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Peak Expiratory Flow Rate and Its Anthropometric Correlates in Healthy Urban Indian School Adolescents Aged 12-17 Years in Western India

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ABSTRACT

Background: Peak Expiratory Flow Rate (PEFR) is a simple, non-invasive measure of pulmonary function, influenced by anthropometric factors. Establishing normative PEFR values for adolescents is crucial for assessing respiratory health, particularly in diverse populations like India. This study aimed to determine normative PEFR values in healthy urban Indian school adolescents aged 12-17 years and evaluate their correlations with anthropometric variables, including height, weight, body mass index (BMI), body surface area (BSA), mid-upper arm circumference (MUAC), and chest circumference.

Methods: A cross-sectional study was conducted among 1,060 adolescents (530 boys, 530 girls) at a private school in Surat, Gujarat, from August 2018 to February 2020. PEFR was measured using a Mini-Wright Peak Flow Meter, and anthropometric data were collected using standardized instruments. Pearson correlation coefficients and multiple regression models assessed relationships between PEFR and anthropometric variables.

Results: Mean PEFR was 344.98 ± 45.35 L/min for boys and 323.26 ± 42.31 L/min for girls, increasing with age. PEFR showed strong correlations with height (r = 0.999), weight (r = 0.990), BMI (r = 0.954), BSA (r = 0.997), and chest circumference (r = 0.979) (all p < 0.001), but a weaker correlation with MUAC (r = 0.229, p <0.001). Height was the strongest predictor in regression models.

Conclusion: Normative PEFR values were established, with height as the primary determinant. These region-specific standards aid in assessing adolescent respiratory health.

Keywords: Peak Expiratory Flow Rate, Adolescents, Anthropometric Variables, Respiratory Function Tests, India, Height

INTRODUCTION

Peak Expiratory Flow Rate (PEFR), defined as "the maximum rate at which an individual can blow exhaled air after taking maximum inspiration," is a key indicator of pulmonary function in adolescents.[1] This measure depends on anthropometric factors such as age, sex, height, and weight, as well as the voluntary effort and muscular strength of the individual.[2] As a simple, non-invasive, rapid, and economical method, PEFR measurement, expressed in liters per minute (L/min), assesses the strength and speed of expiration from total lung capacity. It is widely utilized in respiratory medicine to detect airway obstruction, monitor asthma progression, and evaluate the effectiveness of therapeutic interventions in adolescents.[3] The ability to identify reductions

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in pulmonary function early makes PEFR a valuable tool for managing respiratory conditions in this age group.

The mini-Wright's peak flow meter (mWPFM), a reliable and user-friendly device, enables PEFR measurements to be recorded by adolescents or their guardians at home, facilitating regular monitoring.[4] In the context of India's diverse population, which spans varied geographical and environmental conditions, establishing region-specific PEFR reference values for adolescents is critical.[5] Studies have demonstrated that nutritional status, particularly body mass index (BMI), significantly influences respiratory function. Increased BMI, often linked to fat deposition on the chest wall, can alter PEFR, making it a direct, non-invasive indicator of both lung function and nutritional status in adolescents.[6] Among pulmonary function tests, PEFR stands out for its simplicity and ability to reflect changes in airway dynamics, particularly in conditions like asthma, where expiratory difficulty is a hallmark.[3,4]

PEFR values in adolescents increase progressively with age, height, and weight, with boys typically exhibiting higher values than girls for similar anthropometric profiles.[7] This gender difference underscores the need for sex-specific reference standards to accurately identify abnormal values. The dynamic growth phase of adolescence, coupled with regional and environmental influences, necessitates localized studies to establish normative data.[5,7] Such data are essential for assessing functional abnormalities in adolescents with obstructive airway disorders, such as asthma, and for guiding rational therapy and follow-up.[4]

Additionally, mid-upper arm circumference (MUAC) and chest circumference were included to explore their potential as indicators of muscle mass and thoracic development, respectively, which may influence respiratory muscle strength and lung capacity in adolescents. These less commonly studied variables could provide novel insights into the anthropometric determinants of PEFR in this population.

Furthermore, understanding the relationships between PEFR and anthropometric variables like height, weight, BMI, body surface area (BSA), mid-upper arm circumference (MUAC), and chest circumference can provide insights into how physical growth impacts lung function. This study aims to establish normative PEFR values in healthy urban Indian school adolescents aged 12-17 years and to investigate the influence of these anthropometric factors on PEFR, contributing to the development of region-specific reference standards for clinical and research purposes.

