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Spirometric Values in Healthy Nigerian School Children Aged 6-11 Years

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Authors' contributions

This work was carried out in collaboration between both authors. Author HOA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author IA managed the analyses of the study. Authors HOA and IA managed the literature searches. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Background: Respiratory disorders are among the leading cause of morbidity and mortality in children and the use of spirometry in measuring lung function, diagnosing and monitoring of variety of paediatric respiratory diseases is becoming relevant.

Aims: To determine the standard Forced vital capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1) and Peak Expiratory Flow Rate (PEFR) values for children in this environment.

Methods: The study was descriptive cross sectional study of 710 primary school pupils aged 6-11 years in Kano metropolis.

Results: There was no significant difference in the mean anthropometry and lung function parameter between the males and females studied. The result of this study showed that on the average the $FEV_{1,}$ FVC and PEFR was slightly higher in boys for most ages and the mean Lung function parameters increased with height. When compared to studies in Caucasians, this study had higher mean PEFR for height while the mean FEV_1 and FVC values were lower than that in those studies. The predictive regression equation for the major lung function parameters for both gender were also obtained. FEV_1 – Male: 0.018H+-1.099, Female: 0.019H + - 1.142. FVC- Male: 0.018H + - 1.057 while Female was 0.019H+ -1.181 and PEFR - Male was 0.069H + -5.344 while Female was 0.052H + -3.153.

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Conclusions: It is necessary for African countries especially Nigeria, to have validated Spirometric reference values for children.

Keywords: Cross-sectional studies; Nigerian; healthy children; predictive equation; spirometry.

1. INTRODUCTION

Respiratory disorders account for considerable morbidity and mortality in children and the use of spirometry in measuring lung function and in diagnosing and monitoring variety of paediatric respiratory diseases is on the rise [1]. Lung function indices commonly used for the estimation of lung function are forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1) and peak expiratory flow rate (PEFR). Lung function is however known to be influenced by environmental factors, ethnicity, sex, age, height and weight [2]. The spirometers imported into Africa are calibrated for the physical characteristics of Caucasian subjects who are exposed to different environmental and socioeconomic conditions different from African subjects; furthermore African authors have shown that the lung volumes of African children are approximately 20% lower than those of Caucasian children of equal height [3,4]. It has also been observed that applying prediction formula derived for Caucasian population always overestimated the values for black Africans [5]. Therefore standard values for European and American subjects cannot be properly applied to the African population. Hence African countries especially Nigeria, should have validated spirometric reference values for children. To the best of the authors knowledge, review of the literature showed that limited studies [6,7] have been done in Nigeria to determine the spirometric reference values for normal Nigerian children [6,7]. This study was therefore conducted on healthy Nigerian children with the aim of determining the standard FVC, FEV_1 and PEFR values for children in our environment.

2. SUBJECTS AND METHODS

This was a descriptive cross sectional study of primary school pupils aged 6-11 years in Kano metropolis. *The sample size* was determined using the published table by Krejcie and Morgan [8]. A margin of error of 5% and 99% confidence interval was used to calculate the sample size which came out to be 646 pupils. Adding 10% for possible drop out, the study recruited 710 pupils.

The subjects were identified and each received the consent forms, patient information sheets and questionnaires. Subjects with symptoms or confirmed diagnosis of cardio-respiratory morbidities like asthma, pulmonary tuberculosis, chronic suppurative lung diseases or congenital heart disease; similarly subjects with common cold and those who were unable to perform the required spirometric tests were excluded from the study.

Ethical approval was obtained from the hospital Ethics Committee, the State Ministry of Education and the State Universal Basic Education Board. Written consent was obtained from individual parents and assent from children older than the age of seven years.

Each subject was informed a day prior to their testing that on the test day, they were to have their breakfast by 6am and not to participate in any form of vigorous activity. On the test morning the pupils were rested for at least 30 minutes before the tests.

The height and weight of each child was measured using the combined measuring scale for height and weight to the nearest 0.1 cm for height and nearest 0.1 kg for weight.

The Spirometer (Spiro lab III ™ diagnostic spirometer series MIR009 with a color liquid crystal display (LCD) and *Winspiro Pro* PC Software enhanced to comply with the American Thoracic Society and European Thoracic Society 2005 statement on spirometry). had a daily calibration check with the 3 Litre calibration syringe. The procedure for the required pulmonary function tests was demonstrated to each child and the spirometric test was performed with the patient in the sitting position. The child was required to perform the required vital capacity maneuver by blowing maximally through the mouthpiece with manual occlusion of the nares after a deep inspiration and each child performed the procedure thrice and the *best of the three* measurements was recorded as the child's pulmonary function value.

