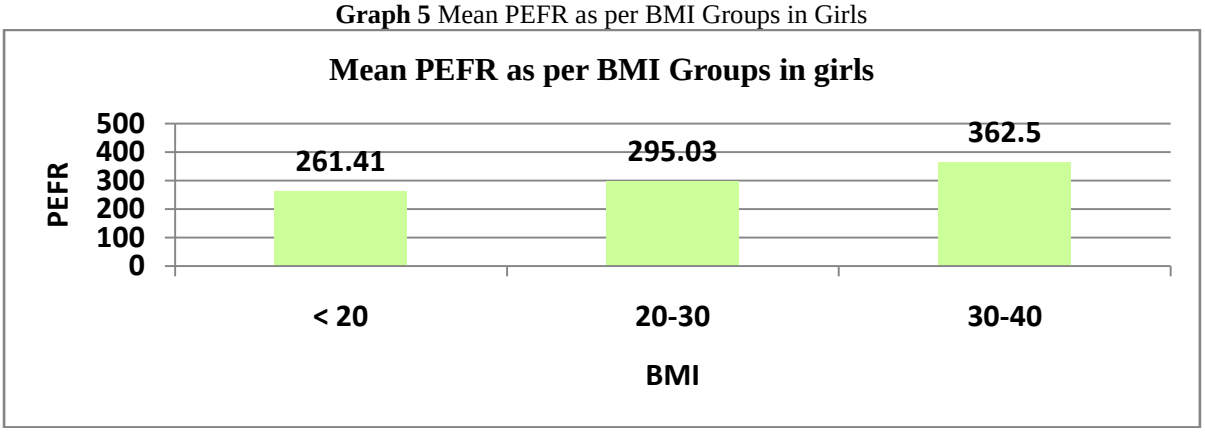


Mean PEFR increases as weight increases in girls and boys. Boys have a higher value of mean PEFR than girls at the given weight as shown in graph 3 & 4.

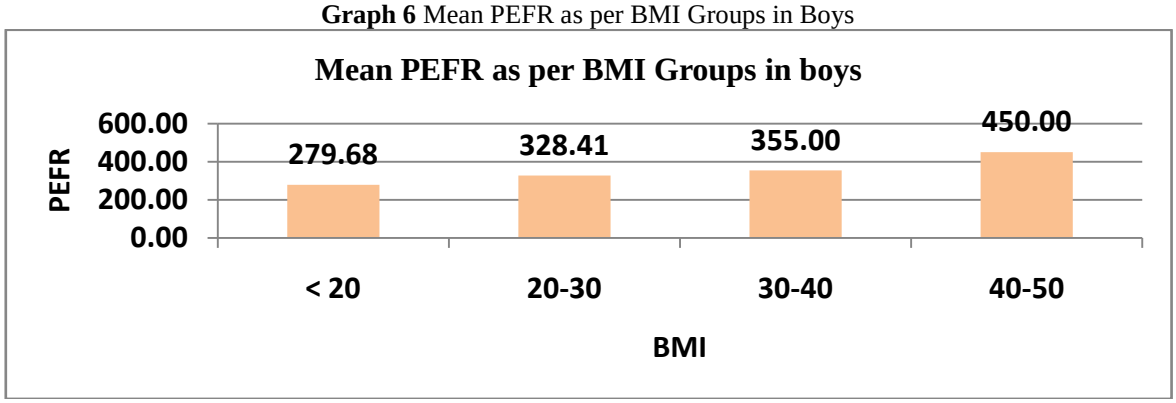
Table 4. Comparison of Mean and SD of PEFR in Study Subjects According to Body Mass Index Groups

Group no	BMI	Girls		Boys	
		No. of subjects	Mean and SD of PEFR (in lpm)	No.of subjects	Mean and SD of PEFR (in lpm)
I	10-20	419	261.41 ± 63.50	592	279.68 ± 97.30
II	20-30	145	295.03 ± 56.61	182	328.41 ± 86.10
III	30-40	4	362.50 ± 29.86	10	355.00 ± 80.86