MATERIALS AND METHODS

Study Setting: This cross-sectional study was conducted in the urban area of Surat, Gujarat, at S.D. Jain School, a private institution selected for its cooperative administration and accessibility. The study focused on adolescents aged 12-17 years attending this school, ensuring a controlled environment for data collection.

Data collection occurred over six months, from August 2018 to February 2020. After collection, data entry forms were reviewed for completeness, with missing or unclear data verified by revisiting the respective student. Data were entered into Microsoft Excel, cleaned, and analyzed over two months, with report writing completed by April 2020.

Study Design: A cross-sectional design was employed, with each participant assessed once during a single visit. No follow-up visits were conducted, ensuring a snapshot of PEFR and anthropometric data across the study population.

Sample Size: The sample size was calculated using OpenEpi software (Version 3, available at http://www.openepi.com/Menu/OE_Menu.htm) based on mean PEFR values from prior studies: 201.13 L/min (SD 44.39) for boys and 194.01 L/min (SD 47.94) for girls for age group 6-17 years[8]. With a 95% confidence level, 80% power, and a 1:1 ratio of boys to girls, the estimated sample size was 962 (divided in equal group). An additional 10% was included to account for potential data loss, resulting in a total sample size of 1,058 rounded to 1,060.

Eligibility criteria: Healthy adolescents aged 12-17 years, both boys and girls, attending S.D. Jain School were included. Participants were deemed healthy based on general and systemic examinations conducted during data collection. Participants were classified as healthy based on a general and systemic examination, including no wheezing or abnormal lung sounds on auscultation, normal vital signs (e.g., heart rate, respiratory rate, and blood pressure within age-appropriate ranges), and no reported symptoms of acute or chronic illness.

Adolescents with a known history of asthma, respiratory illness within the week prior to the study, or major systemic diseases (e.g., respiratory, cardiac, renal, gastrointestinal, or central nervous system disorders) were excluded. Students absent on the day of data collection were contacted during subsequent school visits. Those unavailable throughout the study period or unwilling to participate (as indicated during assent) were excluded.

Sampling Method: A consecutive sampling approach was used, starting with the lowest eligible class (corresponding to age 12) and progressing through all classes up to standard 12 until the required sample size was achieved. All participants were sourced from S.D. Jain School, ensuring uniformity in the study setting.

The study team consisted of one principal investigator and two assistants (one male, one female) to facilitate data collection. Prior to the study, the team underwent training to standardize data collection procedures, including questionnaire administration, anthropometric measurements, and PEFR assessment. Discussions ensured consistency in questioning techniques, handling responses, and using measurement tools. All measurements were conducted in a designated school room, allowing immediate consultation with the principal investigator to resolve any issues.

Study Tools: A predesigned, semi-structured questionnaire was developed based on a literature review of PEFR in adolescents. A pilot study with 10 students validated the questionnaire's feasibility, reliability, and validity, leading to refinements in content and measurement protocols based on further literature review and expert guidance. The final questionnaire, approved by the study guide, collected demographic details and supported anthropometric measurements, including height, weight, BMI, body surface area (BSA), mid-upper arm circumference (MUAC), and chest circumference. General and systemic examinations ensured participants met inclusion criteria. Questions were administered in Hindi or English based on participants' comprehension, with data recorded concurrently.

Instruments: The study utilized standardized instruments for precise data collection. An electronic weighing machine (Dr. Morepen Digital Glass Weighing Machine), calibrated to zero on a flat surface, measured weight to the nearest 0.1 kg. A measuring tape recorded mid-upper arm circumference (MUAC) and chest circumference to the nearest 1 mm. Height was measured using a portable stadiometer, with participants standing barefoot on a flat surface, recorded to the nearest 0.5 cm. A Mini-Wright Peak Flow Meter (MWPFM, 60-800 L/min), cleaned between uses, measured Peak Expiratory Flow Rate (PEFR). Anthropometric measurements included height and weight as described, with Body Mass Index (BMI) calculated as BMI = [Weight (kg) / Height $(m)^2$] and Body Surface Area (BSA) as BSA = [$\sqrt{}$(Height [cm] × Weight [kg] / 3600)]. MUAC was measured on the relaxed left arm at the midpoint between the olecranon process and acromion. Chest circumference was measured at the xiphoid notch level, encircling the bare chest, with participants standing evenly balanced.

