Original Research Article

Study on peak expiratory flow rate in school children from Madurai district, Tamil Nadu, India

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ABSTRACT

Background: Data on peak expiratory flow rate (PEFR) for Madurai district, Tamil Nadu, India, school children is not available. Hence, this study aims to construct predicted equations for PEFR in both sexes in the age group of 5 - 12 years according to the height as a reference.

Methods: About 961 healthy children (493 boys and 468 girls) were randomly selected from six schools of Madurai district. PEFR readings were repeated thrice and the highest value of these 3 readings was taken as the observed PEFR. Linear regression analysis was performed using age, weight, height and body surface area (BSA) as independent variables and PEFR as the dependent variable.

Results: Statistical correlation is found between height, age, BSA, weight and PEFR in both sexes. The variables which show significant positive relationship with PEFR are height (r=0.78), age (r=0.74), BSA (r=0.73), weight(r=0.67) of which height shows the most significant correlation. The regression equation for PEFR with height is: boys: PEFR =3.12 x (height)-211.85, girls: PEFR = 3.07 x (height)- 212.3.

Conclusions: BSA needs further formula-based calculation and age may be falsely given in the school records or may be forgotten by uneducated parents. Weight is having less correlation coefficient compared to other parameters. So, this study recommends deriving predicted equation for PEFR based on height for both genders. The prediction equations for PEFR obtained in this study can be used as local reference for the follow up of children with respiratory disorders in and around Madurai district, Tamil Nadu, India.

Keywords: Body surface area, Height, Peak expiratory flow rate, Weight

INTRODUCTION

Peak expiratory flow rate (PEFR) recording is one among the many lung function tests helpful in evaluation, monitoring, management and follow-up of patients with bronchial hyper reactivity. PEFR is easily estimated using peak expiratory flow meter and is also handy for the children both at home and in clinic. It reflects the severity of outflow obstruction and was shown to anticipate early deterioration of patient's condition before they actually happen.[1]

Bronchial asthma is a common respiratory disease of childhood which has fluctuations in airway diameter and PEFR values signal a forthcoming attack. PEFR is an accepted index of pulmonary function. Personal best PEFR is a useful concept for asthma self-management plan. Serial PEFR monitoring is a reliable investigation for the diagnosis of asthma. A variation of greater than 20% of baseline PEFR may indicate airway hyper reactivity.[2]

Asthma severity can be graded using PEFR if PEFR predicted is>80% and variability of PEFR is <20% as

intermittent and if PEFR predicted is <60% and variability of PEFR is >30% as severe persistent.[3]

Predictive normal values are essential for clinical interpretation of lung function tests. Nomograms predicting PEFR from anthropometric measurements are available for various population groups. While using lung function tests in epidemiology, it is important to ensure that the population from which the regression equation is derived is an appropriate one as predicted normal values are affected by many factors including ethnic, regional and environmental influences.[4]

Importance of having reference values for PEFR in Madurai school children is more because of large incidence of respiratory diseases, especially bronchial asthma. Predictive values for PEFR may be obtained from the height or an individual's personal best value which of these is better still remains an enigma. The personal best PEFR value is the highest measurement achieved when the child is free from signs and symptoms. It is important that the personal best value can be determined only if efforts have been made to ensure that asthma is optimally managed at the time of the measurement.

It should be measured at least twice a day during the monitoring period of 2 to 3 weeks. On these occasions PEFR recording should be done at least 3 times per day and the highest of these values to be recorded. Often it is difficult to have follow up of the children by their parents for very long periods to assess their personal best PEFR. From the clinician point of view, it is difficult to ask the parents to monitor a child suffering from asthma for a long period to find personal best PEFR since their knowledge about this technical aspect is limited. Hence for the practical purposes, the availability of PEFR nomogram or the prediction equation for PEFR based on height is advisable.

Studies of PEFR in Pediatric age groups have been done in certain cities in India and normal curves have been plotted. The studies have been confined to a particular geographical area or city and extrapolation of the studies to include children all over India would be inappropriate. No data is available about peak expiratory flow rate in and around Madurai District. Hence this study aims to construct a normal peak expiratory flow curve in both sexes in the age group of 5-12 years according to height from Madurai district.

