

ASSOCIATION OF ANTHROPOMETRIC PARAMETERS WITH PEAK EXPIRATORY FLOW RATE AMONG SCHOOL-AGED CHILDREN IN WESTERN UTTAR PRADESH: A CROSS-SECTIONAL STUDY

Dr. Tanya Khatter¹, Dr. Bindu T Nair^{2*}, Dr. Poonam Chhillar Vij³

¹ Resident, Department of Paediatrics, Sharda School of Medical Sciences & Research, Sharda University, Greater Noida, UP, India . Email ID – khatter.tanya@gmail.com

² Professor in Department of Paediatrics, Sharda School of Medical Sciences & Research, Sharda University, Greater Noida, UP, India . Email ID: bindu.nair@sharda.ac.in

³ Assistant Professor in Department of Paediatrics, Sharda School of Medical Sciences & Research, Sharda University, Greater Noida, UP, India . Email ID: poonam.vij@sharda.ac.in

*Corresponding Author: Dr. Bindu T Nair, ORCID ID: 0000 0003 4957 0437, Email ID – bindu.nair@sharda.ac.in

ABSTRACT

Background: Growth and body composition influence respiratory function during childhood, but the relationship between anthropometric measures and peak expiratory flow rate (PEFR) may vary across populations. The study evaluated the association of height, weight, and body mass index (BMI) with PEFR among asymptomatic school children in Western Uttar Pradesh, India.

Methods: This observational cross-sectional study included 370 asymptomatic school children aged 8–14 years from a school in Greater Noida, Western Uttar Pradesh. Height and weight were measured and BMI was calculated as weight in kilograms divided by height in metres squared. PEFR was measured in the standing position using a standard peak flow meter; three readings were obtained and the highest value was retained. Pearson correlation coefficients were used to examine the relationships between PEFR and height, weight, and BMI. Statistical significance was defined as $p < 0.05$.

Results: The mean age of the study population was 12.06 ± 1.00 years. Mean height, weight, and BMI were 146.89 ± 7.76 cm, 31.09 ± 11.31 kg, and 26.42 ± 11.44 kg/m², respectively. Mean PEFR was 275 ± 76.66 L/min. PEFR demonstrated a very weak but statistically significant negative correlation with height ($r = -0.114$, $p = 0.028$), a weak positive correlation with weight ($r = 0.262$, $p < 0.0001$), and a weak negative correlation with BMI ($r = -0.345$, $p < 0.0001$).

Conclusion: In this school-based population, PEFR showed statistically significant associations with height, weight, and BMI, although the magnitude of these correlations was modest. The positive association with weight and negative association with BMI illustrate the complexity of interpreting raw PEFR in growing children and support the use of age-, sex-, and body-size-appropriate reference values rather than raw PEFR alone.

KEYWORDS: anthropometry; body mass index; peak expiratory flow rate; school health; pulmonary function

INTRODUCTION

Peak expiratory flow rate (PEFR) is a simple, inexpensive and portable measure of maximal expiratory flow that can be obtained with a peak flow meter. It has been used in children for assessment and monitoring of expiratory airflow and is attractive for school-based respiratory screening because it requires relatively little equipment and can be performed outside a pulmonary function laboratory. However, PEFR is strongly influenced by normal growth and development, including age, sex, height and body habitus. Consequently, interpretation of a measured value requires appropriate reference information rather than reliance on a single absolute value.¹⁻³

Body composition may have an additional influence on respiratory mechanics. Childhood overweight and obesity have been associated in the literature with alterations in lung volumes and pulmonary function, although the direction and magnitude of individual pulmonary function changes vary across studies. Systematic reviews suggest that excess adiposity can reduce functional residual capacity and other lung volumes, while evidence for other pulmonary function parameters is more heterogeneous.^{4,5} The relationship between BMI and PEFR may therefore differ from the relationship between absolute body weight and PEFR, because BMI incorporates both mass and stature.⁴⁻⁶

The present study examined standardized measurements of height, weight and PEFR in 370 school children aged 8–14 years from Greater Noida, Western Uttar Pradesh. The analysis focused specifically on the relationship between anthropometric measures and PEFR within this study population.

The objective of the study was to determine the correlation of PEFR with height, weight and BMI among asymptomatic school children aged 8–14 years in Western Uttar Pradesh. The analysis was exploratory and was intended to describe the observed associations rather than establish causality or derive a new PEFR prediction equation.

METHODS

This was an observational cross-sectional study conducted over 18 months in a school in Greater Noida, Western Uttar Pradesh, India. Anthropometric measurements and PEFR were recorded in all eligible participants.

The study enrolled 370 asymptomatic school children aged 8–14 years. Children with a previous diagnosis of asthma, those receiving medication for asthma or another respiratory illness, those with acute or chronic respiratory illness such as tuberculosis, and those actively experiencing cough, wheeze or coryza were excluded. Institutional ethics approval was obtained before commencement of the study-related work, and assent was obtained from participating students.