PEFR was measured using a Mini-Wright Peak Flow Meter with a standardized protocol. The meter's pointer was set to the bottom of the scale. Participants stood upright, held the meter horizontally, took a deep breath, and blew out forcefully into the mouthpiece in a single blast. After two practice trials, three readings were recorded, with the highest value taken as the PEFR. If readings varied significantly, the procedure was repeated after re-demonstration. The meter was cleaned between participants to ensure hygiene, maintaining reliable data for assessing PEFR and its anthropometric correlates.

Statistical Analysis: Data were managed and analyzed using Microsoft Excel and SPSS (Version 20). Categorical variables (e.g., age, sex) were presented as frequencies and percentages, while continuous variables (e.g., PEFR, height, weight, BMI, BSA, MUAC, chest circumference) were summarized as means and standard deviations. Pearson correlation coefficients were calculated to assess relationships between PEFR and anthropometric variables. Frequency distributions and graphs were generated to visualize trends and correlations.

Ethical Considerations: The study commenced after obtaining approval from the Institutional Ethical Committee. Written permission was secured from the school authorities and class teachers. Informed assent was obtained from each adolescent participant, and voluntary participation, the right to withdraw, confidentiality, and absence of compensation were clearly communicated. Female participants were examined by a female investigator in the presence of their teacher to ensure comfort and privacy. All data were anonymized, and results were reported in aggregate to maintain confidentiality.

RESULTS

The study included a balanced sample of 1,060 adolescents (530 boys and 530 girls) aged 12-17 years, with an equal distribution across age groups (Table 1). The anthropometric variables and PEFR were analyzed by age and gender, and their correlations were assessed using Pearson correlation coefficients (Tables 2 and 3).

Table 1 shows an even distribution of participants across age groups (12-17 years), with each age group comprising approximately 14.7-18.7% of the total sample for both boys and girls. The gender distribution was equal, with 50% boys and 50% girls, ensuring a balanced representation for comparative analysis.

Table 2 presents the mean values of anthropometric variables and PEFR stratified by age and gender. Both height and weight increased progressively with age for both genders. Boys generally had slightly higher mean height (154.30 ± 11.11 cm vs. 153.13 ± 10.79 cm) and weight (54.42 ± 12.50 kg vs. 47.04 ± 11.81 kg) compared to girls overall. BMI and BSA also increased with age, with boys exhibiting higher values than girls across all age groups. For example, at age 17, boys had a mean BMI of 24.00 ± 1.33 kg/m² compared to 20.8 ± 1.77 kg/m² for girls, and a mean BSA of 1.50 ± 0.23 m² compared to 1.42 ± 0.24 m² for girls.

MUAC and Chest Circumference followed a similar trend, with boys showing slightly higher chest circumference (67.26 ± 11.81 cm vs. 63.25 ± 11.80 cm overall) but comparable MUAC values to girls.

PEFR increased with age in both genders, with boys consistently demonstrating higher values than girls. For instance, at age 17, boys had a mean PEFR of 366.36 ± 43.32 L/min, while girls had 339.86 ± 41.43 L/min.

Table 1: Distribution of Adolescents by Age and Gender (n=1,060)

Age (years)	Boys, n (%)	Girls, n (%)
12	87 (16.4)	86 (16.2)
13	78 (14.7)	78 (14.7)
14	84 (15.8)	85 (16.0)
15	88 (16.6)	87 (16.4)
16	95 (17.9)	95 (17.9)
17	98 (18.5)	99 (18.7)
Total	**530 (50.0)**	**530 (50.0)**

Table 2: Anthropometric Variables and PEFR by Age and Gender in Adolescents Aged 12-17 Years

