A Study of Peak Expiratory Flow Rate in Children

Nagasireesha Challa[1], Venkatachalam Madras[2]

[1]Assistant Professor, [2]Professor, Department of Physiology, S. V. Medical College, Tirupati, Andhra Pradesh, INDIA.

Corresponidng Addresses:

[1]challanagasireesha@gmail.com, [2]chalam19madras@gmail.com

Research Article

Abstract: **Background:** A lot of age-specific variations in Peak Expiratory Flow Rate (PEFR) are expected in paediatrics age group compared to adults. Therefore availability of normal values for different age group is absolutely essential for logical interpretation of PEFR. Only few studies are available on ventilator functions for children of South Indians 7–12 years of Age. **Method:** One hundred and eighty apparently healthy school children (93 Male, 87 Female) from age group 7–12 years were included in the study. PEFR was measured in L/min with computarised spirometer, winspiroPRO. **Result:** Positive correlation was seen between age, height, weight, Body surface area, and PEFR. The regression equations for PEFR were determined for boys and girls separately. The prediction equation for PEFR based on Weight, height, age and BSA was PEFR for boys = 1.25(height) + 19.86(age) + 1.03(weight) – 164.55; PEFR for girls = 4.56(height) + 1.671(age) + 1.22(weight) – 451.09 In both male and female children, PEFR significantly increases ($p<0.001$) with height, weight, age, and Body Surface Area (BSA). **Conclusion:** PEFR is a reliable measurement, which can be used in South Indians for assessment of airway obstruction. Prediction formula is derived for use in this population.

Keywords: PEFR, Children, Indian, Height, Weight, Age, BSA.

Introduction

The peak expiratory flow rate (PEFR) measurement is a simple and reliable way of judging the degree of airway obstruction in various obstructive lung diseases, especially asthma.[1] The PEFR is a measurement dependent upon several variables including airway resistance, maximal voluntary muscular effort and the possible compressive effect of the manoeuvre on intrathoracic airways.[2, 3] Bronchial asthma, is one of the most common respiratory ailment in childhood and its prevalence is increasing over 3-fold in urban areas in two decades. Bronchial asthma is associated with frequent fluctuations in airway caliber and one of the earliest signs of an impending acute attack is a fall in the PEFR. Also, the response to the therapy can be monitored using serial PEFR measurements.[4] PEFR is used to screen and monitor the severity of asthma in the community, particularly when the prevalence of asthma and asthma-related hospital admissions are rising.[5] We would not diagnose and manage hypertension without measuring the blood pressure, and it is equally inappropriate to diagnose and manage respiratory disease without measurements of lung function.[6] The way daily assessment of urinary sugar can guide the treatment of diabetes mellitus, daily measurement of PEFR can be used as guideline for the treatment of bronchial asthma.[7] Nomograms predicting PEFR from height are available for western children.[8] Such information is available for North Indian[9] and South Indian adults[10] and North Indian Children living at sea level[11] and highlands[12] but no data is available for South Indian children.[1] India, being a subcontinent, changes in pulmonary functions can occur between children of South Indian origin and children of other regions.[13] From studies in adults, we know that lung volumes are smaller in South Indians as compared to North Indians and therefore it is important to have regional reference values.[1] It is essential to have normal pulmonary function data for south Indian children to interpret accurately the pulmonary function changes in childhood pulmonary diseases.[13] The objective of this study is to obtain PEFR values for healthy South Indian children.

