Patterns of Peak Expiratory Flow Rate Among School-aged Children in Ilorin, North-Central Nigeria.

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ABSTRACT

Peak expiratory flow rate (PEFR), which is necessary to evaluate a child with hyperactive airway diseases such as asthma, is influenced by anthropometry, age, ethnicity, and gender. Hence, we sought to determine the PEFR, explore the relationship with anthropometric parameters, and derive a nomogram among a cohort of 1745 school-aged children in Ilorin, North-Central Nigeria.The study was an analytical cross-sectional study involving school-aged children systematically recruited in Ilorin from public and private primary schools. We collected their socio-demographic and anthropometric parameters and assessed the PEFR with a hand-held Peak Flow Meter (HS Clement Clarke International, Harlow, United Kingdom).Data was analysed with SPSS 20. The overall mean PEFR of 170.45 ± 48.32 L/min was higher in males compared with females (178.32 ± 47.53 vs 162.57 ± 47.85 L/min, p<0.001). In males and females, the PEFR increased with age, weight, and height, with a correlation coefficient ranging from 0.47 to 0.59, p< 0.05. The height-independent equations for predicting PEFR in males and females were [-122.17 + age (years)* 3.95 + height (cm)* 2.06, p<0.001] and [-106.27 + age (years)* 4.87 + height (cm)* 1.74,p<0.001)], respectively. Also, the predicted PEFR was comparable to the observed PEFR among the study children. This study shows PEFR was higher in males than females, with a moderate correlation with the anthropometric parameters. The derived height-independent equations for predicting PEFR were comparable with observed values.

Keywords: Anthropometry; Height;Nigeria; Peak expiratory flow rate;School-aged children.

INTRODUCTION

Measurement of the peak expiratory flow rate (PEFR) is a simple, inexpensive and reliable way of assessing and monitoring the degree of airway obstruction in children with asthma, which could be done and recorded by the child or care giver at home.[1] For a meaningful interpretation of PEFR results in ill children, it is necessary to establish the normal range of observations specific to a population,such as age and gender. The ethnicity, socioeconomic, anthropometric, nutritional and environmental factors have been identified to be determinants of the PEFR measurement.[2-4] Though there are studies on PEFR in Nigerian children, these studies were conducted more than two decades ago without detailed nomograms.[3,5] Therefore, the objectives of the current study were to describe the PEFR of healthy school children aged 6 to 12 years, explore the relationship with anthropometric

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MATERIALS AND METHODS

Study design and settings: This study was an analytical cross-sectional school-based survey carried out over six months (December 2015 to May 2016) among primary school pupils aged 6-12 years in Ilorin, the capital city of Kwara State, North-Central Nigeria. Ilorin had an estimated population of 3,259,613 1,049in 2019 based on the 2006 population census results and an annual growth rate of 2.6%.[7] The main tribes in Ilorin include Yoruba, Hausa, Fulani, Nupe, Kanuri, and Igbos. The typical settlement pattern in Ilorin is urban, semi-urban and rural communities spanning three local government areas (LGA), namely Ilorin West, Ilorin East and Ilorin South.

The capital city has primary, secondary and tertiary educational institutions providing education to the population. Based on the school lists from the State Ministry of Education (at the time of this study), there are 659 primary schools (public and private) in Ilorin: 55 public primary and 205 private primary schools in Ilorin West, 55 public schools and 176 private primary schools in Ilorin South while Ilorin East has 79 public schools and 89 private schools. The three Local Government Areas (LGAs) have a combined population of 109,492 primary school children (Ilorin West has a population of 50,297 [45.9%], Ilorin South and Ilorin East have 31,610 [28.9%] and 27,585 [25.2%] primary school children, respectively).[8]We enrolled pupils from both public and private primary schools in Ilorin.

*Sample size determination***:** Using the Yamane formula (**n** = N / 1+Ne^2),[9]where 'N'is the size of the study population (109,492), and 'e' is the level of precision (2.5%), the minimum sample size calculated was 1577; however,we enrolled 1745 pupil considering a 10% attrition.

Inclusion criteria were all apparently healthy primary school pupils of the selected schools aged 6-12 years. Excluded from the study were children whose parents/guardians declined consent, known with asthma or cardiovascular problems such as

total populations such that 801 (45.9%), 504 (28.9%) and 440(25.2%) students were recruited from Ilorin West, South and East, respectively. A multi-stage stratified random sampling technique was used to select pupils from each LGA after using the school lists provided by the Kwara State Ministry of Education to stratify schools into private and public primary schools. Further selection utilised the proportion of the pupils in the three LGAs and the ratio of public to private primary schools (Figure 1).

