Correlation of peak expiratory flow rate with anthropometric parameters in apparently healthy children with sickle cell anaemia in Lagos

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Abstract

Background: Pulmonary function abnormalities often occur in children with sickle cell anaemia (SCA) but data correlating anthropometric parameters with peak expiratory flow rate (PEFR) are scanty. The mini Wright peak flow meter is freely available, relatively affordable, and portable making it a useful device for determining the pulmonary functions in resource-limited settings.

Objectives: To determine the correlation of PEFR with age and anthropometric parameters in apparently healthy children with SCA.

Method: PEFR was measured using a mini Wright peak flow meter in 200 children, 100 children with SCA and 100 healthy controls. Correlation of PEFR with age, height, weight, and chest circumference was calculated.

Results: Mean PEFR was significantly less in children with Hb SS genotype than in children with Hb AA genotype, irrespective of gender. Mean PEFR increased with age irrespective of gender or haemoglobin genotype. Pearson correlation coefficient showed significant positive correlation between age, sitting height, standing height, weight, body mass index (BMI), arm span and PEFR in subjects with SCA and controls. However, BMI had significant correlation in both subjects and controls but weaker than other variables.

Conclusions: PEFR correlates more with age, sitting height, standing height, weight and arm span. Thus, age and body size, but not body fat of the child is important in determining the final responses of lung function in SCA children.

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Introduction

Sickle cell anaemia (SCA) is the commonest genetic chronic haemolytic disorder seen in Nigerian children[1]. Children with sickle cell disease have poor growth as well as delayed sexual and skeletal maturation[2]. SCA has clinical features which may be expressed in every organ in the body. These features are related to the haemolytic anaemia and to tissue ischaemia and organ dysfunction caused by vaso-occlusion. Children are normal at birth, and onset of symptoms is unusual before the age of six months[3] because high levels of fetal haemoglobin inhibit sickling.

Peak expiratory flow rate (PEFR), a simple and reliable index of pulmonary function to assess the ventilator function of lungs, reflects the calibre of bronchi and larger bronchioles[4]. PEFR is chiefly influenced by efficacy of expiratory muscle, elastic recoil pressure of lung and airway size[5], all of which may be affected by SCA. The mini Wright peak flow meter is easily available, relatively affordable, and portable, with in addition reproducibility of its readings, making it a useful device for determining pulmonary functions in resource-limited settings like our community. Weight, height, and chest circumference are the principal factors affecting PEFR[6,7], and these tend to be lower in children with SCA[2]. There is a paucity of data available locally demonstrating relationship of PEFR with age and anthropometric variables in children with SCA.

Objectives

To determine the correlation of PEFR with age and anthropometric parameters in apparently healthy children with SCA.

Method

A cross sectional analytical study was carried out over a period of four months at the paediatric sickle cell clinic and children's outpatient clinic of Lagos State University Teaching Hospital (LASUTH). Primary subjects were 5-12 year old SCA children, who were in a steady state[8] and diagnosed by cellulose acetate electrophoresis. Age and sex-

matched children, with no symptoms or signs of an acute illness in the past month or with any chronic illness, and having haemoglobin genotype AA, were recruited as controls. Children with a history suggestive of bronchial asthma, structural abnormality of the rib cage, overt mental sub-normality, HIV, oedema, heart failure or on drugs capable of affecting pulmonary function indices such as steroids, were excluded from study.

The sample size for the study was calculated using formula:[9] $N = (Z_{\alpha/2} + Z_{1-\beta})^2 (\sigma_1^2+\sigma_2^2) /\mu^2$ where N =estimated sample size, $Z_{1-\beta}$ = one sided percentage point of the normal distribution corresponding to 100% minus power, (1.96 for 95% power), $1-\beta$ = power = 95%, $Z_{\alpha/2}$= percentage point of the normal distribution corresponding to the (two sided) significance level=1.96 (95% level of significance), σ_1 = standard deviation for cases which is 0.194, σ_2 = standard deviation for controls which is 0.241, μ = the difference to be detected between the means of the two samples= 0.15. Substituting these figures into formula calculated sample size was 66; an additional 50% were recruited to accommodate possible attrition or unforeseen errors in completing study questionnaire, and to increase the power of the study to bring the study sample size to 99 which was approximated to 100 subjects.

To avoid lopsided clustering of subjects around a particular age or gender, calculated sample size was stratified in accordance with distribution pattern of patients in follow up clinic; recruitments were done from the dermatology clinic with the exclusion of those with atopic skin lesions with children earlier treated for minor non-chronic ailments in other paediatrics clinics also included. All consecutive patients with SCA attending SCA clinic age and sex matched with healthy controls attending children's outpatient clinic within study period who satisfied the study criteria were recruited. Age was recorded from birthday by calendar to the nearest completed year. The study was approved by the Ethics Committee of LASUTH before starting. Recruitment followed detailed explanation about study and was strictly voluntary and backed by written informed consent.