The data was pooled from the questionnaire designed for the purpose of this study. The pooled data was analyzed using SPSS version-16. Qualitative data was represented as percentages, while quantitative data was recorded as mean values and standard deviation (SD). Chi square (*χ^2*) test was used to determine associations between the categorical variables; The Student t-test was used to compare the means and standard deviations of the quantitative variables. A *p*-value of <0.05 was considered statistically significant.

3. RESULTS

A total of 710 pupils were studied. Their age and gender distribution as well as the mean height and lung function parameters are shown in Table 1. There was no statistically significant difference in the mean anthropometry and lung function parameter between the males and females studied.

The mean lung function parameters versus height intervals of 10cm are represented in Tables 2 and 3 while the regression equation for predicting the lung function parameters for height, age and weight are represented in Table 4. The mean FEV_1, FVC, PEFR for age at the 25^{th}, 50^{th}, 75^{th} and 95^{th} percentile for males and females are represented in Figs. 1-6. The FEV_1, FVC are measured in Litres while PEFR is measured in Litres per second.

The study comprised of 379 males and 331 females. The male to female ratio was 1: 0.9. There was no statistically significant difference in the mean height or lung function parameters of the males and females studied (See Table 1).

The mean lung function parameters for height of the males and females studied were calculated and it was observed that on the average the males had higher lung function for height than their female counterparts. A predictive regression equation was also generated for the male and female subjects. See Tables 2, 3 and 4.

Table 1. Sociodemographic characteristics, mean height and lung function parameters of the study population

Variable	Number (%)		
Age (years)			
6	99 (13.9)		
7	112 (15.8)		
8	116 (16.3)		
9	137 (19.3)		
10	126 (17.7)		
11	120 (16.9)		
Gender			
Male	379 (53.4)		
Female	331 (46.6)		
Social class			
1	114 (16.1)		
2	171 (24.1)		
3	166 (23.4)		
4	120 (16.9)		
5	139 (19.6)		
Means	**Number ± SD**	**Df**	**P**
Height (cm)			
Male	128.8 ± 9.8	708	0.07
Female	127.5 ± 9.4		
FEV_1 (Litres)			
Males	1.28±0.33	708	0.64
Females	1.27±0.34		
FVC (Litres)			
Male	1.30 ±0.34	708	0.26
Female	1.27 ±0.34		
PEFR (Litres/sec)			
Male	3.56 ± 1.14	708	0.15
Female	3.44 ± 1.03		

FEV_1- Forced expiratory volume in one second, FVC - Forced vital capacity, PEFR- Peak expiratory flow rate. SD- Standard deviation, P- Significant at ≤0.05

The lung function parameters measured were further divided into percentiles for age and sex. Hence the 25th, 50th, 75th and 95th percentiles are represented, making assessing the lower limit and upper limit of normal for each lung function at a glance easier (see Figs. 1-6).

4. DISCUSSION

Spirometry is the method of choice for evaluation of pulmonary function [2,9,10]. It is indicated in all children with recurrent respiratory diseases, such as in the clinical diagnosis of asthma, chronic/ recurrent cough or wheeze, exercise induced cough or breathlessness amongst others [1].

In the United Kingdom, The National Study of Health and Growth (NSHG) of children aged 5 to 11 years studied the respiratory health in ethnic minority children [11]. In that study, Black African/Caribbean and South Asian children were found to have lower FEV_1 and FVC than their white counterparts with the lowest values being observed in Black African/Caribbean boys. Some other studies [12-14] also found Black Caribbean and Indian children (primary school aged and 5–16 years of age) had FEV_1 and FVC values 8 to 13% lower than whites. These previous studies buttresses the fact that ethnicity and environmental exposures play a role in determination of lung functions thereby suggesting that to effectively define what baseline lung function in African children is, the study has to be carried out in Africa. It also brings to the fore the recommendation by Withrow et al. [15] that the use of reference values that adjust for ethnic differences in anthropometric differences may obscure the effect of environmental exposures and lead to complacency toward lower spirometric indices.