Data collection procedure:Before recruitment, an information sheet detailing what the study was all about, a consent form and the study proforma were given to all the eligible subjects for their respective parents/guardians to fill.We enrolled those whose parents/guardians consented to the study.The semi-structured proforma contained information on socio-demographic characteristics and relevant information. All subjects had general physical, respiratory and cardiovascular systems examinations. The height of each pupil was measured in the upright position without shoes to the nearest 0.1 cm with the stadiometer, while the weight was measured to the nearest 0.1 kg with the pupils lightly dressed and shoes removed. The weighing scale was adjusted to zero reading before each measurement. Body Mass Index (BMI) was calculated as body weight in kilograms divided by height in meters squared.

The research team conducted the examinations and measurements in a separate room provided by the school between 9 a.m. and 2 p.m., with pupils called out in batches of 10. These activities were during the school break times to minimise the disruption of academic activity in school. All the measurements were carried out by the investigator and either of three trained research assistants.

The PEFR was assessed using a hand-held Peak Flow Meter (*HS Clement Clarke International*, Harlow, United Kingdom) capable of measuring the PEFR in a single breath. All the children were initially taught and then taken through practical maximum inspiration. Disposable mouthpieces were used and discarded after use by the pupils in a waste bin. We recorded three consecutive values taken in the standing position and chose the best for analysis.

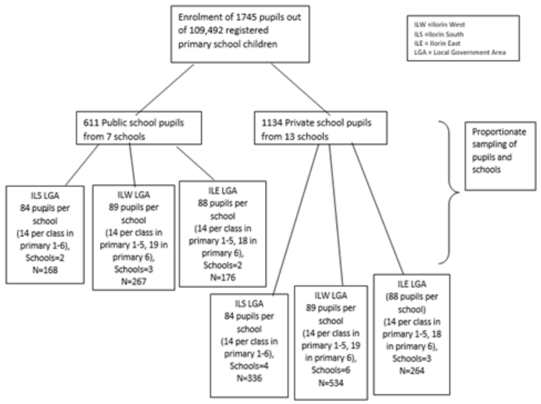


Figure 1: Flow chart of recruitment of pupils from the schools.

Ethical approval was obtained from the University of Ilorin Teaching Hospital Ethical Review Committee and written permission from the Kwara State Ministry of Education. Also, we had approval from the school authorities of the selected institutions. Furthermore, we sought individual written consent from the parents/guardians of the subjects. Assent was also sought from subjects aged ten years and above

Data analysis: Data recorded on the proforma were entered into a microcomputer using numerical codes and analysed with SPSS version20. After ensuring normally distributed quantitative variables, descriptive statistics such as the mean and standard deviation (SD) were calculated, and the student's t-test was used to compare the means of continuous variables. A scattergram was used to show the relationship between the age and anthropometry measurements in the male and female children. A linear regression analysis was used to determine the independent predictors (age and anthropometrics parameters) of changes in the lung function indices of the study population. The p-value of less than 0.05 was considered significant.

RESULTS

included 873 (50.0%) males and 872 (50.0%) females. The pupils from public primary schools were 611 (35.1%) while the remaining 1134 (64.9%) were from private schools. Table 1 shows that the females' mean weight was significantly higher than the weight of the boys; however, the other anthropometric parameters and mean age were comparable.

Mean PEFR in the study pupils

The overall mean PEFR in males was significantly higher than in females, $p<0.0001$. Among the different ages, the mean PEFR was also significantly higher in males than females except for ages 9 and 12 years (Table 2). The children's mean PEFR increased with age (F= 101.432, $p<0.0001$).

Relationship between age and PEFR

In males, there was a moderate positive correlation between age and PEFR (r= 0.47, p<0.0001). There was a significant relationship in the linear regression analysis of age as an independent predictor of PEFR (β=11.683, p<0.001) in males (Figure 2A). Similarly, in females, there was a moderate positive correlation between age and PEFR (r=0.54, p<0.0001). There was a significant relationship in the linear regression analysis of age as an independent predictor of PEFR (β=13.063, p<0.0001) in females (Figure 2B).