Materials and Methods

The present study was conducted on 180 healthy children between 7 and 12 years from two schools in Tirupati town. The Ethical Committee of the Institute approved the design and protocol. The purpose and objectives of the study were explained to the subjects, parents and the school management and their consent was obtained.In the proposed study, 7-12 years children are included. Among them 93 are boys and 87 are girls. A preliminary clinical evaluation was done with history, general physical examination and systemic examination in all the children. Children with major medical illness and those having acute respiratory infections for past 2 weeks of the study were excluded. Children with asthma, persistent cough and atopy were excluded. Consent forms to be filled in by the parents were given to all the children. To determine PEFR of children, the spirometry computer software (winspiro PRO) is used. Winspiro PRO is a database for the management of spirometry and oximetry testing made with any compatible spirometer. Spirobank USB version (Medical International Research; MIR) is used which measures the most important spirometric parameters VC, IVC, FVC, FEV1, FEV6, FEV1/FVC%, PEF, FEF25-75%, ELA (Lung age estimation). All the measurement functions are carried out by the spirometer which can be connected to the software. The types of oximetry tests available range from the simple measurement of the oxygen saturation plus the heart rate, to a sleep monitoring test to evaluate the desaturation events and sleep apnea events, as well as a walking test which follows the international guidelines, which allows the determination of specific parameters (such as the calculation of the area under the curve derived from the reduction in the percentage of SpO2 during the walking phase compared to the base value: AUC/Distance) which give a precise and complete picture of the health of the patient. WinspiroPRO is also invaluable to create a specific database for each patient and to compare the tests made by each patient, thus enabling to manage the patients within the database. Following every test of forced expiration, the instrument makes a quality control check to verify the validity of the test made and, compare the principal measured parameters with the respective normal (predicted) values. This interpretation of the index follows the latest ATS standards. The software gives a graphic presentation of a series of parameters relating to respiratory function. The spirometer uses a turbine flow sensor and an internal temperature sensor for BTPS conversion. The unit is provided with built-in quality assurance features, based on American Thoracic Society (ATS) criteria. The spirometry software displays real-time flow-volume and volume-time curves and produces built-in quality assurance prompts, which are displayed after each unacceptable blow (eg. slow start, abrupt end, short blow). Date of birth (DOB) of the child is entered directly into the computer and the age is calculated from the date of testing and their DOB. Ethnicity of the child is entered. The children's height is recorded in centimeters with shoes off and weight in kilograms. When the child's height and weight are entered into the computer, it will calculate and display their body surface area (BSA) in m^2. Three test blows are done in the standing position with the neck not flexed and with a nose clip and disposable mouth pieces. Children were instructed to inhale completely before inserting the mouthpiece while holding the breath, then exhales forcefully into the spirometer for as long as they could. According to ATS recommendations, a forced expiratory time (FET) of <6 seconds is acceptable in children. The highest value reached was taken as the PEFR for that child. The spirometer gives the predicted values and also calculates the percentage of the predicted normal values because they have reference data already programmed into them. The data so obtained was entered in a suitable master chart and analyzed statistically using the Statistical Package for the Social Sciences (SPSS). Linear regression equations for PEFR in relation to height, weight, age and BSA were determined for boys and girls separately.

Results

A total of 180 children of age group 7-12 years comprising 93 males and 87 females were used for determination of PEFR. 51.7% children were male and 48.3% were females. The sex ratio between male and female children was 1.06:1(nearly equal). Table-1 shows variation of PEFR in both male and female subjects according to their height. In both the genders height and PEFR showed significant correlations $p<0.001$. Table-2 shows variation of PEFR in male and female children according to their weight. In both genders weight and PEFR showed significant correlation with each other $p<0.001$. Table-3 shows variation of PEFR in both male and female subjects according to their age. In both the genders age and PEFR shows significant correlations $p<0.001$. Table-4 shows variation of PEFR with body surface area in both male and female subjects. BSA and PEFR shows significant correlations in both the genders $p<0.001$. Highly significant correlation was observed in all anthropometric parameters but height correlated with PEFR more than other parameters. Since PEFR showed strong linear relationship of height, weight and age, multiple regression equation was chosen for further analysis.

Table 1: Mean values of PEFR in subjects according to their height

Height (cm)	Males(n=93)		Females(n=87)	
	No.	PEFR(L/min)	No.	PEFR(L/min)
116-125	8	183.8 ± 69.4	6	154.0 ± 28.7
126-135	25	206.8 ± 45.3	12	194.4 ± 50.6
136-145	50	239.5 ± 45.7	35	253.9 ± 36.3
146-155	10	285.8 ± 25.8	30	295.9 ± 56.4
156-165	--	---	4	354.0 ± 18.7
	r=0.90;p<0.001		r=0.89;p< 0.001	

Table 2: Mean values of PEFR in subjects according to their weight

Weight (Kg)	Males(n=93)		Females(n=87)	
	No.	**PEFR(L/min)**	**No.**	**PEFR(L/min)**
16-25	24	191.4 ± 47.5	12	179.6 ± 40.0
26-35	50	241.4 ± 44.6	35	240.5 ± 57.4
36-45	15	246.1 ± 58.9	33	297.0 ± 50.1
46-55	4	279.8 ± 34.5	6	294.8 ± 45.3
56-65	--	---	1	297.0 ± 0.00
	r=0.78;p<0.001		r=0.82;p< 0.001	

Table 3: Mean values of PEFR in subjects according to their age

Age (years)	Males(n=93)		Females(n=87)	
	No.	PEFR(L/min)	No.	PEFR(L/min)
7	7	180.8 ± 29.8	5	150.0 ± 49.5
8	16	168.4 ± 36.7	5	192.6 ± 38.2
9	15	215.1 ± 39.3	7	225.3 ± 65.0
10	29	248.9 ± 40.5	20	262.2 ± 54.2
11	17	275.3 ± 33.6	42	273.5 ± 55.9
12	9	265.2 ± 34.0	8	302.0 ± 61.2
	r=0.86;p<0.001		r=0.89;p< 0.001	