Table 2. Mean FEV_1, FVC, PEFR for height in boys

Height (cm)	FEV (Litres) Mean±SD	FVC (Litres) Mean±SD	PEFR (Litres/sec) Mean±SD
100-109	0.73	0.74	2.68
110-119	1.10±0.21	1.03±0.20	2.78±0.50
120-129	1.20±0.32	1.22±0.31	3.17±0.96
130-139	1.36±0.26	1.37±0.27	3.66±0.99
140-149	1.51±0.33	1.54±0.35	4.88±1.03
150-159	2.14±0.12	2.14±0.12	4.98±0.30

Table 3. Mean FEV_1, FVC, PEFR for height in females

Height (cm)	FEV (Litres) Mean±SD	FVC (Litres) Mean±SD	PEFR (Litres/sec) Mean±SD
100-109	0.69	0.77	1.98
110-119	1.01±0.19	1.04±0.19	2.83±0.51
120-129	1.25±0.31	1.23±0.30	3.41±0.85
130-139	1.34±0.32	1.33±0.33	3.47±1.11
140-149	1.55±0.35	1.60±0.38	4.51±1.14
150-159	1.70±0.74	1.86±0.96	5.05±1.04

Table 4. Predictive regression equations of spirometric parameters versus children's height, age and weight

Dependent variable	Gender	Predictive regression equation		
		Height	Age	Weight
FEV_1 (Litres)	Male	0.018H + - 1.099	0.096A + 0.440	0.024W + 0.648
	Female	0.019H + - 1.142	0.107A + 0.351	0.023W + 0.693
FVC (Litres)	Male	0.018H + - 1.057	0.091A + 0.509	0.022W + 0.710
	Female	0.019H + - 1.181	0.100A + 0.431	0.022W + 0.726
PEFR (Litres/sec)	Male	0.069H + - 5.344	0.347A + 0.551	0.90W + 1.226
	Female	0.052H + - 3.153	0.269A + 1.146	0.68W + 1.758

H- For height in centimeters; A- For age in years; W- Weight in Kg

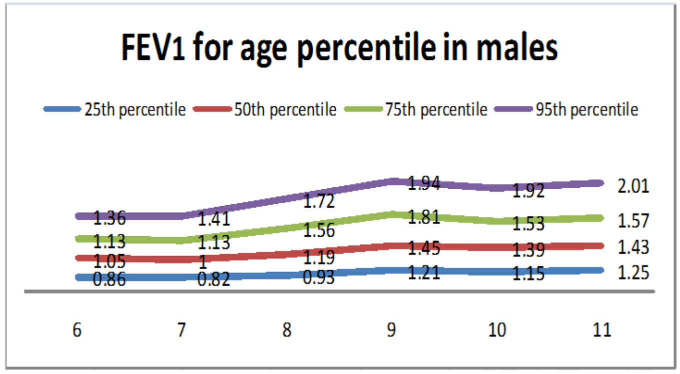

Fig. 1. FEV$_1$ for age percentiles in males

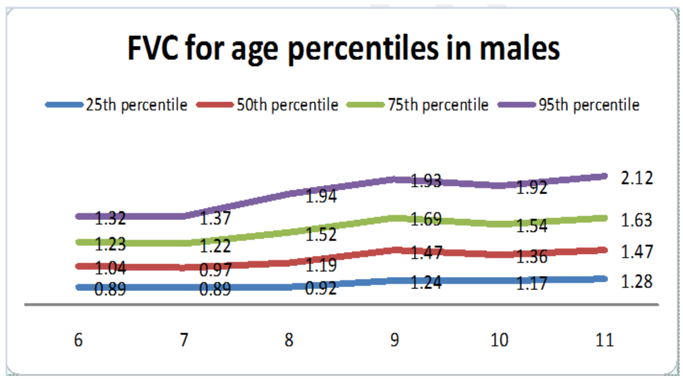

Fig. 2. FVC for age percentiles in males

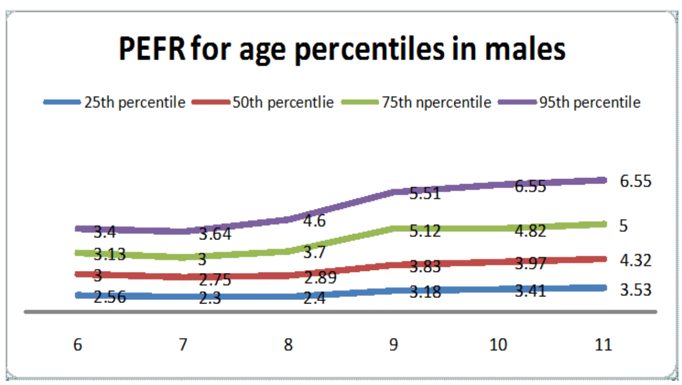

Fig. 3. PEFR for age percentiles in males

The result of this study showed that on the average the FEV$_1$, FVC and PEFR was slightly higher in boys than girls for most ages and the mean lung function parameters increased with height. This is supported by previous studies that have demonstrated that at any given height boys have higher FEV$_1$ and FEV values than girls. [9,16-18] this has been attributed to the differences in thoracic size [19,20].

