

Peak Expiratory Flow Rate and Its Association with Anthropometric and Demographic Parameters among Healthy School Children

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Abstract

Background: Peak Expiratory Flow Rate (PEFR) is a simple, reliable, and cost-effective tool for assessing pulmonary function and detecting airway obstruction. Establishing population-specific normative values is important because PEFR is influenced by demographic and anthropometric factors such as age, gender, height, weight, and body composition. Limited data are available regarding PEFR values among school children in Telangana. **Material and Methods:** A prospective observational study was conducted among 552 apparently healthy school children aged 6–15 years from government and private schools in Siddipet, Telangana. Participants were selected using simple random sampling. PEFR was measured using a Mini-Wright peak flow meter following standard procedures. Anthropometric measurements including height, weight, body mass index (BMI), chest circumference, and chest expansion were recorded. Statistical analysis was performed using SPSS version 27. Correlations between PEFR and anthropometric variables were assessed, and demographic associations were evaluated using appropriate statistical tests. **Results:** The mean PEFR among participants was 319.77 ± 101.21 L/min. PEFR demonstrated a significant progressive increase with age, ranging from 182.72 ± 30.00 L/min in children aged 6–7 years to 445.75 ± 36.90 L/min in those aged 14–15 years ($p=0.001$). Height showed the strongest positive correlation with PEFR ($r=0.968$, $p=0.001$), followed by weight ($r=0.923$, $p=0.001$). BMI showed a weaker positive correlation ($r=0.331$, $p=0.001$). Gender and socioeconomic status did not demonstrate statistically significant associations with PEFR. **Conclusion:** PEFR in school-aged children is significantly influenced by age and anthropometric characteristics, particularly height. The study provides region-specific normative PEFR values that may assist clinicians in pediatric respiratory assessment and early detection of respiratory abnormalities.

Keywords: Peak expiratory flow rate; School children; Anthropometric parameters; Pulmonary function; Respiratory health.

Received: 22 April 2026

Revised: 10 May 2026

Accepted: 23 May 2026

Published: 06 June 2026

INTRODUCTION

Respiratory diseases are a major cause of morbidity and mortality among children, particularly in developing countries such as India. Acute respiratory tract infections significantly contribute to under-five mortality, while chronic respiratory diseases, especially asthma, adversely affect quality of life and school attendance.^[1] Urbanization, environmental pollution, and changing lifestyles have contributed to the increasing burden of pediatric respiratory disorders globally.^[2] Asthma is the most common chronic respiratory disease in childhood and imposes considerable social and economic burdens on families and healthcare systems due to frequent hospital visits and school absenteeism.^[3] The International Study of Asthma and Allergies in Childhood (ISAAC) reported asthma prevalence ranging from 5–15% among Indian children, with substantial regional variation.^[4] More recent studies indicate a rising prevalence of asthma and obstructive airway diseases in India due to urbanization, pollution, allergen exposure, and lifestyle transitions.^[5] However, region-specific pediatric respiratory data remain limited in areas such as Telangana. Assessment of pulmonary function has evolved from a research tool into an essential component of respiratory

evaluation in clinical practice. Pulmonary function tests (PFTs) are routinely used in respiratory medicine, occupational health, sports medicine, and public health screening to assess airway obstruction and overall pulmonary status.^[6] Although PFTs provide important information regarding the physiology, severity, progression, and treatment response of respiratory diseases, they are often difficult to perform in children because of technical complexity, cost, and challenges in obtaining reproducible results.^[7-10] These limitations have encouraged the development of simpler and child-friendly alternatives for evaluating respiratory function.