Relationship between anthropometry and PEFR

In males, there was a moderate positive correlation between the height and PEFR (r= 0.54, p<0.001) with a linear regression analysis of height as an independent predictor of PEFR (β=2.61, p<0.001) as shown in Figure 3A. In females, there was also a moderate positive correlation between the height and PEFR (r=0.59, p<0.001) and a significancein the linear regression analysis of height as an independent predictor of PEFR (β=2.39, p<0.001) as shown in Figure 3B.

In males, there was a moderate positive correlation between the weight and PEFR (r= 0.52, p<0.001) and a significant relationship in the linear regression analysis of weight as an independent predictor of weight and PEFR (r=0.56, p<0.001) and a significant relationship in the linear regression analysis of weight as an independent predictor of PEFR (β=3.81, p<0.001), Figure 3D.

The mean PEFR increased with height and weight with generally higher mean values in males compared with females (Table 3).

Age, gender and height-specific nomogram for school children

In males, the linear regression equation derived from the age and height was used to generate the nomograms (Figure 4A). The equation in males was PEFR= -122.17 + Age (Years)* 3.95 + Height (cm)* 2.06, (R^2=0.31, p<0.0001). In females, the linear regression equation derived from age and height was used to generate the nomogram (Figure 4B). The equation in females was PEFR= -106.27 + Age (Years)* 4.87 + Height (cm)* 1.74 (R^2=0.36, p<0.0001).

Also, using the derived regression equations, we obtained predicted PEFR, which was comparable with the observed mean PEFR among the children in both males and females (Table 4).

Variable	Total Mean ± SD	Males Mean ± SD	Females Mean ± SD	p
Age (years)	**8.98 ± 1.94**	9.04 ± 1.91	8.91 ± 1.98	0.168
Height (cm)	128.96 ± 10.89	128.47 ± 9.88	129.44 ± 11.79	0.062
Weight (Kg)	25.73 ± 6.41	25.33 ± 5.63	26.12 ± 7.08	0.011
BMI (Kg/m^2)	15.25 ± 1.90	15.18 ± 1.68	15.33 ± 2.10	0.101

BMI: Body mass index; SD-Standard deviation.

Table 2: Comparison of the measured PEFR in males and females

Age (Years)	Total PEFR (L/min) Mean ± SD (n)	Males PEFR (L/min) Mean ± SD (n)	Females PEFR (L/min) Mean ± SD (n)	*P*
6	135.17± 33.72 [a] (268)	146.02 ± 33.38 (113)	127.26 ± 31.81 (155)	<0.001
7	141.96 ± 34.14 [a] (179)	152.75 ± 31.52 (102)	127.66 ± 32.35 (77)	<0.001
8	161.83 ± 41.42 [b] (282)	167.19 ± 43.07 (139)	156.61 ± 39.22 (143)	0.032
9	167.18 ± 35.98 [b] (271)	169.60 ± 34.83 (138)	164.66 ± 37.10 (133)	0.259
10	183.57 ± 44.29 [c] (312)	196.57 ± 46.37 (153)	171.06 ± 38.36 (159)	<0.001
11	189.83 ± 44.23 [c] (207)	195.80 ±38.32 (119)	181.76 ± 50.26 (88)	0.024
12	213.65 ± 54.16 [d] (226)	216.24 ± 58.19 (109)	211.24 ± 50.24 (117)	0.489
6-12	170.45 ± 48.32 (1745)	178.32 ± 47.53 (873)	162.57 ± 47.85 (872)	<0.001

The abcd Turkey Post hoc test shows that means with similar alphabets are not significantly different

Table 3: Comparison of PEFR based on the height (cm) and weight (Kg)

Height range (cm)	Male Mean ± SD L/min (n)	Female Mean ± SD L/min (n)	*p*	Weight (Kg)	Male Mean ± SD L/min (n)	Female Mean ± SD L/min (n)	*p*
100-109	109.1 ± 19.4 (21)	114.5 ± 54.8 (21)	0.668	10-19	150.5 ± 36.6 (163)	125.69 ± 28.6 (182)	< 0.001
110-119	153.3 ± 37.6 (149)	126.4 ± 27.6 (208)	< 0.001	20-29	175.7 ± 40.4 (539)	161.0 ± 39.1 (479)	< 0.001
120-129	167.6 ± 30.8 (311)	154.3 ± 36.5 (236)	< 0.001	30-39	209.5 ± 54.3 (157)	193.5 ± 49.7 (162)	0.007
130-139	191.1 ± 45.0 (302)	176.9 ± 36.2 (245)	<0.001	40-49	249.6 ± 69.3 (12)	211.4 ±63.9 (47)	0.074
140-149	219.3 ± 52.5 (73)	199.3 ± 55.0 (109)	< 0.015	50-59	275.0 ± 35.4 (2)	250.0 ± 21.2 (2)	0.482
150-159	266.7 ± 77.2 (12)	220.7 ± 39.6 (44)	0.006				