Age	Sex	Height (m)	Weigh (kg)	BMI (kg/m2)	BSA (m2)	MUAC (cm)	Chest Circumference (cm)	Best PEFR (L/min)
12 yr	Boy	1.46 ± 0.1	41.98 ± 9.36	19.44 ± 1.71	1.16 ± 0.2	20.08 ± 3.77	58.21 ± 9.65	310.11 ± 41.4
	Girl	1.46 ± 0.1	36.62 ± 9.39	16.88 ± 2.05	1.11 ± 0.22	20.45 ± 3.45	58.98 ± 9.6	294.21 ± 39.99
13 yr	Boy	1.51 ± 0.09	50.34 ± 10.37	21.84 ± 1.93	1.29 ± 0.2	21.56 ± 9.79	60.97 ± 10.27	330.54 ± 37.59
	Girl	1.51 ± 0.09	44.22 ± 10.31	19.12 ± 2.22	1.26 ± 0.22	21.47 ± 9.84	62.14 ± 10.33	313.96 ± 36.12
14 yr	Boy	1.53 ± 0.1	53.25 ± 10.6	22.39 ± 1.71	1.35 ± 0.21	22.32 ± 10.03	64.99 ± 9.18	340.56 ± 39.3
	Girl	1.52 ± 0.1	46.4 ± 10.53	19.76 ± 2.06	1.3 ± 0.22	21.49 ± 10.22	65.12 ± 9.14	318.77 ± 37.54
15 yr	Boy	1.56 ± 0.1	57.1 ± 10.56	23.11 ± 1.32	1.42 ± 0.22	23.56 ± 10.52	67.99 ± 7.89	353.17 ± 41.77
	Girl	1.55 ± 0.1	49.43 ± 10.54	20.33 ± 1.7	1.36 ± 0.23	24.44 ± 10.31	68.1 ± 7.88	329.61 ± 40.3
16 yr	Boy	1.59 ± 0.1	60.12 ± 10.84	23.6 ± 1.4	1.47 ± 0.22	23.86 ± 10.4	73 ± 10.84	363.03 ± 40.76
	Girl	1.57 ± 0.1	51.7 ± 10.81	20.69 ± 1.79	1.41 ± 0.23	23.75 ± 10.39	72.95 ± 10.76	338.12 ± 39.17
17 yr	Boy	1.6 ± 0.11	61.79 ± 11.29	24 ± 1.33	1.5 ± 0.23	25.44 ± 10.62	76.24 ± 11.32	366.36 ± 43.32
	Girl	1.57 ± 0.11	52.31 ± 11.26	20.8 ± 1.77	1.42 ± 0.24	24.91 ± 10.69	75.86 ± 11.46	339.86 ± 41.43
Overall	Boy	1.54 ± 0.11	54.42 ± 12.50	22.46 ± 2.18	1.37 ± 0.24	22.95 ± 9.70	67.26 ± 11.81	344.98 ± 45.35
	Girl	1.53 ± 0.11	47.04 ± 11.81	19.65 ± 2.34	1.32 ± 0.25	22.92 ± 9.71	63.25 ± 11.80	323.26 ± 42.31

Table 3: Pearson Correlations (r) Between Mean PEFR and Mean Anthropometric Variables by Gender (Based on Aggregated Data from all Age Groups combined)

Variable	Boys		Girls	
	Pearson Correlation (r Value)	P value	Pearson Correlation (r Value)	P value
Height (m)	0.999	<0.001	0.999	<0.001
Weight (kg)	0.990	<0.001	0.990	<0.001
BMI (kg/m2)	0.914	<0.001	0.954	<0.001
BSA (m2)	0.997	<0.001	0.997	<0.001
MUAC (cm)	0.229	<0.001	0.229	<0.001
Chest Circumference (cm)	0.979	<0.001	0.979	<0.001

Overall, boys had a higher mean PEFR (344.98 ± 45.35 L/min) than girls (323.26 ± 42.31 L/min).

Table 3 highlights the Pearson correlation coefficients (r) between mean PEFR and anthropometric variables for boys and girls, based on aggregated data across all age groups. Height, weight, BMI, BSA, and chest circumference showed very strong positive correlations with PEFR ($r \geq 0.976$, $p < 0.001$) for both genders, indicating that these anthropometric factors are closely associated with lung function as measured by PEFR.

MUAC exhibited a weaker but still significant correlation with PEFR ($r = 0.229$, $p < 0.001$) in both boys and girls, suggesting a less pronounced influence compared to other variables.

The correlation coefficients were identical for boys and girls, indicating that the relationships between PEFR and anthropometric variables are consistent across genders in this population.

The subgraphs (Fig 1a-d) illustrate the strong positive relationships between mean PEFR and key anthropometric variables for boys across ages 12-17 years, based on data from Table 2. Fig 1a shows a scatter plot of PEFR (L/min) against height (m), depicting a linear increase from ~310 L/min at 1.46 m (age 12) to ~366 L/min at 1.60 m (age 17), with a perfect correlation ($r = 0.999$, $p < 0.001$). Fig 1b plots PEFR against weight (kg), showing a similar trend from ~310 L/min at 41.98 kg to ~366 L/min at 61.79 kg ($r = 0.990$, $p < 0.001$). Fig 1c displays PEFR versus body surface area (BSA, m^2), with PEFR rising from ~310 L/min at 1.16 m^2 to ~366 L/min at 1.50 m^2 ($r = 0.997$, $p < 0.001$). Fig 1d shows PEFR against chest circumference (cm), increasing from ~310 L/min at 58.21 cm to ~366 L/min at 76.24 cm ($r = 0.979$, $p < 0.001$). Each subgraph highlights a clear, linear relationship, emphasizing the influence of physical growth on lung function in boys.

