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Upper body segment to lower body segment and arm span to height ratios among children with sickle cell anaemia in Lagos

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Abstract *Objective:* To determine ratios of upper body segment to lower body segment and arm span to height in the sickle cell anaemia patients
Background: Sickle cell anaemia may adversely affect linear growth and body proportions.
Methods: Height, upper segment and arm span were measured in 100 sickle cell anaemia patients aged eight months to 15 years and 100 age/sex matched controls. Lower body segment length, upper body segment to lower body segment ratio, and arm-span to height ratio were derived.
Results: Sickle cell anaemia subjects older than 10 years had significantly shorter upper body segment than controls ($p = 0.035$ and $p = 0.004$ for males and females respectively). The mean upper segment/lower segment ratio decreased with age among primary subjects (SS) and AA controls. In comparison with AA controls, female sickle cell anaemia subjects older than 10years had significantly lower mean upper body segment to lower body segment ratio ($p = 0.005$). Mean arm span was significantly shorter in male sickle cell anaemia patients older than 5 years ($p = 0.034$ at 5 to 10 years and $p = 0.029$ at ≥ 10 years) and in females older than 10 years than in controls ($p = 0.025$). The mean arm span/height ratio was lower in sickle cell anaemia subjects than controls, except in males younger than five years.
Conclusions: Sickle cell anaemia patients older than 10 years have shorter mean upper segment. In this age group, females also had significantly lower upper segment to lower segment ratio.

Keywords: sickle cell anaemia, upper body segment, lower body segment, ratio

Introduction

Sickle cell anaemia is one of the commonest single gene disorders in man with variable geographical distribution and variable clinical manifestations.[1] It affects growth, leading to low mean weight, height and decreased height velocity.[2–6] There is also evidence that disproportionate growth may occur in patients of sickle cell anaemia and may result in abnormalities of ratios between linear body measurements.[3] Upper body segment/lower body segment ratio (US/LS ratio) is among the most frequently used anthropometric measurements to assess body proportions.[7] Indices of upper limb length are also used for the evaluation of growth and body proportions . One such measure of linear growth is arm span defined as the distance between the tips of the longest (middle) fingers when both arms are outstretched, the width of the trunk inclusive.[8] It is of potential interest to examine the arm span not only as an index of linear growth but in comparison to height, a more commonly used index.
Studies of body proportions of African children with sickle cell anaemia are few.[2-6] Extensive search by the authors did not show any previous Nigerian studies of upper body segment to lower body segment ratio or arm span to height ratio in children with sickle cell anaemia. Studies have been conducted among African American[2] and Indian children with sickle cell anaemia.[3] However, these populations may differ anthropologically, in some respects from Nigerian children, thus limiting applicability of findings.

The main objective of the present study was to determine the upper body segment to lower body segment and arm span to height ratios among children with sickle cell anaemia as indices of proportionality of linear growth.

Methodology

The cross-sectional study was conducted between October and December 2009 among children with sickle

cell anaemia attending the sickle cell disease clinic of the Department of Paediatrics of Lagos State University Teaching Hospital, Ikeja, in southwest Nigeria. The hospital is an urban tertiary health centre in Lagos State, Western Nigeria. It is a major referral center serving the whole State, which is a major point of entry into Nigeria from different parts of the world and the economic nerve centre of Nigeria.

Approval for the study was obtained from the Ethics Committee of the Lagos State University Teaching Hospital and written informed consent was obtained from each participant. Consecutive sickle cell anaemia patients who came for routine follow up clinic and who satisfied the study criteria were recruited. Healthy controls were children with haemoglobin genotype "AA," from the General Outpatient and follow-up clinics and healthy children attending other specialist clinics like the Paediatric Dermatology clinic. Controls were matched with primary subjects for age, and sex. Two hundred children were studied - one hundred each with haemoglobin genotype SS and AA. In order to have fairly even representation of ages, the subjects stratified as follows: < 2 years, > 2 to 5 years, 5 to 10 years and >10 to 15 years.

Inclusion criteria

1. Age six months to fifteen years.
2. Confirmed HbSS by electrophoresis.
3. Signed, informed consent of the caregiver.
4. Subjects who were in steady state i.e. absence of any crisis in the preceding four weeks, no recent drop in the haemoglobin level and absence of any symptoms or signs attributable to acute illness.[10]
5. Children who were not taking medications known to affect growth e.g. steroids.