Graph 5 Mean PEFR as per BMI Groups in Girls



Graph 6 Mean PEFR as per BMI Groups in Boys

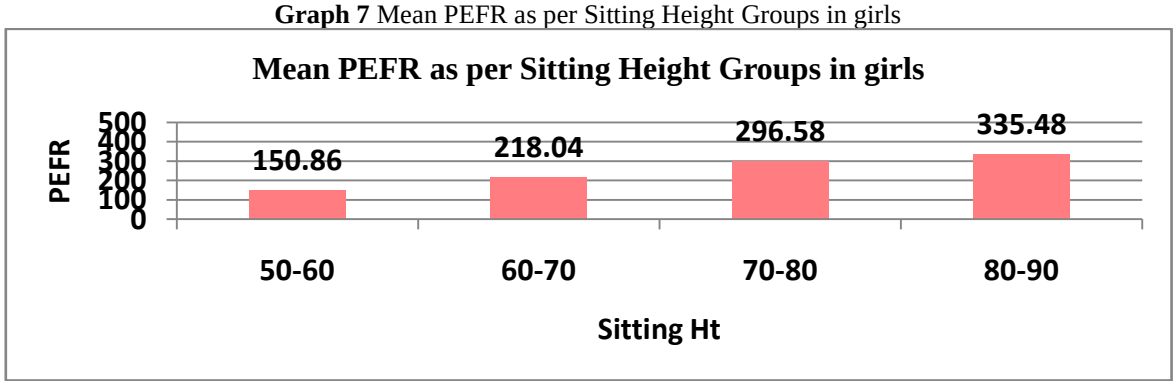


Mean PEFR increases as BMI increases in girls and boys. For any given BMI mean PEFR value in boys is higher than those of girls as shown in graph 5 & 6.

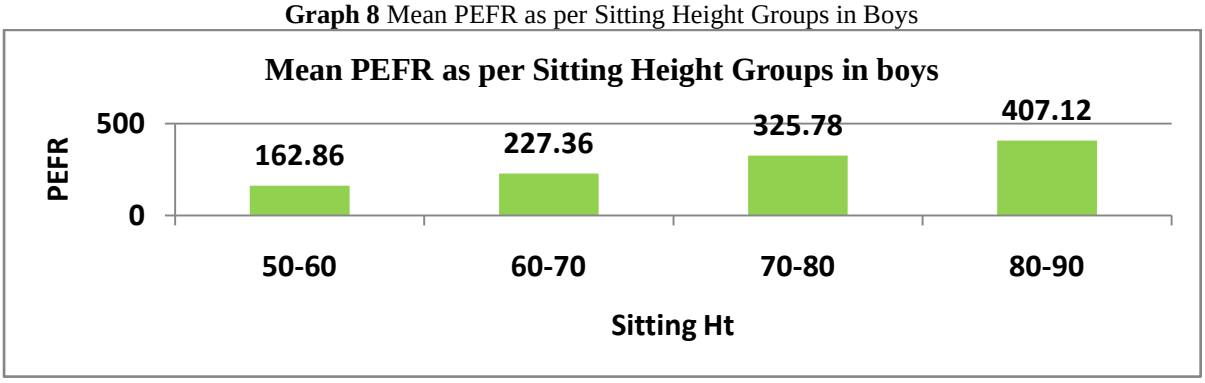
Table 5. Comparison of Mean and SD of PEFR in Study Subjects According to sitting height

Group no	Sitting height	Girls		Boys	
		No. Of subjects	Mean and SD of PEFR (in lpm)	No. Of subjects	Mean and SD of PEFR (in lpm)
I	50-60	35	150.86 ± 43.21	70	162.86 ±38.83
II	60-70	143	218.04 ± 43.75	273	227.36 ± 51.59
III	70-80	348	296.58 ± 40.05	296	325.78 ± 63.62
IV	80-90	42	335.48 ± 50.62	146	407.12 ±73.78

Graph 7 Mean PEFR as per Sitting Height Groups in girls



Graph 8 Mean PEFR as per Sitting Height Groups in Boys



It is seen that PEFR increases sitting height increases in both girls and boys. The mean PEFR value at any given sitting height is higher for boys when compared to girls as shown in graph 7 & 8.

