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Original Research Article

Regression equations for peak expiratory flow rate in children aged 5-10 years of Western Maharashtra, India: a cross-sectional study

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ABSTRACT

Background: Incidence of pulmonary diseases in urban children is on the rise. Peak expiratory flow rate, a component of pulmonary function tests, is a useful measure for initial pulmonary assessment. It is easily implementable on large population due to its simplicity. Studies presenting such data for Indian children are severely lacking, as PEFR is anthropometric, population and region specific. The present study aimed to establish an equation for predicting PEFR in urban children in Pune city in western Maharashtra, India.
Methods: The cross-sectional study was done in Pune, Maharashtra, India. Children from different schools were selected by cluster sampling. The number of participants screened was 2100 of which 1760 were selected. Best of three readings of PEFR was recorded for each child using an EU Scale Peak Flow meter (Breath-O meter, Cipla). Anthropometric data like height, weight, chest expansion, waist/hip ratio were measured and BMI was calculated along with PEFR of each child.
Results: Out of the 1760 children included in the study 933 (53%) were boys and 827 (47%) were girls. The stepwise regression analyses were carried out using age, height, weight and waist/hip ratio as predictor variables.
Conclusions: Final regression equation was derived using height. Approximately 80% of the data was used for prediction of regression equation and remaining 20% data was used as a control group to validate the derived equation. The regression equation formulated shall offer a predicted PEFR value as guideline for healthcare workers in Pune city, Maharashtra, India.

Keywords: Pulmonary function, Urban children, Breath-O meter, India, PEFR, Regression equation

INTRODUCTION

The incidence of pulmonary diseases in children of urban metropolitan cities is steadily increasing across the world with each passing year. Major reason being urbanization which has emerged as a global trend in the 21st century. This is especially true for a developing country like India, where there is a constant shift of population from the villages having cleaner environment to the polluted urban areas. According to WHO, 70% of people globally will live in urban areas by 2050.[1] Most of the pulmonary conditions affecting the younger population at large are essentially easily identifiable and treatable. This creates an urgent need for quick, effective diagnostic tests to identifying those at risk. These tests will help in early detection and hopefully, prevention of progression of pulmonary diseases. The gold standard assessment tool for pulmonary conditions is spirometry, commonly called

Pulmonary Function Tests (PFTs).[2] The information obtained by spirometry will help in management of respiratory tract problems in paediatric and adult population by indicating how well lungs are responding to medical and physiotherapy treatments. However, spirometry is a relatively expensive investigation, available only in hospitals and specialized respiratory and asthma clinics. Therefore, its accessibility and utilization by healthcare workers in routine screening is difficult; not only with respect to the cost but also the technical knowledge required.

A component of PFT which is simpler to assess is the Peak Expiratory Flow Rate (PEFR). It is the maximal flow achieved during an exhalation delivered with maximal force starting from the level of maximal lung inflation.[3] PEFR helps assess & quantify the degree of airway obstruction.[3] It also forms the basis for diagnosis and self-management of asthma & other obstructive airway diseases.[4] PEFR is measured using a standardized Peak Flow Meter (PFM) in litres/min. The PFM is easy-to-use, readily available, suitably accurate, very reliable and validated device for measuring PEFR.[3] It can be used by healthcare workers with ease in routine clinical practice. Despite this PEFR is yet to gain popularity as a tool for assessment of pulmonary health especially in developing countries. Height, weight, race, past & present health of the individual and those around, geographical location, pollution and socio-economic status are responsible for variations in PEFR.[5] This variability creates a need for region specific data for PEFR. Therefore, different regions should have their own normative data of PEFR. India is also geographically and culturally a very diverse country with its citizens leading a varied lifestyle (at home and outside).

The normative data for PEFR has been researched internationally for children.[6] This data however is not applicable to Indian population by virtue of the above-mentioned variables. Studies regarding normative data of PEFR for Indian paediatric population are either very old or for a few select regions only.[7-9] Children of urban and rural regions have varied living and playing habits, which influence & confound the risk factors for respiratory conditions. Thus, the data for rural and urban children for PEFR needs to be separately established.[10] A step towards establishing norms of rural and urban children for PEFR, in the form of cross-sectional study was the need of the hour. Based in an urban setting, the researchers assessed the PEFR of normal children with the help of this study.