Peak Expiratory Flow Rate (PEFR) is a simple, reproducible, and inexpensive method used to measure the maximum speed of

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DOI:

10.21276/amt.2026.v13.i2.718

How to cite this article: Sandeep S, Lavanya B, Reddy BA. Peak Expiratory Flow Rate and Its Association with Anthropometric and Demographic Parameters among Healthy School Children. *Acta Med Int.* 2026;13(2):434-439.

expiration and assess airway obstruction. Since the introduction of the Wright peak flow meter, PEFr has become an important tool in the evaluation and monitoring of obstructive airway diseases, particularly asthma.^[11] The mini-Wright peak flow meter is portable, affordable, and suitable for use in homes, schools, and clinical settings. Unlike conventional pulmonary function tests, PEFr can be reliably performed in children as young as six years, making it especially valuable in pediatric practice.^[12] Its clinical importance has been compared to that of a sphygmomanometer for hypertension or a thermometer for fever.^[13] PEFr has gained global recognition as a reliable tool for diagnosis, monitoring, therapeutic decision-making, and follow-up of patients with obstructive airway diseases.^[14] PEFr values are influenced by several anthropometric and demographic factors including age, sex, height, weight, body surface area, ethnicity, and environmental conditions.^[15] Studies have consistently shown that older children, males, and taller individuals tend to have higher PEFr values due to larger lung volumes and stronger expiratory effort.^[16] Gender differences in pulmonary function may result from variations in body size, hormonal influences, and physiological characteristics.^[17,18] Ethnicity also contributes to lung function variability, while excess body weight may reduce pulmonary performance by increasing airflow resistance and restricting chest wall movement.^[17,19,20] PEFr generally demonstrates a positive correlation with height and an inverse relationship with body weight.^[6] Age also significantly influences PEFr, with values increasing progressively during childhood; boys often exhibit higher values than girls of the same age.^[18,21,22]

Given the considerable ethnic, genetic, nutritional, and environmental diversity within India, population-specific reference standards for PEFr are essential.^[23] Limited information exists regarding normative PEFr values among school children in Siddipet, Telangana. Establishing local reference values and evaluating their association with anthropometric and demographic parameters can facilitate early identification of children at risk of respiratory disorders and support effective disease monitoring and management. Therefore, the present study aims to evaluate PEFr among primary school children in Siddipet and examine its relationship with anthropometric and demographic variables.

MATERIALS AND METHODS

Study Design: The present study was conducted as a prospective observational study to assess Peak Expiratory Flow Rate (PEFr) among apparently healthy school-going children and to examine its association with anthropometric and demographic variables. This design was selected because it enabled the evaluation of pulmonary function under natural conditions without introducing any intervention, while also allowing the identification of potential factors influencing PEFr.

Study Setting: The study was carried out in government and private primary schools located in Siddipet town, Telangana. Inclusion of both categories of schools ensured participation of children from varied socioeconomic and demographic

backgrounds, thereby improving the representativeness and generalizability of the findings to the local population.

Study Population and Sample Size: The study population consisted of apparently healthy school children aged between 6 and 15 years. Children below six years were excluded because they may not perform respiratory maneuvers consistently, while those above 15 years were excluded due to physiological changes associated with puberty that can influence lung function. A total of 552 children were included in the study. Sample size estimation was performed to ensure adequate statistical power for establishing normative PEFr values and evaluating their relationship with anthropometric and demographic variables. Participants were selected using a simple random sampling technique to reduce selection bias.

Eligibility Criteria: Children aged 6–15 years who were apparently healthy and free from acute illness at the time of examination were included in the study. Written informed consent was obtained from parents or guardians and assent was obtained from children wherever applicable. Children with acute respiratory tract infections, chronic illnesses affecting cardiovascular, respiratory, or gastrointestinal systems, structural abnormalities of the chest wall or spine, and those with acute ENT conditions such as tonsillitis were excluded from participation because these conditions could influence respiratory performance and PEFr measurements.

Study Instruments and Anthropometric Assessment: The Mini-Wright peak flow meter (Clement Clarke International, England) was used to measure PEFr. The instrument consists of a cylindrical body containing a spring-loaded piston and a detachable mouthpiece. During forceful expiration, piston displacement moves a pointer across a calibrated scale ranging from 60–800 L/min, thereby recording PEFr. The device was portable, validated for pediatric use, and regularly calibrated and disinfected to ensure accuracy and hygiene. Anthropometric parameters assessed included height, weight, body mass index (BMI), chest circumference, and chest expansion. Height was measured using a stadiometer to the nearest 0.1 cm, while weight was recorded using a calibrated weighing scale to the nearest 0.1 kg. BMI was calculated using the standard formula: weight (kg)/height (m²). Chest measurements were recorded using a non-stretchable measuring tape.