METHODS

In this descriptive study 961 healthy children (493 boys and 468 girls) were randomly selected from six schools of Madurai district for a period of two years from January 2011 to December 2012.These children represent a sizeable proportion of both the rural and urban school children from Madurai.

Inclusion criteria

- School children aged 5-12 years of both sexes.

Exclusion criteria[5]

- H/o cough, cold, fever in the past 3 weeks,
- H/o wheeze in the past,
- H/o any significant drug intake in the past 1 week,
- H/o exercise induced asthma in the past,
- H/o any significant systemic illness,
- Children with muscular weakness. Severe pallor, clubbing, cyanosis, pedal edema, chest, spine abnormalities.

Institutional ethical committee approval was obtained before the commencement of the study. Proper consent was taken from the parents, school authorities before starting the study.

Age was taken as the completed years as per the school records. The children were subjected to full clinical assessment. The anthropometric measurements taken were height and weight. Weight was measured in kilograms (kg) using a standard electronic weighing machine. Weight was taken without footwear and with light clothes. Weighing machine was kept on absolutely flat surface and was calibrated before taking measurements. Accuracy of the weighing machine was up to 50 grams. Any fraction of weight thus measured was corrected to the nearest kilogram. Standing height was measured by making the child to stand against a fixed calibrated stadiometer with adjustable headrest. Height was measured without footwear, with the children standing erect, looking forward with feet closed, back of head and body touching the stadiometer. The measured height was then corrected to the nearest centimetre. Body surface area was calculated from measured height, weight by using Mosteller's formula. BSA (m^2) = $\sqrt{}$ height (cm) x weight (kg) /3600).

PEFR was measured by EU scale peak flow meter (60-800 l/min). It is a plastic cylindrical tube with a graduated scale on the surface and a mouthpiece. Graduation starts with 60 l/min to 800 l/min with accuracy of 10 l/min. Indicator of PEFR remains in place of reading unless brought back manually by the operator. All the measurements of PEFR are taken in the standing position. The purpose of the test and procedure was explained to the children. Then the procedure was demonstrated in detail so as to familiarize them with the procedure and to get their full cooperation.

Each child was told to take a deep breath and then blow into peak flow meter as hard and as fast as possible through mouthpiece and was closely watched to ensure that he/she maintained an airtight seal between their lips and the mouthpiece of the instrument. The procedure was repeated thrice and the highest value of these 3 readings

was taken as the observed PEFR.[6] Disposable mouth pieces were used for recording the PEFR.

Statistical analysis

Statistical analysis was done using the SPSS (statistical package for social science). Statistical methods used were Karl Pearson's correlation coefficient, student t test, P-value and linear regression analysis. Linear regression analysis was performed using age, weight, height and body surface area as independent variables and PEFR as the dependent variable. Prediction equation for PEFR was derived by using both univariate and multiple regression analysis. Since the difference in PEFR between boys and girls at any given height in the age group studied was small but statistically significant, data was analyzed both as a whole sample and separately for boys and girls and separate nomograms relating PEFR to height for boys and girls were constructed using the data.

RESULTS

A total of 961 children (5-12years) participated in the study. Data collected were analyzed with respect to age, weight, height and body surface area. Table 1 shows the distribution of weight, height, body surface area and PEFR across age between the two genders. The mean PEFR values of boys were found to be higher than that of the girls in all age groups. The correlation between the independent variables such as age, height, weight, BSA and the dependent variable i.e. PEFR was assessed both individually and as a group. The correlation analysis was done separately for boys and girls and for the whole sample also. The coefficient of correlation (r) was calculated for all the variables. The statistical significance of the correlation was assessed using the p-value. Table 1 shows linear relationship of PEFR with study variables for the girls and boys separately. Table 2 shows statistically significant positive correlation (p<0.001) between the study variables such as age, weight, height, body surface area and the outcome variable PEFR in the whole study sample and the individual sexes. Though the

correlation between age, weight, body surface area and PEFR was found to be significantly positive, highest positive correlation was observed between height and PEFR both in whole sample (r= 0.780) and among both genders boys (r=0.793, p<0.001),girls (r=0.762, p<0.001)).Table 2 shows correlation coefficients between the studied variables for the girls, boys and entire sample.