Table 6. Pearson Correlation Coefficient (r) of PEFR & Anthropometric Parameters and its significance.

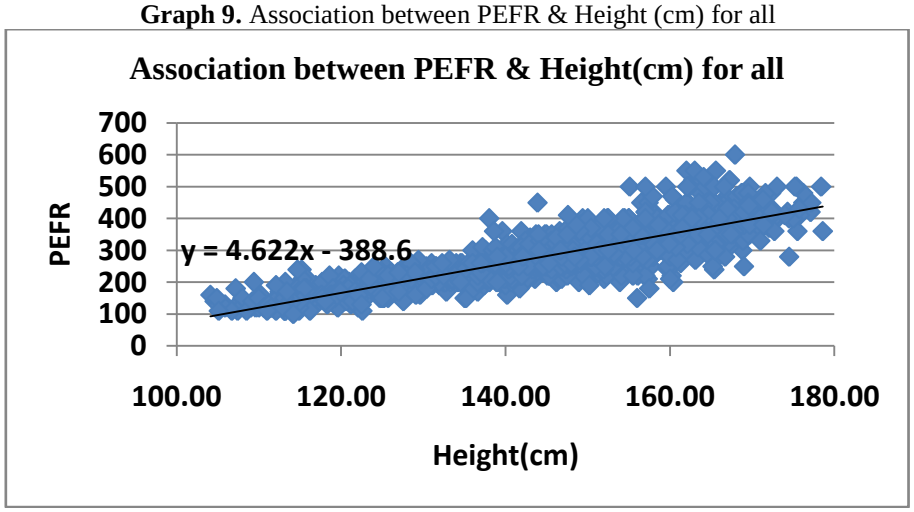
PEFR vs. Parameter	Male		Female		All children	
	R value	P value	R value	P value	R value	P value
PEFR/height	0.864	<0.001	0.826	<0.001	0.850	<0.001
PEFR/sitting height	0.793	<0.001	0.712	<0.001	0.755	<0.001
PEFR/weight	0.693	<0.001	0.694	<0.001	0.689	<0.001
PEFR/BMI	0.340	<0.001	0.437	<0.001	0.359	<0.001

The coefficient of correlation obtained for all the four variables is significant (p <0.001). The correlation of the PEFR with height is positive and highly significant. Highest association is noted between PEFR and standing height (0.850), more in males (0.864) when compared to females (0.826). The correlation between sitting height & PEFR (0.755) is more when compared to weight (0.689) & BMI (0.359) but lesser than standing height. The correlation is more in males (0.793) compared to females (0.712). It illustrates the positive correlation of PEFR with weight as PEFR increases with weight and correlation is statistically significant. The correlation between weight & PEFR is more than PEFR/BMI correlation but lesser than PEFR/height & PEFR/sitting height correlation. The PEFR/weight correlation for boys & girls is 0.693 & 0.694 respectively. There is positive correlation between PEFR and BMI and the correlation is significant. The correlation of PEFR with BMI is lowest. It is 0.340 & 0.437 for boys and girls respectively.

REGRESSION EQUATIONS

Simple regression analysis was done for PEFR to represent the simple regression equations for prediction of PEFR on the basis of anthropometric variables those which were significantly correlated with PEFR.