Socioeconomic Assessment: Socioeconomic status of the participants was assessed using the Modified Kuppuswamy Socioeconomic Scale for urban populations. This scale evaluates educational status and occupation of the head of the family along with total monthly family income, adjusted according to current Consumer Price Index revisions. Based on cumulative scores, participants were categorized into upper, upper middle, lower middle, upper lower, and lower socioeconomic classes.

Data Collection Procedure: After obtaining permission from school authorities and informed consent from parents, children were enrolled in the study. Relevant demographic details, medical history, anthropometric parameters, and clinical examination findings were recorded using a structured proforma. Children were instructed and demonstrated the proper technique for using the peak flow meter. Each participant was asked to stand upright, take a deep breath, and blow forcefully into the mouthpiece. Three attempts were performed with a minimum interval of 30 seconds between readings, and the highest value

was recorded as the PEFR. Disposable mouthpieces and routine disinfection procedures were employed to maintain hygiene and prevent cross-infection.

Statistical Analysis: Collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 27.0. Descriptive statistics such as mean, standard deviation, and percentiles were used to summarize PEFR values according to age and gender. Correlations between PEFR and anthropometric variables were assessed using Pearson's correlation coefficient or Spearman's rank correlation, depending on data distribution. Comparisons between groups were performed using independent t-tests or Mann-Whitney U tests as appropriate. Multiple regression analysis was applied to identify independent predictors of PEFR. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 552 school children participated in the study. The

age distribution was fairly balanced across all age groups. The largest proportion of participants belonged to the 8–9 years age group (21.7%, n=120), followed by 12–13 years (20.1%, n=111) and 10–11 years (19.9%, n=110). Children aged 6–7 years constituted 19.7% (n=109), while the 14–15 years age group represented the lowest proportion at 18.5% (n=102). This indicates that children from different age categories were almost equally represented in the study population [Table 1].

With regard to gender distribution, females constituted 51.1% (n=282) of the study participants, while males accounted for 48.9% (n=270). The nearly equal representation of boys and girls suggests a balanced gender distribution, minimizing gender-related sampling bias [Table 1].

Assessment of socioeconomic status showed that a substantial majority of children belonged to the lower socioeconomic class (87.7%, n=484). Only 8.3% (n=46) belonged to the middle socioeconomic class and 4.0% (n=22) were from the upper socioeconomic class. These findings indicate that the study population predominantly represented children from economically disadvantaged backgrounds [Table 1].

Table 1: Demographic Characteristics of Study Participants (n=552).

Variable	Category	n (%)
Age group	6–7 years	109 (19.7)
	8–9 years	120 (21.7)
	10–11 years	110 (19.9)
	12–13 years	111 (20.1)
	14–15 years	102 (18.5)
Gender	Male	270 (48.9)
	Female	282 (51.1)
Socioeconomic class	Lower	484 (87.7)
	Middle	46 (8.3)
	Upper	22 (4.0)

The mean height of the study participants was 144.16 ± 20.36 cm, with a median height of 144.10 cm (IQR: 127.08–161.53 cm). This indicates that half of the children had heights between 127.08 cm and 161.53 cm, showing a broad variation in height consistent with the inclusion of children across different age groups [Table 2].

The mean body weight of the participants was 39.84 ± 13.60 kg, while the median weight was 37.60 kg (IQR: 29.03–51.48 kg). The relatively wide interquartile range reflects variations in body weight among the children, likely due to age-related growth differences [Table 2].

The average Body Mass Index (BMI) of the study population

was 18.57 ± 2.39 kg/m², with a median value of 18.48 kg/m² (IQR: 16.48–20.02 kg/m²). The narrow spread of BMI values suggests that most children had BMI measurements within a relatively similar range [Table 2].