Regression analysis was done for all the variables in the studied sample collectively and also separately for both genders. Regression coefficients (R) were calculated for all the studied independent variables i.e. age, weight, height and Body surface area as shown in Table 3. Table 3 shows regression analysis of PEFR with individual variables for boys, girls and for the entire sample. The t-value was used to evaluate the significance of the regression coefficients. Regression coefficients were found be statistically significant in all cases (P <0.001). R-square values were used to explain the variabilities in the PEFR values. The coefficient of regression of age to PEFR was statistically significant. In the whole sample 55% of variability in PEFR was explained by age alone, whereas 52.9% and 57.2 % of variability were explained in boys and girls respectively. 45.3% of variability in PEFR in the whole study sample was explained by weight alone with 44.1% of variability among boys and 46.9% of variability among girls and it was the least to show positive correlation with PEFR among the studied variables. BSA showed a statistically significant co-efficient of regression. BSA had shown 52.8% of the variability in PEFR in the whole sample, 52.9% and 57.2% of variability in the boys and girls groups respectively.

Height had shown the maximum positive correlation to PEFR in both boys and girls. The co-efficient of regression derived for height was found to be highly statistically significant both in boys and girls. Height alone explained 60.8% of variability in PEFR in the whole study sample, whereas 52.7% and 57.9% of variability in PEFR were explained by height in boys and girls respectively.

Table 1: Distribution of variables.

Age	Weight (in kg)		Height (in cm)		Body surface area (in m²)		PEFR (in L/min)	
	Girls (n=493)	Boys (n=468)	Girls (n=493)	Boys (n=468)	Girls (n=493)	Boys (n=468)	Girls (n=493)	Boys (n=468)
5	15.27±2.19	15.29±2.19	102.9±3.97	107.2±6.62	0.67±0.06	0.69±0.07	91.4	106
6	15.27±2.49	15.27±2.49	106.61±6.58	109.12±5.9	0.69±0.07	0.71±0.06	102.1	112.8
7	18.4±3.19	18.4±3.19	115.61±5.4	115.57±5.98	0.77±0.08	0.78±0.08	134.5	137.9
8	20.55±3.12	20.55±3.12	119.92±5.58	120.72±6.57	0.83±0.08	0.83±0.09	153.3	160.8
9	21.04±4.67	21.04±4.66	124.01±7.83	124.89±6.24	0.85±0.11	0.86±0.09	177.9	199.1
10	24.1±3.94	24.1±3.94	128.3±6.42	132.2±7.12	0.92±0.09	0.97±0.1	185.9	207.7
11	28.27±6.48	28.27±6.48	134.09±6.97	134.02±6.76	1.02±0.14	1±0.11	200.9	210.5
12	32.45±6.82	32.45±6.83	139.14±7.33	139.32±7.1	1.12±0.14	1.1±0.13	213.5	223

Mean± Standard deviation

Table 2: Statistical correlation of variables with PEFR.

	Girls		Boys		Total	
	Coefficient of correlation(r)	Statistical significance (p)	Coefficient of correlation(r)	Statistical significance (p)	Coefficient of correlation(r)	Statistical significance (p)
Age	0.728	<0.001	0.756	<0.001	0.741	<0.001
Weight	0.664	<0.001	0.685	<0.001	0.673	<0.001
Height	0.762	<0.001	0.793	<0.001	0.780	<0.001
BSA	0.717	<0.001	0.736	<0.001	0.726	<0.001

BSA-Body surface area, PEFR- Peak expiratory flow rate.

Table 3: Univariate analysis.

Variable	Samples	Regression equation	P-value	R	R²
Age	Boys	PEFR =17.07(age in years) +23.99	<0.001	0.728	52.9%
	Girls	PEFR = 17.4(age in years) +9.79	<0.001	0.756	57.2%
	Whole sample	PEFR = 17.49(age in years) +9.79	<0.001	0.741	55%
Weight	Boys	PEFR =4.85(weight in kg) +68.51	<0.001	0.664	44.1%
	Girls	PEFR = 4.52(weight in kg) +64.07	<0.001	0.685	46.9%
	Whole sample	PEFR = 4.73(weight in kg) +65.5	<0.001	0.673	45.3%
Height	Boys	PEFR =3.12(height in cm)-211.85	<0.001	0.762	52.7%
	Girls	PEFR = 3.07(height in cm)-212.30	<0.001	0.793	57.9%
	Whole sample	PEFR = 3.13(height in cm)-216.22	<0.001	0.780	60.8%
BSA	Girls	PEFR = 214.3(BSA in m²)-11.73	<0.001	0.728	52.9%
	Boys	PEFR =200.52 (BSA in m²)-9.83	<0.001	0.756	57.2%
	Whole sample	PEFR =209.503 (BSA in m²)-12.48	<0.001	0.726	52.8%