The subgraphs (Fig 2a-d) mirror the trends for girls, showing strong positive correlations between mean PEFR and anthropometric variables across ages 12-17 years. Fig 2a plots PEFR against height (m), with PEFR increasing from ~294 L/min at 1.46 m (age 12) to ~340 L/min at 1.57 m (age 17) ($r = 0.999$, $p < 0.001$). Fig 2b shows PEFR versus weight (kg), rising from ~294 L/min at 36.62 kg to ~340 L/min at 52.31 kg ($r = 0.990$, $p < 0.001$). Fig 2c illustrates PEFR against BSA (m^2), increasing from ~294 L/min at 1.11 m^2 to ~340 L/min at 1.42 m^2 ($r = 0.997$, $p < 0.001$). Fig 2d depicts PEFR versus chest circumference (cm), growing from ~294 L/min at 58.98 cm to ~340 L/min at 75.86 cm ($r = 0.979$, $p < 0.001$). These linear trends underscore the significant impact of anthropometric growth on PEFR in girls, though with slightly lower PEFR values compared to boys.

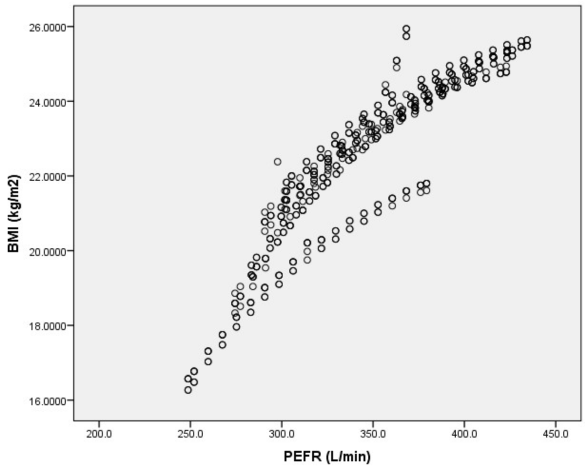

Fig 1a:

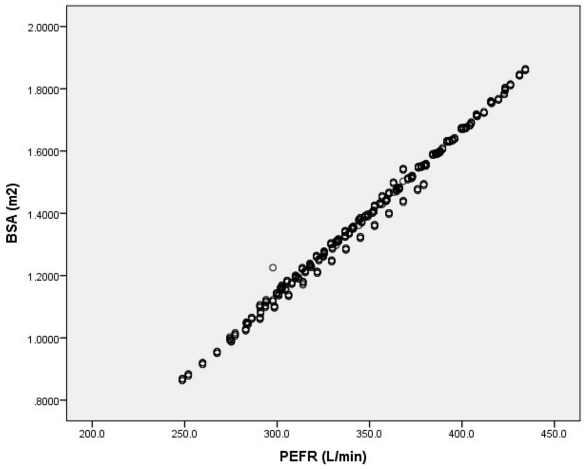

Fig 1b:

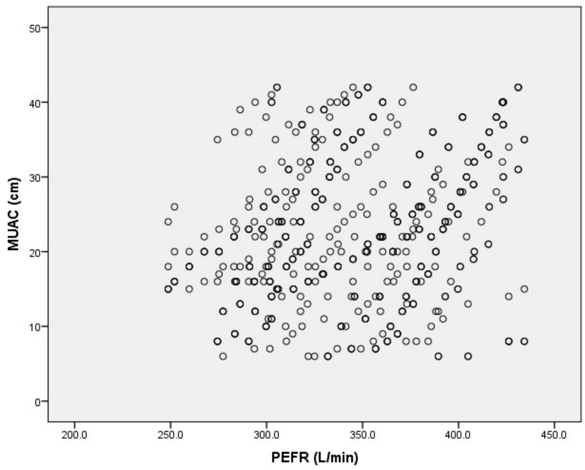

Fig 1c:

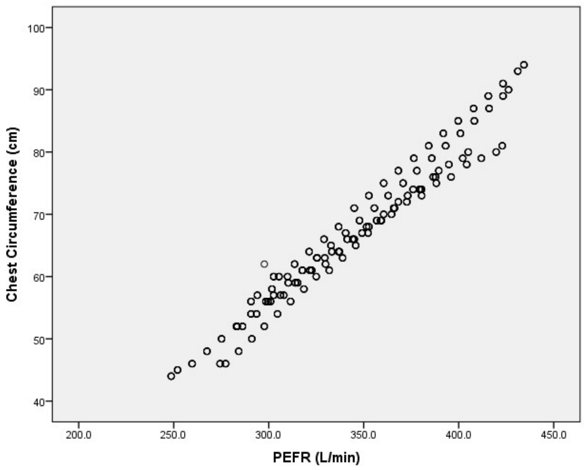

Fig 1d:

Figure 1: Relationships Between Peak Expiratory Flow Rate (PEFR) and Anthropometric Variables in Boys Aged 12-17 Years (1a: Peak Expiratory Flow Rate vs. Height, 1b: Peak Expiratory Flow Rate vs. Weight, 1c: Peak Expiratory Flow Rate vs. Body Surface Area (BSA), and 1d: Peak Expiratory Flow Rate vs. Chest Circumference)

DISCUSSION

Peak Expiratory Flow Rate (PEFR) is a straightforward, non-invasive method to assess respiratory function, particularly useful for monitoring conditions like asthma and evaluating treatment efficacy. This study, conducted among healthy urban Indian school adolescents aged 12-17 years in Surat, Gujarat, using a Mini-Wright Peak Flow Meter, aimed to establish normative PEFR values and investigate their relationships with anthropometric variables such as age, sex, height, weight, body mass index (BMI), body surface area (BSA), mid-upper arm circumference (MUAC), and chest circumference. The findings provide insights into how these factors influence PEFR in this population, contributing to region-specific reference values essential for clinical practice in India's diverse demographic and environmental landscape.[5] Various studies have used age, height, weight, and BSA to predict PEFR, either individually or in combination.[9-12] In this study, these variables, along with BMI, MUAC, and chest circumference, were analyzed to construct regression models for PEFR prediction. Height emerged as the most reliable and accurate measurement due to its ease of assessment and strong correlation with PEFR, unlike age or weight, which can be challenging to measure accurately in field settings.[7] Given that PEFR values vary with racial, socioeconomic, genetic, and lifestyle factors, region-specific reference values are crucial, as international standards may not fully apply to Indian adolescents.[5,7]

The study found a mean PEFR of 344.98 L/min (SD 45.35) for boys and 323.26 L/min (SD 42.31) for girls, with boys consistently showing higher values across all ages, aligning with findings from other Indian studies [7,13-16] For instance, at age 12, boys had a mean PEFR of 310.11 L/min (SD 41.4) compared to 294.21 L/min (SD 39.99) for girls, increasing to 366.36 L/min (SD 43.32) and 339.86 L/min (SD 41.43) at age 17, respectively. These results are consistent with studies like Abraham B et al.[13], which reported higher PEFR in boys, and Ramachandra K et al.[5], which noted mean PEFR values of 302 L/min for boys and 183 L/min for girls in a similar age range.