The mean chest circumference was 68.92 ± 9.93 cm, with a median of 68.70 cm (IQR: 60.95–77.58 cm). Similarly, the mean chest expansion was 4.70 ± 1.03 cm, and the median chest expansion was 4.55 cm (IQR: 3.90–5.40 cm). These findings indicate normal variations in chest dimensions and respiratory movement among the study participants [Table 2].

Table 2: Anthropometric Characteristics of Study Participants.

Variable	Mean \pm SD	Median (IQR)
Height (cm)	144.16 ± 20.36	144.10 (127.08–161.53)
Weight (kg)	39.84 ± 13.60	37.60 (29.03–51.48)
BMI (kg/m ²)	18.57 ± 2.39	18.48 (16.48–20.02)
Chest circumference (cm)	68.92 ± 9.93	68.70 (60.95–77.58)
Chest expansion (cm)	4.70 ± 1.03	4.55 (3.90–5.40)

The mean pulse rate among the study participants was 82.39 ± 8.04 beats per minute, with a median value of 82.00 beats per minute (IQR: 76–89 beats/min). This indicates that the central 50% of children had pulse rates ranging between 76 and 89 beats per minute, suggesting that most participants had pulse rates within the normal physiological range for

their age [Table 3].

The mean respiratory rate was 18.11 ± 2.73 breaths per minute, while the median respiratory rate was 18.00 breaths per minute (IQR: 16–20 breaths/min). The relatively narrow interquartile range indicates limited variation in respiratory rates among the children and reflects a generally stable

respiratory status in the study population [Table 3].

The mean Peak Expiratory Flow Rate (PEFR) among the participants was 319.77 ± 101.21 L/min, with a median value of 320.50 L/min (IQR: 235.25–405.50 L/min). This shows that half of the study participants had PEFR values between

235.25 and 405.50 L/min. The wide spread in PEFR values likely reflects differences in age, body size, and growth characteristics among the children included in the study [Table 3].

Table 3: Clinical Parameters and PEFR Distribution.

Variable	Mean \pm SD	Median (IQR)
Pulse rate (beats/min)	82.39 ± 8.04	82.00 (76–89)
Respiratory rate (breaths/min)	18.11 ± 2.73	18.00 (16–20)
PEFR (L/min)	319.77 ± 101.21	320.50 (235.25–405.50)

A very strong positive correlation was observed between PEFR and height ($r = 0.968$), indicating that PEFR values increased considerably with increasing height among the study participants. This association was statistically significant ($p = 0.001$), suggesting that taller children tended to have better expiratory flow rates and greater lung function capacity [Table 4].

Similarly, PEFR showed a strong positive correlation with body weight ($r = 0.923$). The statistically significant p -value of 0.001 indicates that children with higher body weight

generally demonstrated higher PEFR values. This relationship may be explained by growth-related increases in body size and lung capacity [Table 4].

In contrast, the correlation between PEFR and BMI was weaker ($r = 0.331$), although it remained statistically significant ($p = 0.001$). This finding suggests that while BMI had some positive influence on PEFR, its effect was less pronounced compared to height and weight. Therefore, height and weight appeared to be stronger determinants of PEFR in the study population [Table 4].

Table 4: Correlation of PEFR with Anthropometric Variables.

Variable	Correlation coefficient (r)	P value
Height	0.968	0.001*
Weight	0.923	0.001*
BMI	0.331	0.001*

The mean PEFR values showed a progressive increase with advancing age among the study participants. Children aged 6–7 years had the lowest mean PEFR of 182.72 ± 30.00 L/min, with a median value of 180.00 L/min (IQR: 157.50–200.50). In the 8–9 years age group, the mean PEFR increased to 257.14 ± 34.74 L/min, with a median of 255.00 L/min (IQR: 232.00–284.00) [Table 5].

A further increase in PEFR was observed among older children. Participants aged 10–11 years had a mean PEFR of 324.30 ± 42.63 L/min, while children aged 12–13 years showed a mean value of 401.81 ± 40.58 L/min. The highest

PEFR values were recorded in the 14–15 years age group, with a mean of 445.75 ± 36.90 L/min and a median of 448.00 L/min (IQR: 411.75–475.25) [Table 5].