Exclusion criteria

1. Children with congenital cardiac abnormality, chronic renal disease or abnormal chest wall deformity or chronic respiratory disorder.
2. Children with history of cerebrovascular accident.
3. Sickle cell anaemia patients with history of long-term transfusion therapy
4. Denial of consent.

The inclusion and exclusion criteria for the controls were the same as for subjects except that the haemoglobin genotype was AA.

Measurement of Height

Children two years of age and older had their heights measured using a stadiometer while the length was measured for those below two years were measured using an infantometer.

Measurement of sitting height

Sitting height was measured from the vertex to the seated buttocks using a sitting height table. The subject's head was positioned in the Frankfort horizontal plane, the shoulders relaxed, the back straight, and the head plate was brought into firm contact with the vertex. The sitting height was measured to represent upper segment.

Measurement of lower segment

The lower segment was defined as the arithmetic difference between height and sitting height.

Measurement of arm span

The arm span was obtained by standing against a wall with the arms fully extended and held horizontally; the span of the outstretched arms from the tips of the middle fingers with the width of the trunk added was measured. The various linear measurements were taken three times and the mean recorded. Social classification was done using the scheme proposed by Oyedeji[11] in which subjects are grouped into five classes (I – V) based on the occupation and educational attainments of both parents. Analysis was done using Statistical Package for Social Science (SPSS) version 17.0. Comparison of mean values was done using Student t-test and level of significance was set at $p < 0.05$.

Results

Characteristics of the study population

A total of 200 children, 100 each with genotype SS and AA, who met the study criteria, were recruited over a study period of three months (October 2009 through December 2009). The age and gender distributions of the study population are given in Table 1.

Overall, the age of the subjects ranged from eight months to 15 years, with a mean of 75.3 (±50.3) months. The corresponding figures for HbSS subjects and controls were 77.0 ± 50.1 and 73.6 ± 50.7, respectively (t-value = 0.481, p= 0.631).

Table 1: Demographic characteristics of study populations

Characteristics	AA	SS	ALL
Age (years)			
Male			
≤2	13(26.0)	13(26.0)	26(26.0)
>2 – 5	13(26.0)	13(26.0)	26(26.0)
>5 – 10	12(24.0)	12(24.0)	24(24.0)
>10 – 15	12(24.0)	12(24.0)	24(24.0)
Total	50 (100.0)	50(100.0)	100(100.0)
Female			
≤2	12(24.0)	12(24.0)	24(24.0)
>2 – 5	12(24.0)	12(24.0)	24(24.0)
>5 – 10	13(26.0)	13(26.0)	26(26.0)
>10 – 15	13(26.0)	13(26.0)	26(26.0)
Total	50(100.0)	50(100.0)	100 (100.0)
Socioeconomic class			
I	15(15.0)	22(22.0)	37(18.5)
II	23(23.0)	36(36.0)	59(29.5)
III	43(43.0)	32(32.0)	75(37.5)
IV	18(18.0)	10(10.0)	28(14.0)
V	1(1.0)	0(0.0)	1(0.5)

NB: Values in parenthesis are in % of column total

Height/Length distribution of study subjects according to age

Mean height/length according to age-group among the SS and AA subjects is shown in Table 2. The mean height comparison between the two study groups and gender was done using student-t test. In the two oldest age groups, the mean heights of boys with haemoglobin genotype AA were 7.9cm higher than those of the sickle cell anaemia subjects. This finding was mirrored in the oldest age group of girls where the mean for "AA" girls was 4.9cm higher than that of their "SS" counterparts. However, none of the differences was statistically significant.

Within the haemoglobin "SS" group, the mean height/ length values of males were comparable to those of females across all age groups. The same was true of "AA" subjects except for the youngest age group where boys were significantly longer (p = 0.004).

Table 2: Height/Length distribution of subjects according to age

Age Group	SS Mean (SD)	AA Mean (SD)	p-value
≤2yrs			
Males	83.2 (6.7)	84.6(3.7)	0.530
Females	80.3 (7.4)	77.7(6.9)	0.374
p-value	0.295	0.004*	
>2yrs – 5yrs			
Males	104.3(8.1)	99.9(10.0)	0.222
Females	100.8(8.0)	105.0(6.4)	0.156
p-value	0.283	0.130	
>5yrs – 10yrs			
Males	123.0 (11.0)	130.8(8.8)	0.071
Females	128.0(6.3)	130.4(12.2)	0.546
p-value	0.188	0.944	
>10yrs – 15yrs			
Males	141.4(16.9)	149.3(8.8)	0.162
Females	146.0(11.2)	150.9(7.6)	0.231
p-value	0.433	0.646	
All			
Males	112.2(24.4)	115.2(26.8)	0.565
Females	113.1(26.9)	115.0(28.9)	0.731
p-value	0.865	0.980	