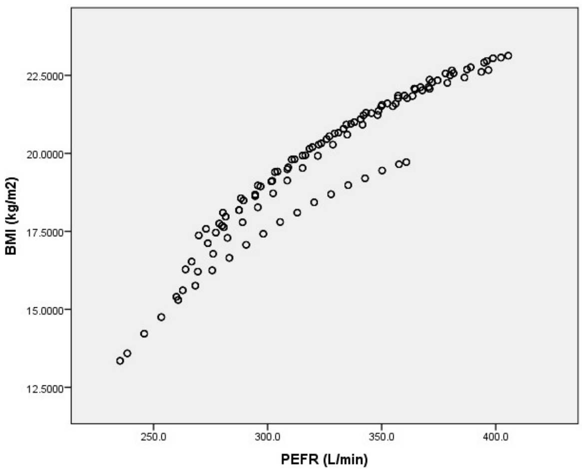

Fig 2a

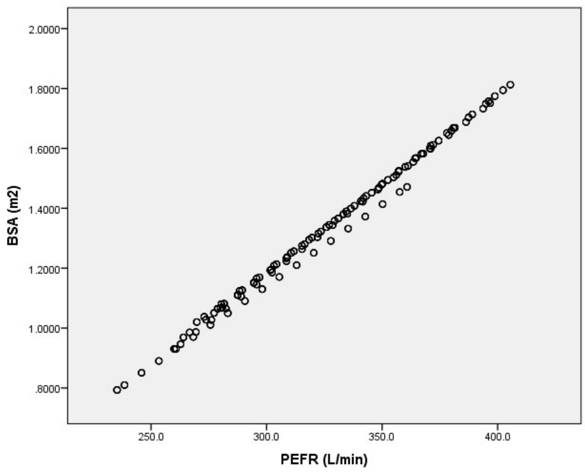

Fig 2b

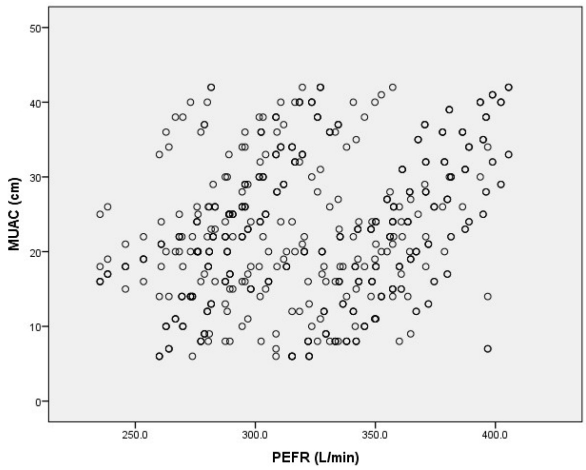

Fig 2c

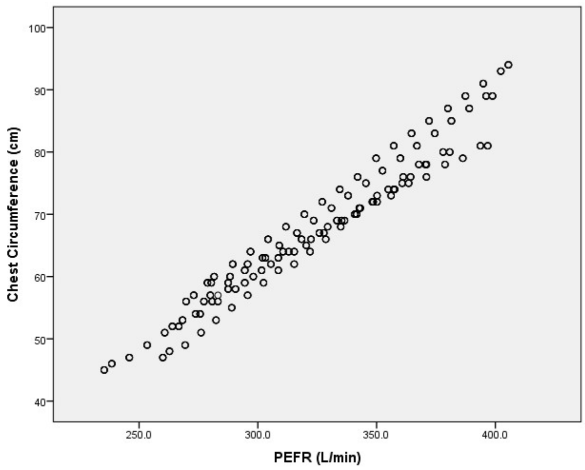

Fig 2d

Figure 2: Relationships Between Peak Expiratory Flow Rate (PEFR) and Anthropometric Variables in Girls Aged 12-17 Years (1a: Peak Expiratory Flow Rate vs. Height, 1b: Peak Expiratory Flow Rate vs. Weight, 1c: Peak Expiratory Flow Rate vs. Body Surface Area (BSA), and 1d: Peak Expiratory Flow Rate vs. Chest Circumference)

Regional variations were evident when comparing with studies like Parmar VR et al.[17], which found PEFR values in northern Indian adolescents comparable to Western populations, while Singh HD et al.[18] reported lower values in southern India. Malik SK et al.[19] found no urban-rural differences in Punjab, but Kashyap S et al.[20] noted comparable PEFR values in high-altitude tribal adolescents to urban northern Indian students, unlike lower values in rural Rajasthan reported by Sharma R et al.[21]. These discrepancies may reflect nutritional status, physical activity levels, or environmental factors, with urban adolescents potentially benefiting from better nutrition and activity, though further research is needed to confirm these influences.[13,21]

PEFR showed a strong positive correlation with age, with values increasing from 310.11 L/min at age 12 to 366.36 L/min at age 17 in boys, and from 294.21 L/min to 339.86 L/min in girls. Linear regression models yielded R^2 values of 0.7687 for boys and 0.7254 for girls, indicating that 76.87% and 72.54% of PEFR variability was explained by age, with a correlation coefficient of 0.859 ($p < 0.05$).[22-24] Studies like Sarawade S et al.[25] and Durairaj P et al.[1] similarly reported linear increases in PEFR with age, while Rahman MA et al.[26] noted higher PEFR values in boys (e.g., 354 L/min at age 12) than girls (312 L/min). Height was the most strongly correlated variable, with mean heights of 154.30 cm (SD 11.11) for boys and 153.13 cm (SD 10.79) for girls, and a correlation coefficient of 0.995 ($p < 0.001$), with R^2 values of 0.9823 and 0.9587, respectively. This aligns with findings by Pande JN et al.[22] and Chowgule RV et al.[23], who reported strong linear correlations between height and PEFR. Abraham B et al.[13] found a correlation coefficient of 0.96, with an R^2 of 0.919, reinforcing height as a key predictor.[27,16,28]