METHODS

Study type, location and duration

It is an observational, analytical cross sectional study conducted at Department of Cardiovacular and Pulmonary Physiotherapy, Sancheti College of Physiotherapy, Pune, Maharashtra, India. Study done in seven schools across Pune city, from June 2013 to January 2015.

Inclusion criteria

Inclusion criteria were; Age group of 5-10 years, Healthy, asymptomatic children with regards to cardiorespiratory system and Urban city dwelling children, residing in the same city for at least 5 years.

Exclusion criteria

Exclusion criteria were; Congenital or acquired cardiac/respiratory conditions, Trauma &/or surgeries to rib cage or thoracic spine, any reported or known cardiorespiratory or musculoskeletal pathology, Children with history of hospitalization due to cardiac or pulmonary disorders in the past 2-3 years and having any respiratory infection symptoms at time of assessment, e.g., Cough or cold.

Procedure

Schools of Pune city were selected by cluster sampling. This was done by dividing the city into four geographical zones. Three schools were randomly selected from each zone. Thus total schools for data collection were twelve. On approaching these schools permission was given by only seven schools. Then informed written consent was taken from the school authorities and later from parent of each child participating in the study. This was done by providing prior consent forms to the class teacher to be filled in by the parents on one or two days before the day of data collection. On the day of assessment only those students whose parental consent was provided and were in accordance with the inclusion criteria were included. The outcome measures for each child were peak expiratory flow rate measured using the Breath-O meter with EU Scale (Cipla Ltd.) & anthropometric measurements such as height, weight, BMI.[11] Before data collection the students were gathered in a group of 10 or 15 and explained the procedure along with demonstration of how they are expected to use the peak flow meter. Any questions regarding the same were answered. Also during the study first anthropometric data was collected followed by PEFR. During the PEFR measurement, the child was asked to take a deep breath and blow as hard & fast as he/she could into the peak flow meter device. The child was given sufficient trial runs and encouraged to blow harder each time and the best of three readings was documented. BMI was also later calculated. It was seen that each of schools had approximately 300 students from age group 5-10 yrs. Thus, a total of 2100 children from seven schools were the sample size before the study started. However, the actual students included in final study were 1760 with drop outs of 340 students. The reason for dropping out of the study was found to be due to parental non-consent, acute illness of the child at the time of study, being a part of the exclusion criteria or absence of child at the time of data collection. The study thus included 827 girls and 933 boys. The data collection procedure is schematically represented in Figure 1.