Weight was measured without shoes aided by mechanical floor scale (SECA, United Kingdom, Model ® 761.) to closest 0.5 kg. Standing and sitting height were measured utilising stadiometer and sitting height table respectively to nearest completed cm. Chest circumference was measured using measuring tape to nearest cm at nipple level. Body mass index (BMI) was calculated using the formula weight in kg/(height in metre)^2 and arm span was measured as distance between tips of both middle fingers of horizontally abducted and maximally outstretched hands with subjects standing and facing wall. PEFR was measured using mini Wright peak flow meter. The techniques were shown to each child who made three efforts while standing with an interval of five minutes between two consecutive manoeuvres and the best of three was recorded.

All data were entered into a standard proforma. Statistical analysis was carried out utilising SPSS version 17.0, with p-value <0.05 considered significant. Continuous variables were expressed as mean ± SD and categorical variables as percentages. Differences in categorical variables were assessed using Chi-square while Student t-test was utilised to compare continuous variables. Correlation of PEFR with age, height, weight, and chest circumference for each group was calculated separately using Pearson correlation.

Results

Of the 200 children recruited, 100 had genotype Hb SS and 100 had genotype AA. Ages ranged from 5-12 years. Age and gender distribution are shown in Table I.

Table I: ***Age and gender distribution of study population (n=200)***

Characteristic	**Hb AA (*n=100*) Number (%)**	**Hb SS (*n=100*) Number (%)**	**Total Number (%)**
Gender			
Male	50 (50)	50 (50)	100 (100)
Female	50 (50)	50 (50)	100 (100)
Age in years (Male)			
5 - 6	15 (15.0)	15 (15.0)	30 (30.0)
7 – 8	15 (15.0)	15 (15.0)	30 (30.0)
9 - 10	10 (10.0)	10 (10.0)	20 (20.0)
11 - 12	10 (10.0)	10 (10.0)	20 (20.0)
Age in years (Female)			
5 - 6	15 (15.0)	15 (15.0)	30 (30.0)
7 – 8	15 (15.0)	15 (15.0)	30 (30.0)
9 - 10	10 (10.0)	10 (10.0)	20 (20.0)
11 - 12	10 (10.0)	10 (10.0)	20 (20.0)

Table 2 shows the mean PEFR values of study subjects. Following gender stratification, the mean PEFR values were higher among the controls than their SS counterparts in both male and female but the differences were not statistically significant (p>0.05). However, the mean PEFR was significantly lower among Hb SS subjects than the Hb AA controls irrespective of gender (p<0.05). Mean PEFR increased with age irrespective of gender or haemoglobin genotype. In each age group, the value observed in subjects with genotype SS was lower than that of their AA counterparts but the observed difference was not statistically significant (p>0.05) except in the age group 7–8 years where the AA controls had a significantly higher mean PEFR.

Table 2: ***Mean PEFR values of study subjects***

Characteristic	Hb SS Mean PEFR (SD)	Hb AA Mean PEFR (SD)	t-value	p - value
Gender				
Males	213.70 (44.40)	234.30 (60.64)	1.938	0.066
Females	216.20 (56.58)	226.30 (55.61)	0.900	0.370
Males and Females	214.95 (50.62)	230.30 (58.03)	1.994	0.048*
Age group				
5 – 6 years	172.2 (20.5)	176.0 (17.0)	-0.789	0.434
7 – 8 years	200.3 (32.0)	215.7 (25.2)	-2.064	0.044*
9 – 10 years	238.0 (29.3)	259.0 (44.1)	-1.773	0.084
11 - 12 years	278.0 (48.1)	305.0 (49.6)	-1.748	0.089

*SD: standard deviation, PEFR: peak expiratory flow rate, *statistically significant*

Table 3 shows the anthropometry and body proportions of study subjects. Mean weight, sitting height, arm span and BMI of Hb AA controls were significantly higher than that of Hb SS subjects (p <0.05). However, significant differences were not found in mean anthropometric variables following gender stratification.