Weight also showed a strong correlation with PEFR, with mean weights of 54.42 kg (SD 12.50) for boys and 47.04 kg (SD 11.81) for girls, and a correlation coefficient of 0.972 ($p < 0.001$), with R^2 values of 0.9567 and 0.9356. Studies by Abraham B et al.[13] ($r = 0.791$, $R^2 = 0.625$) and Sagher FA et al.[24] ($r = 0.6$) confirmed this relationship, as did Carson JWK et al.[29] and Gharagozlo M et al.[30]. BMI, with means of 22.46 kg/m² (SD 2.18) for boys and 19.65 kg/m² (SD 2.35) for girls, correlated strongly with PEFR ($r = 0.858$, $p < 0.001$; $R^2 = 0.8395$ for boys, 0.733 for girls), consistent with Shubhankar M et al.[4], though Abraham B et al.[13] found no significant BMI correlation. BSA, averaging 1.37 m² (SD 0.24) for boys and 1.32 m² (SD 0.25) for girls, showed a near-perfect correlation ($r = 0.987$, $p < 0.001$; $R^2 = 0.9838$ for boys, 0.9719 for girls), supported by Vijay Krishna K et al.[31] and Parmar VR et al.[17]. Chest circumference, with means of 67.26 cm (SD 11.81) for boys and 63.25 cm (SD 11.80) for girls, also correlated strongly ($r = 0.914$, $p < 0.001$; $R^2 = 0.8253$ for boys, 0.8867 for girls), though Durairaj P et al.[1] noted it as the least correlated among anthropometric variables. MUAC, with means of 22.95 cm (SD 9.70) for boys and 22.92 cm (SD 9.71) for girls, showed a weaker correlation ($r = 0.458$, $p < 0.001$; $R^2 = 0.7047$ for boys, 0.7226 for girls), consistent with Abraham B et al.[13] ($r = 0.653$, $R^2 = 0.427$), indicating it is not independently associated with PEFR.

Multiple regression analysis confirmed that height, weight, BMI, BSA, age, and chest circumference were independently associated with PEFR, while MUAC was not, aligning with Abraham B et al.[13] and Sharma M et al.[32]. The higher PEFR values in boys compared to girls may be attributed to greater expiratory muscle strength, lung elastic recoil, and airway size, potentially influenced by higher physical activity levels in boys.[24] Regional differences, with lower PEFR values in southern Indian adolescents compared to northern or Western populations, may reflect variations in anthropometric parameters, nutrition, or environmental factors like pollution.[16,33] For instance, Swaminathan S et al.[16] reported lower PEFR values in Tamil Nadu compared to this study, while Taksande A et al.[27] noted higher values in Western children. These findings underscore the importance of region-specific reference values for adolescents, as inter-individual variability due to size, nutrition, and socioeconomic factors significantly affects PEFR.[7]

LIMITATIONS

The study was conducted in a single urban school in Surat, potentially limiting generalizability to rural or other urban populations. The sample size, though sufficient, was smaller than initially calculated, which may affect statistical power. Self-reported health status and non-inclusion of physical activity status could introduce bias. Environmental factors like air pollution were not assessed which my influence PEFR measurements. PEFR measurements were not adjusted for temperature or altitude, as Surat's conditions could affect readings, however, all measurements were taken within a short span of time at the same location, so, chances of inter observation effect is very low, however, it should be taken into account when this study data is compared with other region.

CONCLUSION

This study established normative PEFR values for healthy urban Indian adolescents aged 12-17 years, demonstrating strong correlations with height, weight, BMI, BSA, and chest circumference, with height being the most significant predictor. Boys exhibited higher PEFR values than girls, reflecting physiological differences. These findings highlight the need for region-specific reference values in India due to variations in anthropometric and environmental factors. The data provide a foundation for clinical assessment of respiratory function in adolescents, aiding in the early detection and management of conditions like asthma. Future studies should explore rural populations and environmental influences to enhance the applicability of PEFR reference standards across diverse Indian settings. Multicentric studies to validate norms across India among diverse sample are needed.

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Availability of Data: The data generated during this study are available upon reasonable request. Interested readers may contact the corresponding author.

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