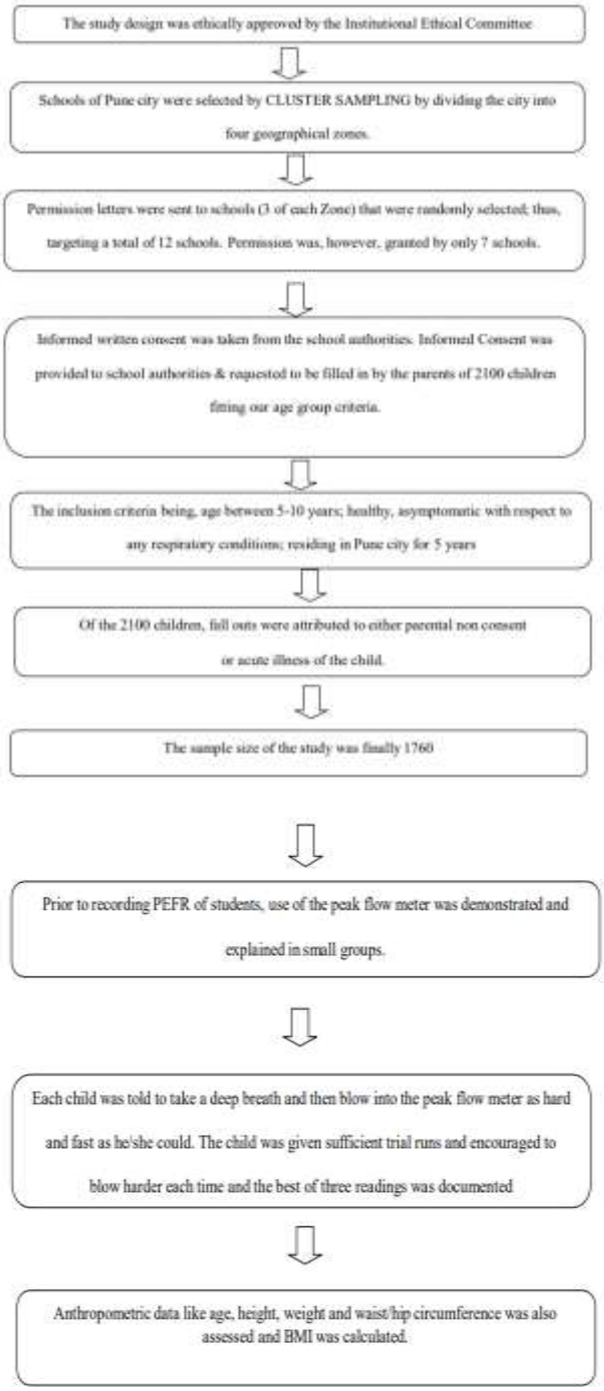

Figure 1: Schematic representation of data collection done in the study.

Statistical analysis

The parametric data was analysed using the Pearson's coefficient of correlation: **r** and $\mathbf{r^2}$ were calculated. The height, weight and BMI of each age group was correlated with the recorded PEFR. Confidence interval was set at 95% and p value $\leq$0.05. We used stepwise regression analysis to assess if any variable had the greatest predictive capacity for PEFR. The analyses were derived using age, height, weight and BMI as predictor variables and it revealed that height is the most significant factor for predicting PEFR values for boys as well as girls. Approximately 80% of the data was used for prediction of regression equation. The remaining 20% data was used as a control group to validate the derived equation. Using the derived equation, predicted values were calculated for each control subjects. Paired sample t test was used to compare the mean of each set of measured and predicted values. Out of 1760 students 933 were boys and 827 were girls. From the 933 boy's approximately 80% i.e., 755 were selected for predicting regression equation. Similarly, from the 827 girl's 80% i.e., 666 were selected for predicting regression equation. Final Regression equations were then calculated for boys & girls.

RESULTS

A total of 1760 healthy children out of 2100 fulfilled study criteria. 933 (53%) boys and 827 (47%) girls were assessed. The mean age of the children was 7.62±1.55 years. The mean weight of the children was 23.43±7.01 kg. Mean height of the children was 123.64±10.37 cm. Graphical representation of mean PEFR values in age group of 5-10 years is shown in (Figure 2). Gender wise graphical representation of mean PEFR values in 5-10 years age group is shown in (Figure 3). The final regression equations for predicting PEFR in boys and girls are as follows: For boys;

$$\boldsymbol{PEFR}\ (\boldsymbol{lit/min}) = -\mathbf{209.002} + \mathbf{2.982} * \boldsymbol{Height}\ (\boldsymbol{cm})$$

For girls,

$$\boldsymbol{PEFR}\ (\boldsymbol{lit/min}) = -\mathbf{124.212} + \mathbf{2.163} * \boldsymbol{Height}\ (\boldsymbol{cm})$$

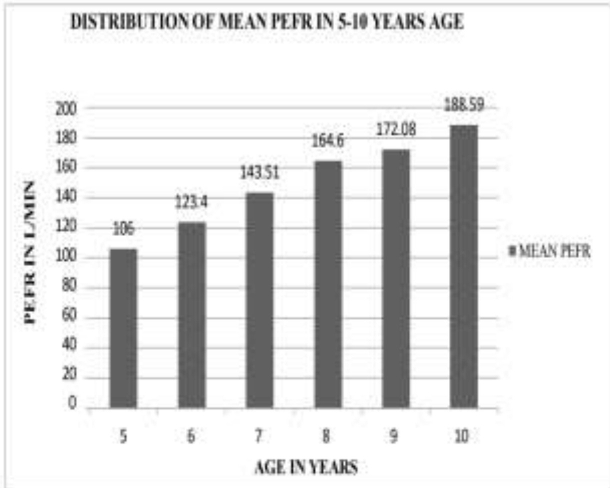

Figure 2: Graphical representation of mean PEFR data measured in 5-10 years age group during the study.