Table 4: Mean values of PEFR in subjects according to their BSA

BSA	Males(n=93)		Females(n=87)	
	No.	PEFR(L/min)	No.	PEFR(L/min)
<1	23	191.6 ± 48.0	11	169.2 ± 35.0
1 – 1.20	50	238.5 ± 44.6	26	222.3 ± 40.2
1.20 – 1.40	17	254.0 ± 57.5	42	293.9 ± 49.8
> 1.40	3	273.6 ± 39.5	8	306.3 ± 49.7
	r=0.50;p<0.001		r=0.71;p< 0.001	

Table 5: Multiple Regression equations to predict PEFR in boys and girls based on age, height (cm) and weight (kg)

Group	Intercept	Age	Height	Weight
Boys (n=93)	-164.5582	19.86	1.2507	1.0330
Girls (n=87)	-451.0933	1.671	4.5556	1.2223

The regression equations in our study are:

PEFR for boys = 1.25(height) + 19.86(age) + 1.03(weight) – 164.55

PEFR for girls = 4.56(height) + 1.671(age) + 1.22(weight) – 451.09

Discussion

Peak Expiratory Flow Rate (PEFR) is one of the useful and simple parameters for assessing the lung function status in general population and also for making a diagnosis and monitoring treatment of patients with bronchial asthma and chronic obstructive lung disease.[14, 15] PEF is determined in large part by the lung volume, lung elastic recoil, and muscular effort.[16] Asthma is an important health problem in school-aged children and schools seemed to be an obvious site to find and work with children whose asthma was under-recognized and under-treated. [17] Ethnic variations, physical activity, environmental conditions and altitude of dwelling, tobacco smoking and changes in age, height, sex and socioeconomic status can affect normal values of pulmonary function. India is a subcontinent with varying geography and with a large multi-ethnic population.[18] Regional differences in lung function in healthy Indians can thus be expected. Therefore, in order to have accurate prediction formulae for measurements of lung function, pulmonary function studies should be carried out in various parts of India. The purpose of this study was to derive normative standards for lung function in children aged 7 to 12 years residing in Tirupati town and to calculate regression equations. In present study we studied PEFR of 180 healthy, normal school children between 7-12 years. PEFR showed a linear positive correlation with height (r=0.90, p<0.001 for boys and r=0.82, p<0.001 for girls) age (r=0.86, p<0.001 for boys and r=0.89, p<0.001 for girls), weight (r=0.78, p<0.001 for boys and r=0.82, p<0.001 for girls) and BSA (r=0.5, p<0.001 for boys and r=0.71, p<0.001 for girls).

Regression Equations

PEFR calculated using prediction equations developed in some studies for a 10 year-old, 140 cm tall with 34 kg weight child.

S.No.	Study	Prediction Equation	PEFR (l/min)
1	Vijayan *et al.* (2000)	M=0.063(Ht)+0.061(Wt)-6.784 F=0.02(Ht)+0.070(Wt)-1.613	246.6 214
2	Swaminathan, Venkatesan and Mukunthan(1993)	M=4.08(Ht)-284.55 F=3.92(Ht)-277.01 M=2.04(Ht)+4.78(A)+2.73(Wt)-134.29 F=2.03(Ht)+3.18(A)+2.71(Wt)-132.92	286.6 271.8 291.9 275
3	Parmar, Kumar and Malik (1977)	M=5.058(Ht)-408.664 F=2.03(Ht)-273.45	299 312
4	Sharma *et al.* (1997)	M=0.0278(Ht)+0.1307(A)+0.0233(Wt)-2.52 F=0.2382(A)+0.0299(Wt)-0.1716	208 193.6
5	Nair *et al.* (1997)	M=1.2(A)+1.971(Ht)-83.490	204
6	Chowgule, Shetye and Parmar (1995)	M=0.0823(Ht)-6.9387 F=0.0704(Ht)-5.5233 M=0.0706(Ht)+0.0706(Wt)-5.8592 F=0.0303(Ht)+0.0308(Wt)-2.3075	274 259 385.5 252
7	Pande *et al.* (1997)	M=11.972(A)+2.969(Ht)-274.628 F=7.843(A)+2.905(Ht)-243.833	260 241
8	Malik *et al.* (1981 and 1982)	M=4.92(Ht)-368.89 F=4.9(Ht)-371.8	319.9 314.2
9	Singh and Peri (1978)	M=5.00(Ht)-420.4 F=5.03(Ht)-434.4 M=24.46(A)-25.5 F=24.47(A)-33.3 M=10.75(Wt)-46.0 F=8.611(Wt)-7.8	279.6 269.8 219 211.4 319 285
10	Godfrey *et al.* [91] (1970)	M=5.288(Ht)-422.76 F=5.278(Ht)-422.34	317.56 316.6
11	Present study	M=1.25(Ht)+19.86(A)+1.03(Wt)-164.55 F=4.56(Ht)+1.671(A)+1.22(Wt)-451.09	244 245.5

In the present study, the PEFR of children are similar to that of South Indian children of other studies and lower than the North Indian children and White American school children. These differences are probably attributable to ethnic and nutritional factors.