BSA-Body surface area, P value -Statistical significance, R-Regression value, R² -variability.

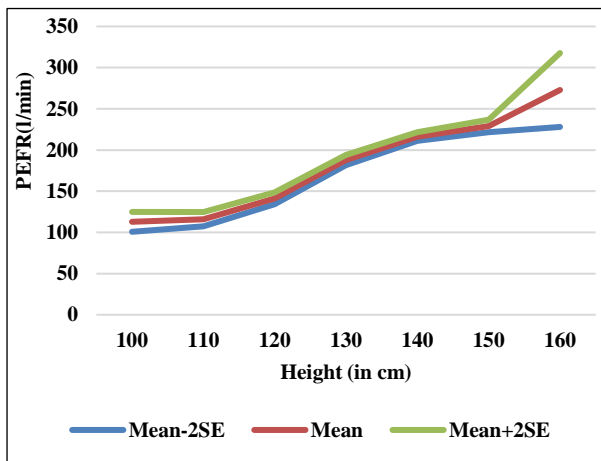**Figure 1: Height based PEFR nomogram for boys (5-12 years).**

Figure 2: Height based PEFR nomogram for girls (5-12 years).

Since height showed maximum positive correlation and also the best co-efficient of regression, a regression equation was used to construct a prediction tool for both genders where height was the independent variable and PEFR was the dependent variable as shown in (Figure 1 and 2) for boys and girls respectively. The predicted or the derived PEFR may be used as the normal value for a child of a given height.
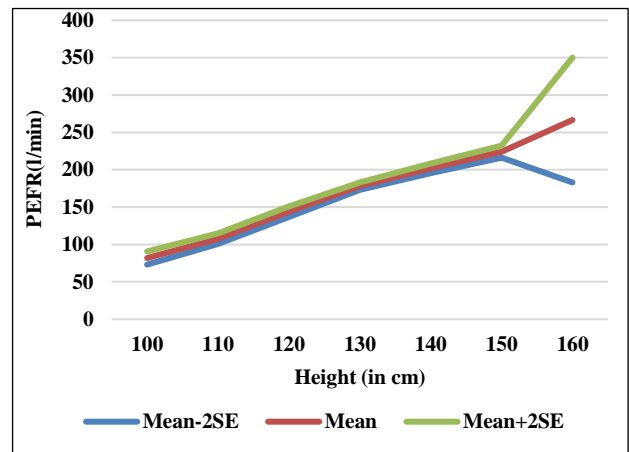
Figure 1 shows the PEFR nomogram from various heights for boys (5-12 years) The upper and lower levels denote the +2 SE (+95%) and -2 SE (-95%) around the mean respectively. Middle line denotes the mean PEFR. The mean PEFR value was plotted using the regression equation PEFR=3.12 (height in cm)- 211.85 r =+0.0.762, P<0.001. Figure 2 shows the PEFR nomogram from various heights for girls (5-12 years) The upper and lower

levels denote the+2 SE (+95%) and -2 SE (-95%) around the mean respectively. Middle line denotes the mean PEFR. The mean PEFR value was plotted using the regression equation PEFR=3.07 (height in cm)-212.30, r= +0.793, P < 0.001.

Multiple regression equation was found to be

- For boys:
  PEFR=20.7(age)+1.43(height)+0.95(weight)-158,
- For girls: PEFR=11.6 (age)+2.34 (height) +0.31(weight)-189.

DISCUSSION

There are a number of non-equivalent scales used in the measurement of PEFR

- Wright scale,
- EN 13826 or EU scale,
- ATS (American thoracic society) scale.