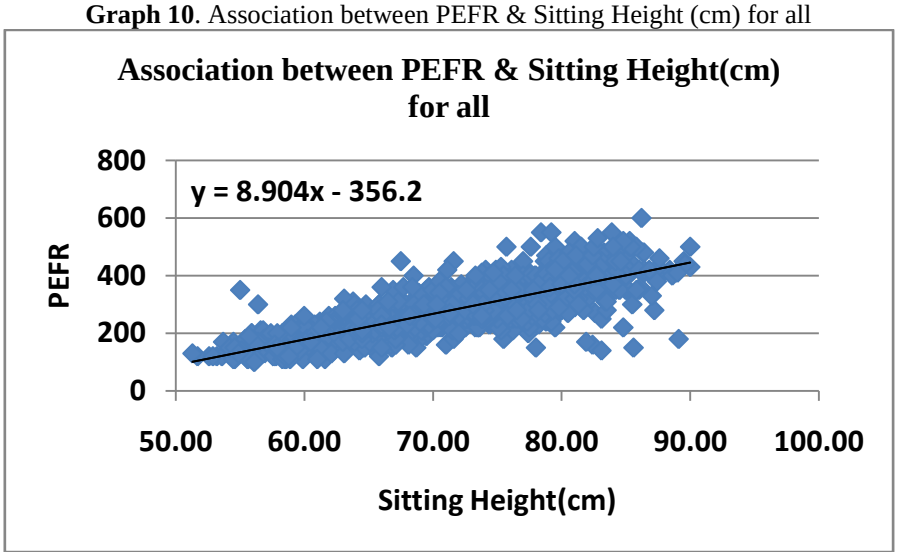
Graph 9. Association between PEFR & Height (cm) for all



The PEFR values increased in linear relation to height. The regression equation based on height for all:

Combined equation : PEFR (l/min) = 4.622 Ht (cm) - 388.6

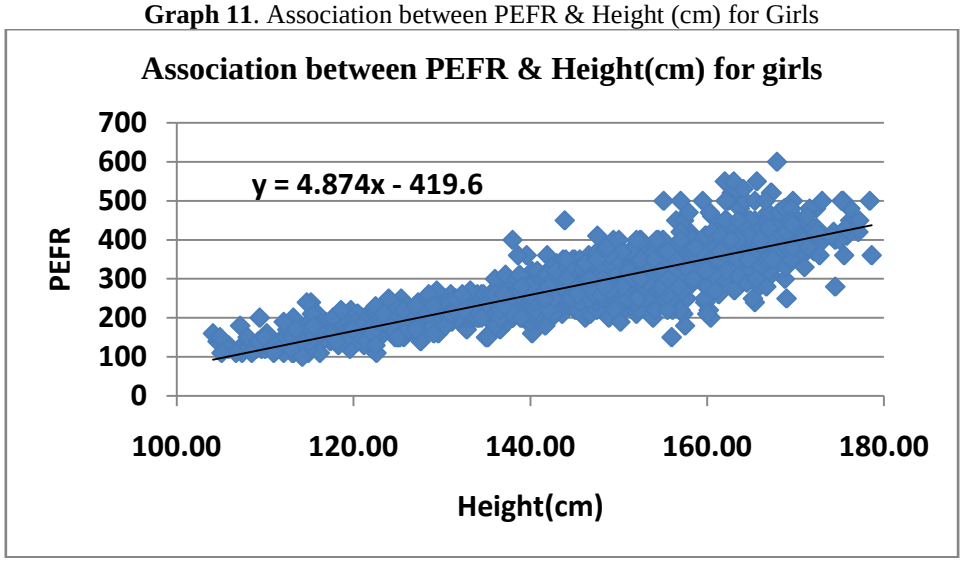
Graph 10. Association between PEFR & Sitting Height (cm) for all



The PEFR values increased in linear relation to sitting height. The regression equation based on sitting height for all:

Combined equation : PEFR (l/min) = 8.904 Sitting Ht (cm) – 356.2

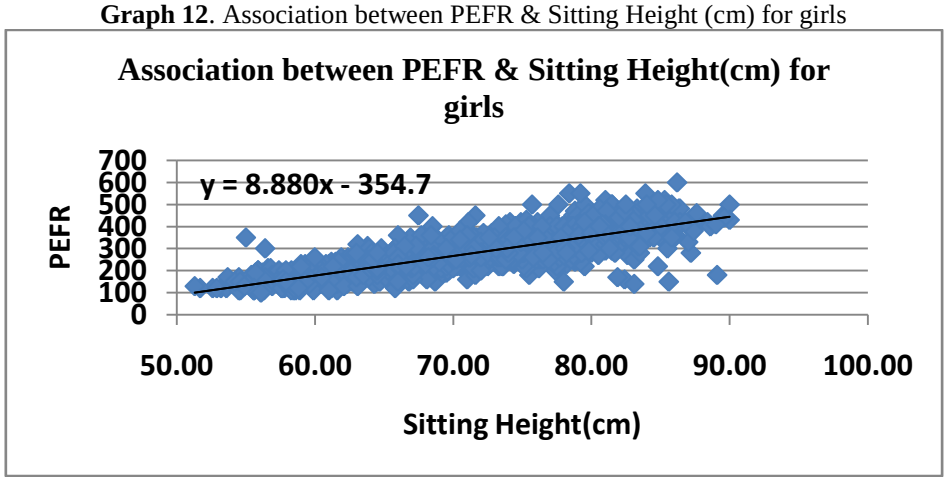
Graph 11. Association between PEFR & Height (cm) for Girls



The PEFR values increased in linear relation to height. The regression equation based on height for girls:

For girls : PEFR (l/min) = 4.874 Ht (cm) - 419.6

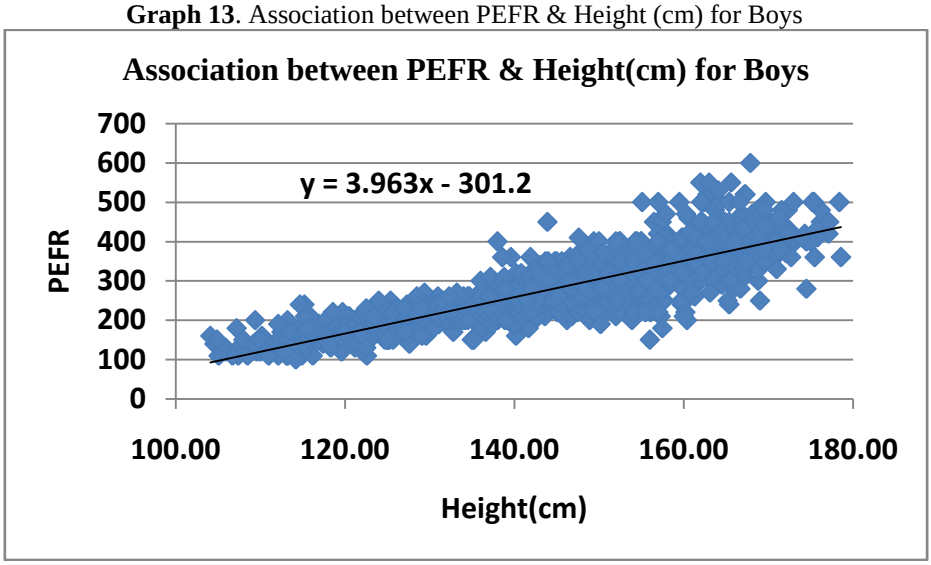
Graph 12. Association between PEFR & Sitting Height (cm) for girls



The PEFR values increased in linear relation to sitting height. The regression equation based on sitting height for girls.

For girls : PEFR (l/min) = 8.80 Sitting Ht (cm) – 354.7

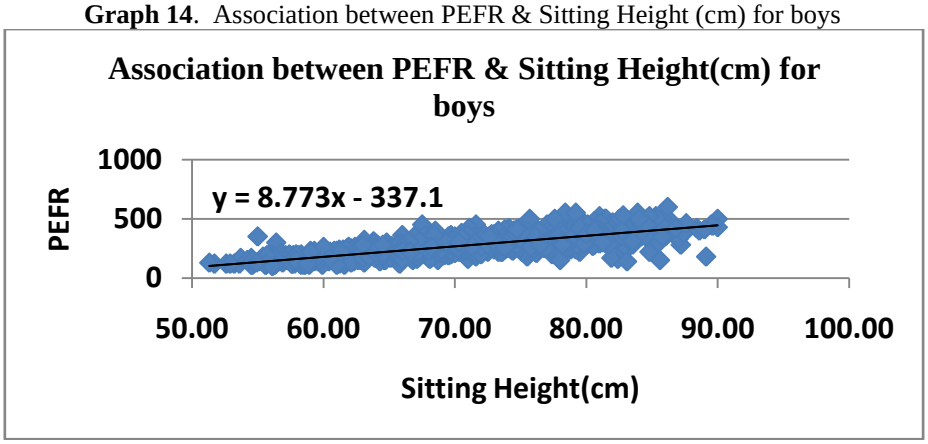
Graph 13. Association between PEFR & Height (cm) for Boys