The findings demonstrate a clear age-related rise in PEFR values, indicating that expiratory flow rates improve as children grow older, likely due to increases in lung volume, airway size, and overall physical development. The association between age and PEFR was found to be statistically significant ($p = 0.001$), suggesting that age is an important determinant of PEFR among school children [Table 5].

Table 5: Association of PEFR with Age Groups.

Age group	n (%)	Mean \pm SD	Median (IQR)	P value
6–7 years	109 (19.7)	182.72 ± 30.00	180.00 (157.50–200.50)	0.001*
8–9 years	120 (21.7)	257.14 ± 34.74	255.00 (232.00–284.00)	
10–11 years	110 (19.9)	324.30 ± 42.63	322.50 (288.00–353.25)	
12–13 years	111 (20.1)	401.81 ± 40.58	402.00 (369.00–428.00)	
14–15 years	102 (18.5)	445.75 ± 36.90	448.00 (411.75–475.25)	

Among the study participants, 270 (48.9%) were males and 282 (51.1%) were females, indicating an almost equal gender distribution. The mean PEFR among males was 320.46 ± 98.73 L/min, with a median value of 311.00 L/min (IQR: 241.50–398.00) [Table 6].

Female participants demonstrated a mean PEFR of 319.11 ± 103.70 L/min, with a median value of 323.50 L/min (IQR: 232.00–410.25). The PEFR values among females were

comparable to those observed in males, with substantial overlap in the interquartile ranges [Table 6].

Although males showed a slightly higher mean PEFR compared to females, the difference between the two groups was not statistically significant ($p = 0.876$). This finding suggests that gender did not have a significant influence on PEFR in the present study population [Table 6].

Table 6: Association of PEFR with Gender.

Gender	n (%)	Mean \pm SD	Median (IQR)	P value
Male	270 (48.9)	320.46 ± 98.73	311.00 (241.50–398.00)	0.876
Female	282 (51.1)	319.11 ± 103.70	323.50 (232.00–410.25)	

The majority of study participants belonged to the lower socioeconomic class (87.7%, n=484), while 46 children (8.3%) were from the middle socioeconomic class and 22 children (4.0%) belonged to the upper socioeconomic class. This indicates that the study population predominantly represented children from economically disadvantaged backgrounds [Table 7].

The mean PEFr was 316.85 ± 101.65 L/min among children from the lower socioeconomic class, with a median value of 310.00 L/min (IQR: 233.00–403.75). Children from the middle socioeconomic class had a slightly higher mean

PEFr of 334.54 ± 98.89 L/min, with a median of 353.00 L/min (IQR: 257.00–404.50). The highest mean PEFr was observed among children from the upper socioeconomic class at 353.18 ± 91.19 L/min, with a median value of 365.50 L/min (IQR: 281.25–425.50) [Table 7].

Although a gradual increase in PEFr values was observed from lower to upper socioeconomic groups, the association between socioeconomic status and PEFr was not statistically significant ($p = 0.151$). This suggests that socioeconomic background did not significantly influence PEFr among the study participants in the present study [Table 7].

Table 7: Association of PEFr with Socioeconomic Status.

Socioeconomic class	n (%)	Mean \pm SD	Median (IQR)	P value
Lower	484 (87.7)	316.85 ± 101.65	310.00 (233.00–403.75)	0.151
Middle	46 (8.3)	334.54 ± 98.89	353.00 (257.00–404.50)	
Upper	22 (4.0)	353.18 ± 91.19	365.50 (281.25–425.50)	

DISCUSSION

The present prospective observational study was conducted among apparently healthy school-going children aged 6–15 years in Siddipet, Telangana, with the objective of establishing normative Peak Expiratory Flow Rate (PEFr) values and assessing their association with demographic and anthropometric variables. A total of 552 children from government and private schools were included, ensuring representation from diverse socioeconomic backgrounds. Standardized PEFr assessment using the Mini-Wright peak flow meter and systematic anthropometric measurements enhanced the reliability of the observations.