Age (years)	Male				Female			
	n	Predicted PEFR (L/min)	Observed Mean PEFR (L/min)	p	n	Predicted PEFR (L/min)	Observed Mean PEFR (L/min)	p
6	113	142.8 ±15.5	146.0 ± 33.4	0.355	155	125.7 ± 8.9	127.3 ± 31.8	0.547
7	102	154.2 ± 11.6	152.8 ± 31.5	0.674	77	135.6 ± 11.4	127.7 ± 32.4	0.050
8	139	164.2 ± 13.2	167.2 ± 43.1	0.433	143	151.2 ± 12.8	156.6 ± 39.2	0.118
9	138	181.8 ± 13.2	169.6 ± 34.8	0.001	133	162.5 ± 11.8	164.7 ± 37.1	0.515
10	153	189.0 ± 13.5	195.6 ± 46.4	0.092	159	174.0 ± 13.0	171.1 ± 38.4	0.368
11	119	200.6 ± 15.0	195.0 ± 38.3	0.139	88	192.5 ± 14.6	181.8 ± 50.3	0.057
12	109	212.5 ± 15.5	216.2 ± 58.2	0.522	117	203.7 ± 15.1	211.2 ± 50.2	0.123

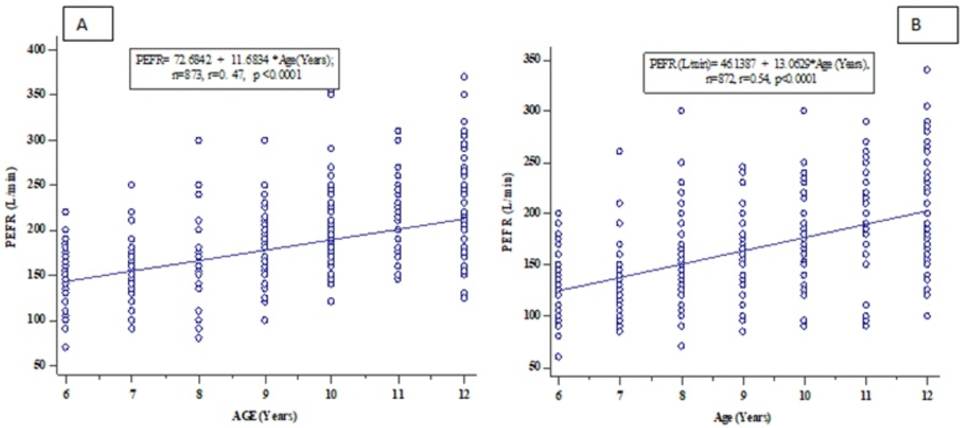
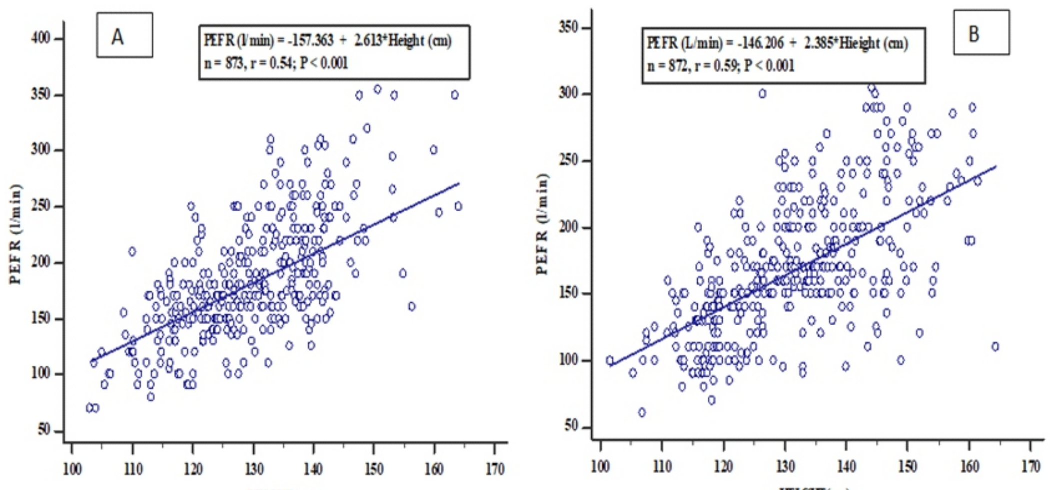


Figure 2: The scattergram of age and PEFR with a regression line and equation for males (A) and females (B).