Height and weight were measured for all participants. BMI was calculated as weight in kilograms divided by height in metres squared (kg/m^2). BMI was analysed as a continuous variable. Because BMI in school-aged children varies with age and sex, interpretation of BMI in pediatric populations is preferably based on age- and sex-specific reference standards rather than adult cut-offs.^{7,8}

PEFR was measured using a standard peak flow meter. Each child was instructed to stand upright with the mouthpiece correctly positioned. Three readings were obtained, and the highest of the three measurements was recorded as the final PEFR for analysis, consistent with methods used in previous school-based PEFR studies.⁹⁻¹²

Statistical analysis

Continuous variables were summarized using mean $\pm$ standard deviation and median with interquartile range; categorical variables were summarized using frequencies and percentages. Data distribution was assessed using the Shapiro–Wilk test. Pearson correlation coefficient was used to assess the linear association between PEFR and each anthropometric parameter: height, weight and BMI. A two-sided p value <0.05 was considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics version 25.0.

The analysis was limited to bivariate correlations between PEFR and each anthropometric parameter. No multivariable regression model, age- or sex-stratified regression equation, BMI-for-age categorization, or adjusted effect estimate was performed.

RESULTS

Participant characteristics

A total of 370 children were included. The mean age was 12.06 ± 1.00 years. Females constituted 222 (60.0%) participants and males 148 (40.0%). The anthropometric distribution is shown in **Table 1**.

Table 1. Anthropometric characteristics of the study population (n=370).

Anthropometric parameter	Mean $\pm$ SD	Median (IQR)	Range
Height (cm)	146.89 ± 7.76	147 (140–153.75)	120–159
Weight (kg)	31.09 ± 11.31	31.6 (19.492–40.7)	14.09–53.4
BMI (kg/m^2)	26.42 ± 11.44	19.89 (17.4–37.375)	12.75–53.5

The mean PEFR of the study population was 275 ± 76.66 L/min. Fifty-three (14.32%) children had PEFR values below 80% of predicted, while 317 (85.68%) had values within the study-defined normal range.

Pearson correlation analysis demonstrated statistically significant associations between PEFR and all three anthropometric parameters examined. PEFR had a very weak negative correlation with height ($r=-0.114$, $p=0.028$), a weak positive correlation with weight ($r=0.262$, $p<0.0001$), and a weak negative correlation with BMI ($r=-0.345$, $p<0.0001$). The largest absolute correlation coefficient among the three variables was observed for BMI (**Table 2**).

Table 2. Pearson correlations between PEFR and anthropometric parameters (n=370).

Anthropometric parameter	Pearson r with PEFR	p value	Interpretation of magnitude
Height (cm)	-0.114	0.028	Very weak negative correlation
Weight (kg)	0.262	<0.0001	Weak positive correlation
BMI (kg/m^2)	-0.345	<0.0001	Weak negative correlation

DISCUSSION

This study examined the relationship between anthropometric parameters and PEFR in 370 asymptomatic school children aged 8–14 years from Greater Noida, Western Uttar Pradesh. The principal finding was that PEFR was

significantly associated with height, weight and BMI, although all observed correlations were modest. Weight showed a positive association with PEFR, whereas height and BMI showed negative associations in this dataset.

Relationship of PEFR with height and weight

Growth is a fundamental determinant of respiratory function in childhood. As children mature, airway calibre, thoracic dimensions and respiratory muscle capacity change, and these factors generally contribute to increasing expiratory flow. Multiple Indian studies have therefore reported positive associations between PEFR and height and/or weight.^{9,13} The present findings should be interpreted against this established background, while recognizing that the direction and magnitude of an association can vary according to the population studied, age distribution, sex distribution and statistical model.

The negative correlation between height and PEFR observed in the present dataset ($r=-0.114$) is therefore different from the direction reported in several Indian reference studies. Importantly, the magnitude of the association was very small. A statistically significant p value should not be interpreted as evidence of a clinically important relationship. The result may reflect characteristics of this particular sample, including its age distribution, sex distribution, body-composition pattern or other unmeasured factors. Because the present analysis was based on simple bivariate correlation, it cannot determine whether the observed association with height persists after adjustment for age, sex, weight or pubertal development.

The positive correlation between weight and PEFR ($r=0.262$) is directionally consistent with earlier Indian school-based observations.^{9,13,14} Absolute weight may partly capture overall body size and respiratory muscle mass during growth. However, weight alone does not distinguish lean mass from adipose mass and therefore should not be interpreted as a direct determinant of pulmonary function. This distinction becomes important when weight and BMI show correlations in opposite directions, as occurred in the present study.