In this study, EU scale was used which is a log-linear scale and measures peak expiratory flow rate in liters/minute.[7] The peak flow meter used in present study is the breath-o-meter, manufactured and distributed by Cipla respiratory, India. It is a handy, compact device that has gradations in liters per minute. It's scale ranges from 60 l/min to 800 l/min. The EU scale is a highly sensitive and accurate flow measuring technique, which minimizes any error in the values obtained using the earlier Wright's scale. The predicted value of PEFR was given in the pamphlet of the instrument. The values plotted in that pamphlet are mentioned in the Table 4. Authors felt inconvenient to use this chart as authors were unable to calculate normal PEFR for each centimeter of the height. Subsequently on searching the literatures authors found that PEFR is dependent on various biological factors like height, weight, age, body surface area, and chest circumference.[8] Even though statistical correlation is established between these independent variables and PEFR, height was found to be statistically correlating well compared to the other parameters.[10]

Table 4: Reference value in the instrument.

PEFR for various heights								
Height(cm)	85	90	95	100	105	110	115	120	125
PEFR(l/min)	87	95	104	115	127	141	157	174	192
Height(cm)	130	135	140	145	150	1550	160	165	170
PEFR(l/min)	212	233	254	276	299	323	346	370	390

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So, height-based prediction equation is available for PEFR. But the known fact is that PEFR is variable to each race and ethnicity.

Table 5: Heterogenicity of PEFR.

Study	Observations on PEFR
Al-Dawood K, et al[1]	Saudi Arabian children <other Arab, Europe, North American children
Sagher FA, et al[9]	Libyan children >Europe and American children
Seo WH, et al[10]	Korean children <European and Sri lank and children >African, Turkish children
Mahajan KK, et al [11]	Haryana children >other state children
Parmar VR, et al[12]	North Indian children=western children
Singh HD, et al[13]	South Indian children <North Indian, western children

So, researchers went on doing studies for the establishment of local reference values of PEFR based on height worldwide. Some of the interesting observations in those studies are mentioned in the Table 5. The Table indicates the need for region specific local reference values of PEFR in each country. Indian studies showed higher PEFR values for north Indian children compared to south Indian children. In south Indian children, reference values for PEFR is available for the children of Tamil Nadu and Kerala in the literatures.[2] The representing samples were taken from Chennai and Palakad district respectively. In the present study statistical correlation was found between height, age, BSA, and weight in all groups. Weight is having less correlation coefficient compared to others. BSA was found to have good correlation that would need separate calculation by using précised formula. The age may be a biased one as it could have been wrongly given by the parents in the school records for various reasons. So, for practical purposes, the scientific judgement can be made possible by using height based predicted equations. Similar to the previous studies, present study also has highest correlation of PEFR with height by which authors also insist upon height based predicted equations for PEFR.[15] Boys had higher PEFR value than girls at a given height as like previous studies.[16]

The boys are taller than girls especially between 5-7 years of age in present study.

Table 6: Comparison of previous studies.

Study PEFR(l/min)	Height(cm)					
	120		**140**		**160**	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Swaminathan S et al[2] (Chennai)	205	193	286	272	368	350
Carson JWK et al[17] (Dublin)	250	244	344	332	469	457
Taksande A et al[18] (Maharashtra)	217.4	178.9	311.4	251.7	405	324.5
Malik SK et al[19] (Punjab)	222	216	320	314	418	412
Pulickal AS et al[20] (Kerala)	154.2	139.36	243.1	199.2	333.8	258.1
Present study (Madurai)	162.6	156.1	224.9	213.3	287.4	278.9

Table 6 comparing the PEFR for the children of Madurai district with children of Palakad district and Chennai, the present study group shows lower value .But the girls of Madurai district show higher PEFR values than the girls of Palakad district.[20] The probable reason could be the mean height of the female children from Madurai district is higher than that of the female children from Palakad district. PEFR values from Dublin (western) school, Punjab school children were at higher levels compared to present study.[17,19]

CONCLUSION

It is necessary to have separate reference value of PEFR for each region because of ethnic and environmental influences. So, regression equations and PEFR nomogram for Madurai district school children who belongs to both urban and rural areas were derived. Though BSA correlate well with PEFR in present study some difficulties exist in its practical application as BSA needs further formula-based calculation. So, predicted equation for PEFR based on age, height and weight for both genders was derived using these independent variables through multivariate regression analysis. Age may be falsely given in the school records or may be forgotten by uneducated parents and weight is having least correlation, correlating height alone as an independent predictor of PEFR is becoming ideal and the same was derived through univariate regression analysis. It is concluded that the prediction equations for PEFR obtained in this study can be used as local reference for the follow up of children with respiratory disorders in and around madurai district.