The PEFR values increased in linear relation to height. The regression equation based on height for boys:

For boys : PEFR (l/min) = 3.963 Ht (cm) – 301.2

Graph 14. Association between PEFR & Sitting Height (cm) for boys



The PEFR values increased in linear relation to sitting height. The regression equation based on sitting height for boys.

For boys: PEFR (l/min) = 8.773 Sitting Ht (cm) – 337.1

IV. Discussion

The aim of our study was to establish reference values of PEFR for school going children of Mumbai (Maharashtra), so that local reference standards are available when this measurement is being used for assessment of bronchospasm or its reversal in day-to-day monitoring of asthmatic children.

PEFR & Weight - There is positive correlation of PEFR with weight as PEFR increases with weight and correlation is statistically significant. Boys had a higher value of mean PEFR than girls at the given weight. Our study is in accordance with previous studies [20, 21].

PEFR & Height - There is positive correlation of PEFR with height as PEFR increases with height and correlation is statistically significant. Boys had a higher value of mean PEFR than girls at the given height. The mean PEFR of boys in various height groups closely match with that of the girls till the age of 15 years. After 15 years, PEFR values of the boys are higher and more progressively increasing than that of the girls, because the growth period of boys is prolonged than that of girls until maturity & because of the greater chest volume in the taller subjects. The growth of the airway passages and the expiratory muscle effort also increase with an increase in the height. Apart from the influence of the differential growth in both the gender, the performance of the PEFR test in an individual is affected by various factors like genetic factor, nutrition & environment. Height is an outward expression of the nutritional standards of growing child. Nutritional standards are a major determinant of Ventilatory capacity in children with increasing age, height and lung capacities increase within the same age group. A well nourished child with greater height who can put forth a greater muscular effort can give a greater PEFR reading.

PEFR & Sitting Height - There is positive correlation of PEFR with sitting height as PEFR increases with height and correlation is statistically significant. Boys had a higher value of mean PEFR than girls at the given sitting height. Some workers [22,23] observed greater influence of sitting height on PEFR ($r = 0.88$) as compared to standing height, however our finding are similar to observation by Raju PS et al [12] who found influence of sitting height on PEFR relatively lower than standing height. Total height appears more nearly to indicate functional growth than does sitting height [24]. This is the probable reason for better correlation of standing height than sitting height with PEFR. Studies conducted in western countries reported that the racial differences were greatly reduced when sitting height was used as a predictor for Ventilatory function values [25]. It is, probably because impact of variable body proportions of different races are minimized when sitting height was used.

PEFR & BMI - There was increase in mean PEFR with increase in BMI. So there is positive correlation between PEFR and BMI and the correlation is significant but it is much lesser than correlation with other parameters. Similar findings were reported by some authors [26, 27].

Prediction Equation for PEFR - It will be possible to predict PEFR for a given height by calculating it from our equation:

(A) PEFR (Girls) : PEFR (l/min) = 4.874 Ht (cm) - 419.6

(B) PEFR (Boys) : PEFR (l/min) = 3.963 Ht (cm) – 301.2

(C) PEFR (Combined) : PEFR (l/min) = 4.622 Ht (cm) - 388.6

(D) PEFR (Girls): PEFR (l/min) = 8.80 Sitting Ht (cm) – 354.7

(E) PEFR (Boys) : PEFR (l/min) = 8.773 Sitting Ht (cm) – 337.1

(F) PEFR (Combined) : PEFR (l/min) = 8.904 Sitting Ht (cm) – 356.2

Height has been taken as the basis for equations to estimate the value of PEFR in a given individual as height can be easily and accurately measured if proper technique is used. It has significant correlation with PEFR & formula based on height gives the best approximation of observed values.