BMI showed the strongest absolute correlation with PEFR among the three anthropometric variables examined, although the association remained weak ($r=-0.345$). This inverse relationship is biologically plausible because excess adiposity can influence respiratory mechanics through increased chest-wall and abdominal loading, altered respiratory muscle mechanics and reductions in functional residual capacity. Systematic reviews of children and adolescents have reported adverse effects of obesity on several lung-volume measures, particularly functional residual capacity and expiratory reserve volume.^{4,5} Studies specifically examining PEF have also reported lower values among children with obesity compared with non-obese children.⁶

BMI in children requires age- and sex-specific interpretation. In this study, BMI was analysed as a continuous variable, and the observed inverse correlation with PEFR represents an association between the measured BMI and raw PEFR values. It does not establish a causal relationship. The WHO 2007 reference provides age- and sex-specific BMI-for-age standards for school-aged children and adolescents, reinforcing the importance of interpreting pediatric BMI in a developmental context.^{7,8}

Weight was positively correlated with PEFR, whereas BMI showed an inverse correlation. Since BMI incorporates height as well as weight, these measures represent different aspects of body size. The findings therefore suggest that a single anthropometric measure may not adequately describe expected expiratory flow in growing children. When PEFR is used clinically, prediction equations that account for relevant developmental variables are preferable to interpretation of the raw value alone.

Pediatric PEFR reference values vary across Indian populations. Pande and colleagues studied school children in Delhi and Nellore and found that age, sex, height and weight contributed differently to PEFR prediction according to sex and region.¹⁵ Pulickal and Fernandez, studying 1,403 rural South Indian school children, reported strong correlations between height and PEFR and developed height-based prediction equations.¹¹ The Jabalpur study of 2,156 healthy school children also found strong positive correlations between PEFR and height, weight and BMI and developed sex-specific prediction equations incorporating height and weight.¹⁰ Similar regional work from South Gujarat and Madurai has demonstrated significant relationships of PEFR with anthropometric variables and has emphasized the need for regional reference values.^{16,17} These findings support the concept that pediatric PEFR reference values should be interpreted with attention to age, sex, body size and population characteristics.^{13,18}

The present study was not designed to derive normative PEFR equations. Participants were selected from a school population and the analysis was intended to examine associations between anthropometric measures and PEFR. The findings therefore describe relationships within this sample and should not be used to generate reference equations for the wider pediatric population.

PEFR is attractive for school-based respiratory screening because it is portable, inexpensive and relatively simple to perform. However, its interpretation in children must account for normal growth and body size. The present findings support the broader principle that raw PEFR should not be interpreted without reference to appropriate pediatric norms. International pulmonary-function reference work emphasizes the importance of appropriate reference equations and lower limits of normal rather than relying on a single universal absolute value.^{3,19}

For school screening programs, anthropometric measurement can be obtained alongside PEFR with minimal additional burden. Height, in particular, is routinely measured in school health settings and is commonly incorporated into pediatric pulmonary reference equations.^{11,15,18} The present data also suggest that BMI may carry information about

variability in expiratory flow; however, BMI should be interpreted using pediatric age- and sex-specific standards rather than adult categories.^{7,8}

The results do not support using BMI, weight or height alone as a screening test for asthma, and they do not establish that any anthropometric characteristic causes airflow limitation. They indicate that growth and body habitus should be considered when interpreting PEFR in children. PEFR can be useful as a monitoring or screening measure, but abnormal values require appropriate clinical assessment rather than being equated with a definitive diagnosis of asthma.²⁰

Strengths

First, the study included a relatively sizeable school-based sample of 370 children within a defined pediatric age range. Second, anthropometric measurements and PEFR were obtained systematically during the same screening process. Third, PEFR was recorded as the highest of three attempts, reducing the effect of an isolated submaximal effort. Finally, the analysis provides regional data from Western Uttar Pradesh, where pediatric PEFR information is less extensive than in some other parts of India.

LIMITATIONS

Several limitations should be considered. The cross-sectional design permits identification of associations but not temporal or causal relationships. The sample was obtained from a selected school in Greater Noida and may not represent children from other socioeconomic, geographic or rural–urban settings. PEFR is effort-dependent and can be affected by technique, motivation and cooperation.

In addition, BMI was analysed as a raw continuous variable rather than an age- and sex-standardized BMI-for-age measure. Future studies should address these issues through multivariable modelling and age- and sex-stratified analyses using appropriate pediatric growth and pulmonary-function reference frameworks.

CONCLUSION

PEFR significantly correlated with height, weight and BMI, although the strength of each association was modest. Weight showed a weak positive association with PEFR, while height and BMI showed weak negative associations. These findings add regional evidence that anthropometric characteristics are relevant to the interpretation of pediatric PEFR. They also demonstrate why raw PEFR values should be interpreted against appropriate age-, sex- and body-size-specific reference standards.

DECLARATIONS

Consent for publication: YES

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