Table 1: Description: PEFR data arranged as per specific height and age group from the present study.

Age (yrs)	PEFR of height upto 110 cm		PEFR of height 111-120 cm		PEFR of height 121-130 cm		PEFR of height 131-140 cm		PEFR of height 141-150 cm		PEFR of height 151-160 cm	
	*Mch	^Fch	Mch	Fch	Mch	Fch	Mch	Fch	Mch	Fch	Mch	Fch
5	98.64	96.47	114.5	100	151.6	132	-	-	-	-	-	-
6	116.8	107.5	127.9	116.8	140.3	135.8	-	130	-	-	-	-
7	136.6	113.6	144.4	139.8	151.3	142	215	146.6	-	-	-	-
8	-	120	148.5	146	171.9	156.3	189	167.2	205	155	-	-
9	-	-	177.6	139.2	175.3	144.4	196.5	167.2	205	174.1	-	180
10	-	-	-	-	175	165.4	194.2	174.2	218.7	188.5	265	186.6

*Mch- Male Children, ^Fch- Female Children

Table 2: Variability of mean PEFR values among age groups of 5-10 years between previous Indian studies and present study.

Age (yrs	Singh et al.[25] (South India) PEFR-l/min		Deshpande et al.[26] (Maharashtra) PEFR-l/min		Sharma et al.[27] (West Rajasthan) PEFR-l/min		Sharma et al.[19] (West Rajasthan) PEFR-l/min		Basha et al.[7] (Karnataka) PEFR-l/min		Present study (Pune, Maharashtra) PEFR-l/min	
	*Mch	^Fch	Mch	Fch	Mch	Fch	Mch	Fch	Mch	Fch	Mch	Fch
5	-	-	-	-			-	-	-	-	111	99.8
6	121.6	113.3	-	-	149	121	-	-	-	-	128	118
7	147.4	134.2	-	-	182.1	154.5	148.3	117.6	-	-	147.7	138.7
8	184.1	148.1	147.4	167.6	200.8	178.6	157.2	147.9	208.5	208.5	172	154.6
9	197.4	181.9	186.4	178.8	230.2	206.3	209.3	148.3	231.5	218.4	188.58	155.58
10	227.5	214	217.6	201.2	236.4	214	179.2	170.8	244.3	236.4	200.37	171.71

*Mch- Male Children, ^Fch- Female Children

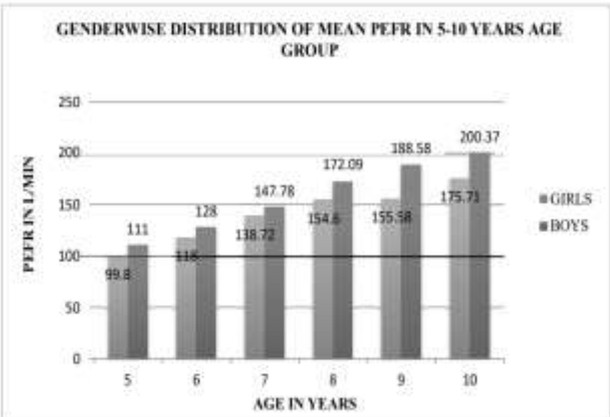

Figure 3: Gender wise graphical representation of mean PEFR data measured in 5-10 years age group during the study.