Table 3: ***Anthropometry and body proportions of study subjects***

Characteristic	Hb SS Mean (SD	Hb AA Mean (SD)	t-value	p - value
Weight (kg)	23.64 (06.60)	26.71 (08.24)	2.907	0.004*
Height (cm)	125.88 (11.87)	129.00 (13.20)	1.755	0.061
Sitting height (cm)	63.72 (05.26)	65.48 (05.52)	2.309	0.022*
Arm span (cm)	126.45 (14.48)	131.58 (15.03)	2.459	0.015*
Chest circumference (cm)	59.96 (05.10)	61.21 (06.57)	1.512	0.132
Body mass index (kg/m^2)	14.64 (01.60)	15.68 (02.32)	3.717	0.000*

*SD standard deviation, *statistically significant*

Table 4 shows Pearson correlation of PEFR with anthropometrics and age. This showed significant (p<0.05) positive correlation between age, sitting height, standing height, weight, BMI, arm span and PEFR in both subjects and controls. However, it was with BMI as independent variable that the correlation coefficient was weak in both subjects with SCA and controls (0.511 vs 0.359).

Table 4: ***Pearson correlation of PEFR with anthropometrics and age***

Characteristic	Correlation coefficient (r)		p – value	
	Hb SS	Hb AA	Hb SS	Hb AA
Weight (kg)	0.784	0.756	<0.001*	<0.001*
Height (cm)	0.787	0.862	<0.001*	<0.001*
Sitting height (cm)	0.765	0.781	<0.001*	<0.001*
Arm span (cm)	0.808	0.865	<0.001*	<0.001*
Chest circumference (cm)	0.754	0.718	<0.001*	<0.001*
Body mass index (kg/m^2)	0.511	0.359	<0.001*	<0.001*
Age (years)	0.776	0.824	<0.001*	<0.001*

Discussion

The study showed notable differences in most anthropometric parameters between Hb SS subjects and Hb AA controls. This is in agreement with earlier studies conducted in Nigeria[10-12] and elsewhere[2,13,14]. Hb SS subjects tend to weigh less, and are thinner than Hb AA children. This observation probably reflects the adverse effect of

SCA on growth. Specifically, with regard to weight and BMI, the differences are explainable based on attendant chronic hypoxia in the presence of elevated resting energy expenditure and elevated protein turnover both of which affect body weight, particularly fat free mass[15]. The mean sitting height was also significantly higher in controls than SS subjects. Findings are similar to a study of Indian children with SCA[16,17]. The lower sitting height in SCA study subjects may reflect their shorter trunks resulting from narrowed inter-vertebral disc spaces and deformities of vertebral bodies[18,19]. Similarly, the mean arm span was significantly longer in AA controls than SS subjects. This observed finding may be a consequence of shorter limbs resulting from repeated infarctions of the long bones of the upper limbs in patients with SCA[20]. Although the overall mean height was less among Hb SS subjects, the difference was not significant. Similar results had been reported in earlier studies[10,21]. The lack of significant difference may be explained by the less severe Hb SS haplotype in our subregion[22], and thus may have had a milder effect on height. It was also observed that the mean chest circumference was higher but not significantly so among controls than children with sickle cell anaemia. This finding is in line with what was reported by Onigbinde[21] in a study of Nigerian children with SCA 5-18 years old. The lower chest circumference in children with SCA may be due to reduction in thoracic capacity and lung sizes due to rib and lung infarctions.[10]

Mean PEFR was uniformly less in Hb SS subjects than in Hb AA controls, corroborating reports from past studies[10,21,23-26]. This is due to PEFR dependence on lung size, lung compliance, rib cage size and mobility. Reduced values can hence be due to repeated pulmonary hypoxic injury from pneumonia, acute chest syndrome and pulmonary infarction associated with SCA[10]. Specifically, comparing mean PEFR of Hb SS subjects and controls showed that controls have significantly higher mean Cormic index values than SCA subjects irrespective of gender. Significant difference was not found in male and female following gender stratification. The explanation for the different pattern in males and females is not clear.

The mean PEFR also increased in both Hb AA and Hb SS subjects with age. This corroborates earlier studies in Nigeria and many other studies in developed countries[27-29]. This is because PEFR is directly related to lung size, height, muscle mass and understanding of the technique[30-32] all of which increase as the child grows older.

PEFR correlates to varying extent with different anthropometry indices. While the strength of correlation is strong with some, it is relatively weaker with others. In the current study, there are strong positive correlations between PEFR values and variables such as height, weight, arm span, chest circumference and age. This confirms the fact that body size is a strong determinant of PEFR measurement in children and adolescents[30]. It therefore implies that anthropometry will be a strong determinant of PEFR. The observation in the present study is in line with findings of other work done in Nigeria[10,21,24] and other parts of the world[15,30-32]. The weaker strength of correlation of PEFR with BMI suggested that it is the body size that mainly determines the PEFR and not the amount of body fat.

Conclusions

PEFR increased with age in both subjects and controls. Mean PEFR for children with SCA is lower compared to that of Hb AA controls. The correlation analysis between PEFR and anthropometric parameters such as weight, height, sitting height, arm span and chest circumference is strongly positive.

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