The mean PEFr observed in the present study was 319.77 ± 101.21 L/min, which was comparatively higher than values reported in several previous studies. Manjarecka et al. reported mean PEFr values of 255.3 ± 56.5 L/min in boys and 210.6 ± 55.7 L/min in girls.^[24] Similarly, Karunakar et al. reported lower PEFr values ranging from 142.60 ± 27.31 L/min to 233.91 ± 37.16 L/min across age groups.^[25] Parikh and Parekh also observed lower average PEFr values in boys and girls.^[26] Variations between studies may be related to differences in ethnicity, environmental influences, nutritional status, anthropometric characteristics, and geographic factors.

One of the major findings of the present study was the significant increase in PEFr with advancing age. Mean PEFr rose progressively from 182.72 ± 30.00 L/min in children aged 6–7 years to 445.75 ± 36.90 L/min in the 14–15-year age group ($p=0.001$). This finding indicates that pulmonary function improves as children grow older due to increases in lung volume, airway size, and physical development. Similar age-related increases in PEFr have been reported by Abraham et al,^[27] Bedi and Dang,^[28] Rajasekhar et al,^[29] Karunakar et al,^[25] and Parikh and Parekh (26), all of whom demonstrated progressive increases in PEFr with age. These findings strongly support the observations of the present study.

Gender-wise analysis showed nearly equal participation of males and females. Mean PEFr values were 320.46 ± 98.73 L/min in males and 319.11 ± 103.70 L/min in females, with

no statistically significant difference ($p=0.876$). This suggests that gender did not significantly influence PEFr in the present study population. Similar observations were reported by Gururaja,^[30] and Kyejo et al,^[6] who found no significant gender differences in PEFr. However, studies by Manjarecka et al,^[24] Ramamani and Kannan,^[31] and Bedi and Dang,^[28] reported significantly higher PEFr values among boys. These differences may be explained by variations in age composition, growth patterns, and anthropometric profiles among study populations. The present study demonstrated a strong positive correlation between PEFr and anthropometric parameters, particularly height and weight. Height showed the strongest association with PEFr ($r=0.968$, $p=0.001$), identifying it as the most important predictor of pulmonary function. Weight also exhibited a strong positive correlation ($r=0.923$, $p=0.001$), while BMI demonstrated a weaker positive relationship ($r=0.331$, $p=0.001$). Similar findings have been reported by Abraham et al,^[27] Mishra et al,^[28] Rajasekhar et al,^[29] Karunakar et al,^[25] Kyejo et al,^[6] and Singh et al,^[32] who consistently identified height as the strongest determinant of PEFr. Growth-related increases in body size and lung capacity may explain these associations. The weaker relationship with BMI suggests that body composition alone may have a limited impact on respiratory performance compared to overall growth parameters.

Most participants in the present study belonged to the lower socioeconomic class (87.7%). Although PEFr values showed a gradual increase from lower to upper socioeconomic categories, the association was not statistically significant ($p=0.151$). This finding contrasts with Gururaja,^[30] who reported better PEFr values among children from higher socioeconomic groups. Differences in socioeconomic distribution and environmental conditions may explain these variations.

The present study had several strengths, including a prospective design, relatively large sample size, and inclusion of children from different school settings. Standardized PEFr measurement and strict inclusion criteria minimized measurement bias and enabled the establishment of region-specific normative PEFr values. The findings contribute valuable baseline data for pediatric respiratory assessment in Siddipet and surrounding regions.

CONCLUSION

The present study established normative PEFr values among apparently healthy school-going children aged 6–15 years in Siddipet, Telangana, with a mean PEFr of 319.77 ± 101.21 L/min. PEFr showed a significant increase with advancing age, reflecting progressive improvement in pulmonary function during growth. Among anthropometric variables, height emerged as the strongest determinant of PEFr, followed by weight, while BMI demonstrated a weaker positive association. Gender and socioeconomic status did not significantly influence PEFr values. These findings suggest that age and anthropometric characteristics, particularly height, are important predictors of PEFr and support the use of population-specific reference values for pediatric respiratory assessment.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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