DISCUSSION

PEFR as a measurement of ventilatory function was introduced by Hadorn in 1942 and accepted as an index of spirometry in 1949.Although, it is effort dependent, Peak Expiratory Flow (PEF) helps to assess an individual's response to bronchodilator aerosol.[4-7] Effective bronchodilators are known to increase the diameter of the larger airways. This makes PEFR a very important diagnostic and prognostic tool for various pulmonary conditions, restrictive or obstructive. Unfortunately for us, healthcare workers in India till date refer to international data of PEFR values while assessing children of India. Not considering the wide variety of variables, essentially due to lack of Indian norms. Researchers worldwide are also trying to find PEFR for their own country due to its variability in children globally.[6-13] These studies show variability in terms of height, weight, race, geographical variation, ethnicity, gender, environmental factors, pollution and economic status.[5] Indian studies also show a similar variability.[7-11,14-20] A study by Taksande et al shows variation in PEFR values in children from Wardha, Maharashtra as those compared to other parts of the country.[8] PEFR can be assessed efficiently for children mostly above 5 years of age, as below this age there is difficulty in understanding the assessment process and room for error.[21] Also, the anatomical & physiological growth of lungs is complete only by the age of 8-10 years.[3,22] In the present study children of 5-10 years age group of urban residencies in the District of Pune in the state of Maharashtra were studied.

Along with overall physical growth, there is a change in the lung size and volumes; taller individuals tend to have larger lungs and greater volumes and hence higher PEFR values.[23, 24] As the lung size is continuously changing, this also makes it difficult to assign one single value of PEFR to children of varying age groups. The PEFR of a child of 10 yrs. will differ to that of a 5-year-old child. The (Table

1) shows PEFR values assessed in the present study arranged in terms of specific height and age group.

Mohammad et al found that PEFR is influenced by race, weight, cigarette smoking, environmental conditions like air pollution among other factors.[6] The influence of anthropometric measures on PEFR is seen in various studies both in international and Indian studies as mentioned earlier. Basha et al have reported a good correlation between PEFR and height, weight, and thus the BMI.[7] In the current study the correlation between anthropometric data and PEFR has given mixed results despite which the correlation of PEFR with height is positive in all age groups. However, that with BMI, weight, and waist circumference is not consistently positive. On comparing the present data with a study by Carson (which is a representative of PEFR values in the western population) PEFR across all heights and ages showed lower values.[5] The authors justify this by virtue of the shorter stature of children in the Indian subcontinent as compared to their western counterparts for a given age group. The (Table 2) shows comparison of PEFR values of present study with other equivalent Indian studies.[7,19,25-27] This intra-country variability over the years made the authors realize the strong influence of urbanization leading to air pollution, in terms of increasing density of the respirable suspended particulate matter (RSPM), an important factor influencing PEFR.[28] This has also resulted in increased levels of air pollutants exceeding the prescribed standards, in most urban areas. Thus, predisposing children of urban regions to early infections and re-infections. Mondal et al found in their study that 80% of asthmatics report disease onset prior to 6 years of age.[22] Therefore, the need for diagnosing in the nascent phase thereby facilitating treatment and preventing its chronicity.

Limitations

The main limitation of present study is that it covers a single urban centre rather than being multicentre, reducing wider applicability of regression equation developed through the study.

CONCLUSION

The study shows that, PEFR increases with increasing age in urban children of age group 5 to 10 years with a good positive correlation to height. PEFR values from the current study were also found to be increased in boys as compared to girls of the same age group. The current PEFR data on statistical analysis has been able to generate a gender-wise regression equation for predicted PEFR with height as the most significant factor. It is already known that, PEFR assessment is helpful in detecting nascent cases of pulmonary afflictions, predicting the exacerbation and monitoring patient status, and improving quality of life by combining it with medical care. Thus, we conclude that the predictive regression equation generated from this study may help form basis of guideline for medical practitioners and PHC workers for routine PEFR assessment in Western urban Maharashtra at altitudes similar to Pune.

Recommendations

This will hopefully encourage a widespread use of PFM as a diagnostic and prognostic tool. The authors foresee a probable shift in basic assessment tools currently being used for children suffering from pulmonary conditions. We hope predicted PEFR will help to improve quality of life and in turn participation in society of such children. This will especially prove beneficial in the recent scenario post COVID-19 pandemic where rapid and precise respiratory system assessment has become paramount in helping children vulnerable to various pathologies. In future we hope to perform a multi-centric study pan India and help create a normogram of PEFR vs. height, which will then have wider applicability of predicted PEFR values in Indian children as a whole.

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