There is possibility that some might not have recalled the previous history of respiratory illness correctly and might have had subtle grade of asymptomatic small airways obstruction which is not detectable by clinical examination. We have tried our best to gather correct & reliable history. It is highly unlikely for a child to have an episode of bronchospasm in the absence of complaints of cough. In addition genetic makeup of the individual which contributes to one third of the phenotypic expression also influences the performance of the individual.

Age, height, weight, BMI and BSA has all been used in studies either alone or in combination to predict PEFR previously [28-32]. Parmar et al studied PEFR values in healthy north Indian school children, which were similar to the findings from the western countries [16]. Singh et al found that PEFR in south Indian school

children was lower than that observed in western and north Indian children [33]. Malik et al observed the PEFR from Punjab, north Indian school children and found that the height standardized value of PEFR showed no rural-urban differences [13]. Mahajan et al reported higher predicted values of PEFR in Haryanavis than those in children of other Indian states [34]. Kashyap et al measured the PEFR of healthy tribal children living at high altitude in the Himalayas and found that the values are comparable with those of north Indian urban children [35]. These studies have showed that there were differences in the lung function values due to difference in ethnicity among these subjects.

Our study findings are found to be lower than that of white population for both age and sex group. Probable reason for this is the difference in body size which depends upon racial, genetic, climatic and nutritional factors [36]. Studies conducted in Western countries reported that the Ventilatory function values were significantly different between Mexican- American, white and black children population and presented the regression equations, separately for each race, to predict these Ventilatory function values using height as a dependant variable [37]. The same group also reported that the racial differences were greatly reduced when sitting height was used as a predictor for Ventilatory function values [25]. In a UK study, it was reported that the difference in lung functions between boys and girls is smaller when the function is related to stature than to sitting height. They further stated that the difference was further reduced when fat free mass/stature^2 and percentage body fat are included in the prediction equations [38].

Table 25 - Comparison of PEFR (L/min) predicted from the present study with those of previous studies in children –

SOURCE OF DATA	HEIGHT					
	120cm		140cm		160cm	
	Boys	Girls	Boys	Girls	Boys	Girls
Parmar et al (1977) [16]	198.29	228.51	299.45	312.17	400.61	395.83
Singh & Peri (1978) [33]	179.60	169.20	279.60	269.80	379.60	370.40
Malik et al (1982) [13]	222	216	320	314	418	412
Mahajan et al (1984) [34]	196.70	-	296.70	-	396.70	-
Kashyap et al (1992) [35]	202.33	175.10	303.73	263.30	405.13	351.50
Swaminathan (1993) [7]	205	193	286	272	368	350
Sharma R (2002) [39]	199.20	186.70	285.88	273.90	372.50	361
Taksande A et. al., 2008 [26]	211	212	317	318	422	423
Mohammadzadeh I.2006 Iran [40]	216	222	314	320	412	415
Manjunath CB et al (2013) [37]	188	210	273	298	358	386
Shallu Mittal et. al., 2013, India (Punjab) [41]	193	205	272	286	350	368
Present study	174.36	165.28	262.76	253.62	360.24	332.88

V. Conclusion

Peak flow meter is a simple, reliable & reproducible method of assessing the PEFR to assess children with respiratory illness. Our study proved the positive correlation between age, weight, height, sitting height & BMI with PEFR. In our study PEFR has very good correlation with height better than sitting height, weight & BMI. Boys have higher PEFR than girls for any given height. It gives a preliminary local reference value of PEFR for school-going children of Mumbai. Predictive equations can be derived relating the PEFR with height & sitting height. Further studies are needed including larger sample size and region wise comparisons including racial, socioeconomic, and genetic factors to understand the difference in PEFR in other parts of country.

Conflicts of interest: No potential conflict of interests is relevant to this study.

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