When compared to the European thoracic society and the Polgar normal spirometry values, this study had higher mean PEFR for height while the mean FEV$_1$ and FVC values were lower than that in those studies [21-25]. This is also in keeping with the study by Withrow et al. [15] who documented that children of African origin had lower FEV$_1$ and FVC than their counter parts from other ethnic groups. Though the factors influencing lung growth are not fully understood but it is thought that these reported differences in FEV_1 and FVC between black and white children has been attributed in part to differences in body proportions, sitting height being less in proportion to standing height in African American and other factors apart from anthropometry that had been found to contribute to lung function include prenatal exposures, such as in utero growth and maternal smoking during pregnancy, postnatal exposures, such as poverty in childhood, low birth weight among others [15,26]. However the exact cause of the higher PEFR in this study could not be ascertained. This finding is similar to what was documented by Tsanakas et al. [27] who also documented unexpectedly high peak flow rates in normal Greek children. They also could not identify the cause.

The height, age and weight were found to be highly correlated with the lung function parameters measured hence a linear regression equation was generated to predict the lung function parameters for individual height, weight and age.

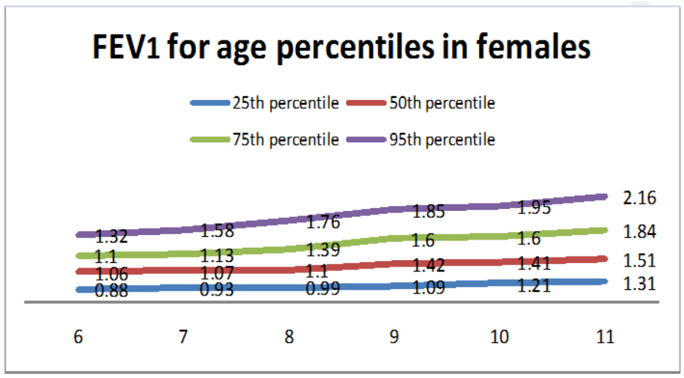

Fig. 4. FEV_1 for age percentiles in females

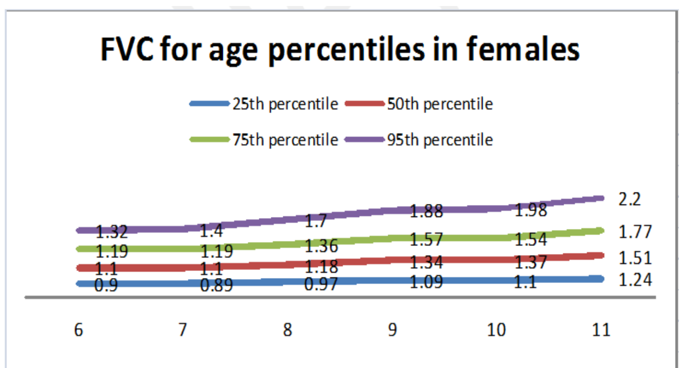

Fig. 5. FVC for age percentiles in females

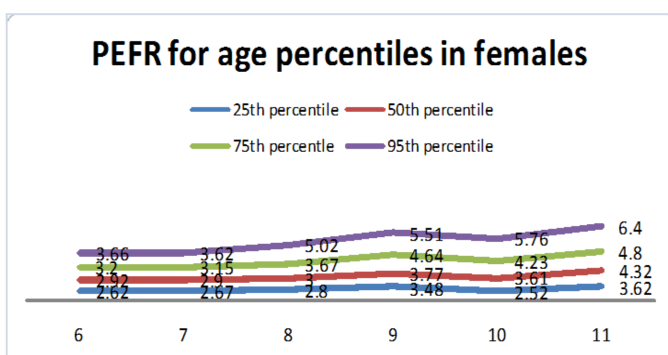

Fig. 6. PEFR for age percentiles in the females

5. CONCLUSION

The result of this study showed that on the average the FEV_1, FVC and PEFR was slightly higher in boys than girls for most ages and the mean lung function parameters increased with height. When compared to studies in Caucasians, this study had higher mean PEFR for height while the mean FEV_1 and FVC values were lower than that in those studies. It is therefore necessary for African countries especially Nigeria to have validated spirometric reference values for children.

CONSENT

Written consent was obtained from individual parents and assent from children older than the age of seven years.

ETHICAL APPROVAL

Ethical approval was obtained from the hospital Ethics Committee, the State Ministry of Education and the State Universal Basic Education Board (ethical clearance reference-AKTH/MAC/SUB/12^A/P3/793).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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