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REFERENCES

1. Al-Dawood K. Peak expiratory flow rate in Saudi schoolboys at Al-Khobar City, Saudi Arabia. Saudi Med J. 2000;21(6):561-4.
2. Swaminathan S, Venkatesan P, Mukunth R. Peak expiratory flow rate in South Indian children. Ind Paediatr. 1993;30(2):207-11.
3. Andrew H Liu. Childhood asthma. Behrman RE, Kleigman RM, eds. In: Nelson's textbook of paediatrics. 19th ed. Elsevier: Saunders company. USA. 2012;780-801.
4. Seaton A, Seaton D, Leiteh GA, eds. Epidemiology and respiratory diseases. In: Crofon and Douglas respirtory diseases, 4th ed. UK: Blackwell Science Oxford.1989:90.
5. Gardnner RM, Hankinson JL, Clausen JL, Crapo RO, Johnson RL, Epler GR. Standardization of spirometry 1987 update: statement of the American Thoracic Society. Am Rev Respir Dis. 1987;136:1285-98.
6. Ullah MI, Cuddhy V, Savoners KB, Addis GJ. How many blows really make an FEV1, FVC or PEFR. Thorax. 1983;38:113-8.
7. Kodgule RR, Singh V, Dhar R, Saicharan BG, Madas SJ, Gogtay JA, et al. Reference values for peak expiratory flow in Indian adult population using a European Union scale peak flow meter. J Postgraduate Med. 2014;60(2):123.
8. Jain SK, Kumar R, Sharma DA. Factors influencing peak expiratory flow rate (PEFR) in normal subjects-II. Lung Ind. 1983;1(3):92.
9. Sagher FA, Roushdy MA, Hweta AM. Peak, expiratory flow rate nomogram in Libyan school children. East Med Health J. 1999:5(3):560-3.

10. Seo WH, Ahn SH, Park SH, Kim J, Ahn KM, Ko BJ, Lee SI. The standard range of peak expiratory flow rates of Korean children. Asian Pac J Allerg Immunol. 2011;29(2):143-9.
11. Mahajan KK, Mahajan SK, Maini BK, Srivastava SC. Peak expiratory flow rate and its prediction formulae in Haryanavis. Indian J Physiol Pharmacol. 1984;28:319-25.
12. Parmar VR, Kumar L, Malik SK. Normal values of peak expiratory f low rate in healthy North Indian school children, 6-16 years of age. Indian Pediatr. 1977;14:591-4.
13. Singh HD, Peri S. Peak expiratory flow rate in South Indian children and adolescents. Indian Pediatr. 1978;15:473-8.
14. Shiyas KP, Gopi Mohan G. Factors affecting peak expiratory flow rates in children of 9-12 years of age. Int J Pediatr Res. 2017;4(11).
15. Paramesh H. Normal peak expirtory flow rate in urban and rural children. Indian J Pediatr. 2003;70(5):375.
16. Gharagozlo M, Khajooe V, Moin M, Rezvani M. Peak expiratory flow rate in healthy children from Tehran. IJMS. 2003;28(1):26-8.
17. Carson JWK, Hoey H, Taylor MRH. Growth and other factors affecting peak expiratory flow rate. Arch Dis Childhood. 1989;64:96-102.
18. Taksande A, Jain M, Vihekar K, Chadurvedi P. Peak expiratory flow rate of rural school children from Warda district, Maharashtra in India. World J Pediatr. 2008;4(3):211-4.
19. Malik SK, Jindal SK, Sharda PK, Banga N. Peak expiratory flow rate of healthy schoolboys from Punjab. Indian Peditr. 1981;18:517-21.
20. Pulickal AS, Fernandez GV. Peak expiratory flow rate in healthy rural south Indian school children preclicted from body height. Indian J Public Health. 2007:51(2):117-9.