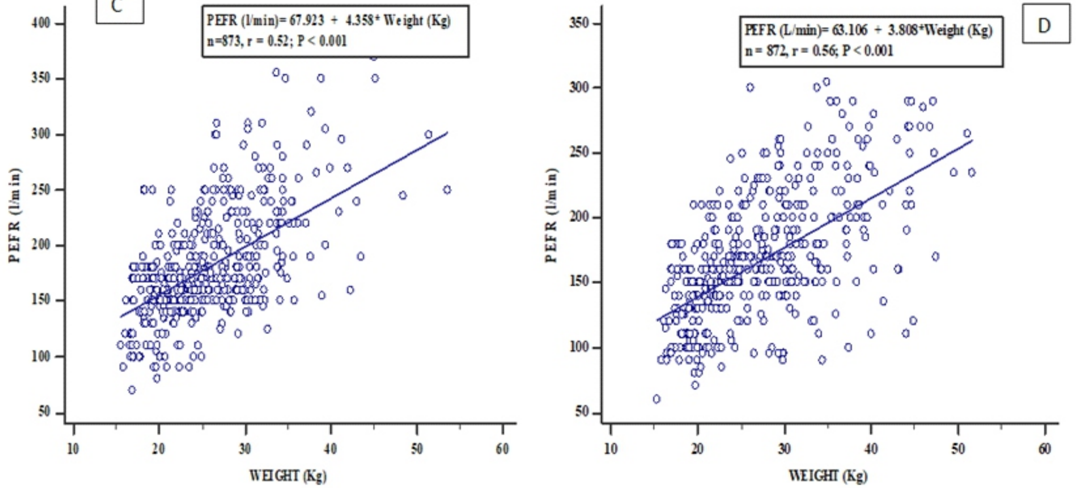
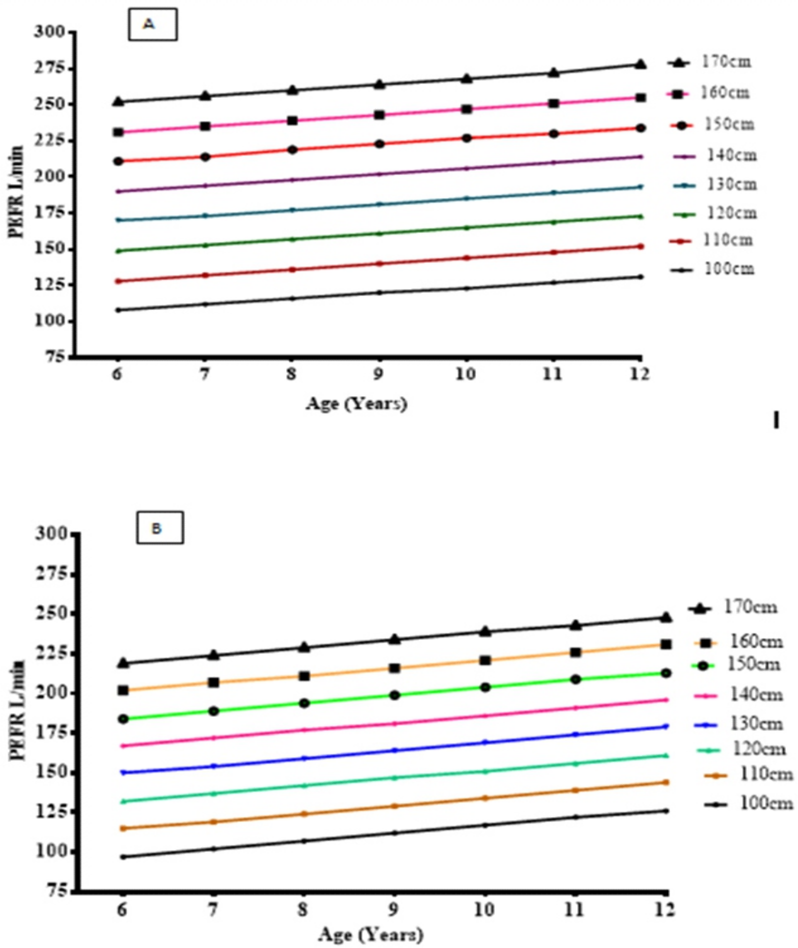