Environmental factors such as overcrowding, recurrent chest infections and atmospheric pollution may be responsible for these findings. The lower PEFR values in Indian children could be an effect of lower lung volumes due to a smaller chest size. Within India also, ethnic differences have been shown to account for differences in PEFR and therefore it is important to establish reference values for each region.

Conclusion

There is a statistically significant increase in PEFR along with an increase in height, age, weight and BSA. Height is the best predictor. Age and weight also correlate with PEFR but less predictive in comparison to height.The PEFR of children are similar to that of South Indian children of other studies and lower than the North Indian children and White American school children.

References

1. Swaminathan S, Venkatesan P, Mukunthan R. "Peak expiratory flow rate in Indian Children" *Indian Pediatrics 1993; 30: 207-211.*
2. Primhak RA, Biggins JD, Tsanakas JN, Hatzimichael A, Milner RDG, Karpouzas JG. "Factors affecting peak expiratory flow rate in children" *Br.J.Dis Chest 1984; 78: 26-35.*
3. Pande JN, Mohan A, Khilnani S, and Khilani GC. "Peak Expiratory Flow Rate in School – Going Children" *Indian J Chest Dis Allied Sci 1997; 39: 87-95.*
4. Paramesh H, "Normal Peak Expiratory Flow Rate in Urban and Rural Children". *Indian J of Pediatr 2003; 70 (5): 375-377.*
5. Amar Taksande, Manish Jain, Krishna Vilhekar, Pushpa Chaturvedi. "Peak expiratory flow rate of rural school children from Wardha district, Maharashtra in India". World J Pediatr 2008; 4(3): 211-214.
6. PHC180 Booker R (2008) Spirometry in primary care. Primary Health Care. 18,10,37-47.
7. Soumya Swaminathan. Pulmonary Function Testing in Office Practice. Indian J Pediatr 1999; 66: 905-914.
8. M.Rosenthal, SH Bain, D.Cramer, P.Helms, D.Denison, A.Bush and JO Warner. "Lung function in white children aged 4 to 19 years: I – Spirometry". *Thorax 1993; 48: 794-802.*
9. Malik SK, Jindal SK, Jindal V, Bansal S. Peak expiratory flow in healthy adults. Indian J Chest Dis 1975, 7: 167-171.
10. Natarajan S, Radha K. Peak expiratory flow rate in normal South Indians. . Indian J Chest Dis Allied Sci 1978, 20: 178-182.
11. S.K. Malik, S.K. Jindal, P.K. Sharada and N. Banga. "Peak expiratory flow rate of healthy school boys from Punjab". *Indian Pediatrics 1981; 18: 517-521.*
12. Kashyap S., Puri DS, Bansal SK. "Peak expiratory flow rates of healthy tribal children living at high altitudes in the Himalayas". *Indian Pediatrics 1992; 29: 283-286.*
13. Vijayan VK, Reetha AM, Kuppurao KV, Venkatesan P and Thilakavathy S. "Pulmonary Function in Normal South Indian Children Aged 7 to 19 Years" *Indian J Chest Dis Allied Sci 2000; 42: 147-156.*
14. Neeraj Mathur, Subhodh Kumar Rastogi, C.Kesavachandran and G.G.Agarwal. "Prediction models for peak expiratory flow rates in North Indian male population based on ordinary and weighted least square estimation". Current Science 2007; 93(7):959-963.
15. Rajendra Prasad, S.K.Verma, G.G.Agarwal and Neeraj Mathur. "Prediction Model for Peak Expiratory Flow in North Indian Population". The Indian Journal of Chest Diseases and Allied Sciences 2006; 48:103-106.
16. Tariq Omar, Husain Alawadi, Ayman O.Soubani and George E.Tzelepis. "Peak Expiratory Flow with or without a brief postinspiratory pause". Chest 2005; 128:442-445.
17. Barbara P.Yawn. "Asthma screening, case identification and treatment in school-based programs". Curr Opin Pulm Med 2006; 12:17-20.
18. V K Vijayan, K V Kuppurao, P Venkatesan, K Sankaran, R Prabhakar. "Pulmonary function in healthy young adult Indians in Madras". Thorax 1990; 45:611-615.