Figure 3:The scattergram diagrams of height and PEFR with a regression line and equation for males (A) and females (B); and the weight and PEFR with the regression line for males (C) and females(D)



The determinants of PEFR include ethnicity,anthropometrics, and environmental factors[2,10]and the current study provides valuable insights into the PEFR of a cohort of 1745 school-aged children in Ilorin. North-central Nigeria.Though the mean PEFR obtained in this study is lower compared to a similar study in northcentral Nigeria,[3]a notable trend observed in this study was the consistent increase in mean PEFR with increasing age among the study participants. This finding is in keeping with reports from previous studies.[3, 6, 10-13]These observed patterns of PEFR align with the expected developmental trajectory of lung functions during childhood and adolescence. As children grow and mature, their lung volumes and capacities tend to increase, leading to improved respiratory functions.

Another finding from our study was the differences in the PEFR between males and females, with males exhibiting a higher mean value. This gender difference in lung function is consistent with existing literature, suggesting that males tend to have larger lung capacities and greater lung function than females.[6,10,11]Understanding these gender-specific differences in lung function can be crucial for evaluating respiratory health and addressing potential respiratory issues in school children, particularly in environmental exposures or respiratory illnesses.

The anthropometric parameters (weight and height) showed a moderate positive correlation with the mean Peak Expiratory Flow Rate as reported in other studies.[3, 6, 10-15] Further analysis demonstrated that height significantly predicts PEFR in both males and females. This finding suggests that as individuals increase in height, their PEFR tends to increase as well, reinforcing the fact that height plays a role in explaining variations in PEFR as in other studies.[3,6,10-12,15]The observed relationship between height and PEFR can be explained by several factors. First, taller individuals typically have larger lung volumes due to increased thoracic cavity size. This larger lung capacity allows for greater air intake and exhalation, muscle mass. Stronger respiratory muscles in taller individuals could contribute to increased force during expiration, potentially leading to higher PEFR values. Lastly, genetic and developmental factors may also play a role in the observed relationship, but further research is needed to explore these aspects.[2] Additionally, our findings highlight the importance of considering gender differences when using height as a predictor for PEFR. Healthcare providers should be cautious when applying reference values for PEFR, as these values may need to be gender-specific and adjusted based on height to account for variations in lung functions.[15,16]

The positive correlation and the regression analyses provide robust evidence that weight explains variations in PEFR among individuals. This finding suggests that as individuals' weight increases, their PEFR tends to increase as well. Several mechanisms may explain the observed relationship between weight and PEFR.[2] First, increased body weight may lead to larger lung volumes, which can accommodate greater air intake and exhalation, potentially resulting in higher PEFR values. Second, higher body weight is often associated with increased muscle mass, which can enhance the force generated during expiration, contributing to higher PEFR values. Third, adipose tissue is prevalent in individuals with higher body weight, may serve as a reservoir for energy, potentially benefiting respiratory muscle function. Our findings also emphasis the importance of considering gender-specific factors when using weight as a PEFR predictor. Hence, healthcare providers should be mindful of potential variations in the relationship between weight and PEFR based on gender, and they may need to adjust reference values accordingly.

The predicted PEFR from the height equation was also comparable to the mean observed values, consistent with a study reported in India.[16] The implication of this is that with a known height of a pupil, the expected PEFR can easily be derived from the equation. A few studies derived nomograms in this study have both the age and various heights based on sex and, as such, may be helpful in primary health care levels.

Strengths and Limitations

The strengths of this study include a large sample size (1745) and involved primary school pupils selected across rural, semi-urban and urban parts of Ilorin in North-central Nigeria. However, our limitation is mainly that this study is limited to Ilorin, part of north-central Nigeria; hence, we cannot generalise our findings to the whole country.

CONCLUSION

This study shows a lower mean PEFR compared to some studies in Nigeria, with a moderate correlation of the anthropometric parameters with PEFR in both males and females. The derived equation for predicting PEFR shows comparability with observed values. Hence, the derived charts based on the age and sex for various heights may be helpful in the evaluation of a child with hyperactive airway disease.

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Conflict of interest: None declared.

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