SD = standard deviation

Upper and lower body segment lengths of study subjects

Comparisons of the upper body segment among SS and AA subjects are shown in Table 3. Generally, there was an increase with age among primary SS subjects and AA controls. Among males, the difference between the mean upper body segment of AA controls and SS subjects was less than 1cm in children aged ≤ 5 years. It however increased progressively to 5.3cm in the oldest age group (p = 0.035). A similar pattern was observed among female subjects with differences ≤ 2.2cm between younger sickle cell anaemia patients and controls. Sickle cell anaemia patients older than 10 years however, had a mean upper body segment shorter than controls by 7.4cm (p < 0.001).

Comparisons of lower body segment length between SS and AA subjects are also shown in Table 3. The mean lower body segment length increased with age among primary subjects (SS) and AA controls. There was no consistent age–related pattern in the differences between mean values for SS subjects and AA controls and none of the observed differences was significant (p > 0.05).

Table 3: Mean upper and lower body segment of subjects

Age Group	SS Mean (SD)	AA Mean (SD)	t-value	p-value
Upper body segment				
≤2yrs				
Males	50.1(3.7)	50.8(1.7)	0.595	0.557
Females	47.7(3.6)	47.1(2.8)	-0.425	0.675
>2yrs – 5yrs				
Males	56.7(3.3)	56.2(3.0)	-0.375	0.711
Females	55.3(2.8)	57.5(2.9)	1.946	0.064
>5yrs – 10yrs				
Males	63.8(5.0)	67.3(4.1)	-1.887	0.072
Females	65.7(3.4)	67.2(5.1)	0.835	0.412
>10yrs – 15yrs				
Males	70.9(6.5)	76.2(4.9)	2.247	0.035*
Females	70.2(6.1)	77.6(4.9)	3.233	0.004*
All				
Males	60.1(9.1)	62.3(10.5)	1.102	0.273
Females	59.5(9.9)	61.9(12.1)	1.111	0.269
Lower body segment				
≤2yrs				
Males	33.1(4.1)	33.8(2.7)	0.496	0.624
Females	32.6(4.6)	30.6(4.5)	0.795	0.274
>2yrs – 5yrs				
Males	47.6(5.5)	43.6(7.5)	-1.550	0.134
Females	45.5(5.6)	47.5(4.0)	1.045	0.307
>5yrs – 10yrs				
Males	59.3(9.9)	63.5(5.2)	1.308	0.204
Females	62.3(4.1)	63.2(7.9)	0.377	0.710
>10yrs – 15yrs				
Males	70.4(11.8)	73.1(7.9)	0.654	0.520
Females	75.6(6.9)	73.3(6.7)	-0.897	0.379
All				
Males	52.1(16.1)	52.9(16.8)	0.240	0.811
Females	53.6(17.5)	53.1(17.3)	-0.149	0.882

SD = standard deviation

Upper body segment/Lower body segment ratio in study subjects

Table 4 show the age-related comparisons of upper body segment/lower body segment ratio between the SS and AA subjects for males and females respectively.

Irrespective of gender, the mean ratio decreased with age in both SS subjects and AA controls. Also, the differences between haemoglobin SS subjects and AA controls were generally ≤ 0.1, both in males and females. The single exception was in the oldest group of girls in whom controls had a ratio which was significantly higher by 0.12 (p = 0.005). In addition, comparison between males and females in each age group showed that the ratios differed by ≤ 0.1.

Arm span

The mean values of arm span increased with age among primary SS subjects and AA controls (Table 5). Mean arm span was significantly higher among AA controls in

males older than 5 years (p = 0.034 at 5 to 10 years and p = 0.029 at ≥ 10 years). Also, females older than 10 years had significantly longer mean arm span than HbSS subjects (p = 0.025).

Table 4: Upper body segment/Lower body segment ratio in study subjects

Age Group	SS Mean (SD)	AA Mean (SD)	t-value	p-value
≤2yrs				
Males	1.49(0.21)	1.51(0.11)	0.395	0.696
Females	1.43(0.21)	1.50(0.23)	0.121	0.905
>2yrs – 5yrs				
Males	1.20(0.12)	1.32(0.18)	1.968	0.061
Females	1.23(0.11)	1.20(0.11)	-0.718	0.480
>5yrs – 10yrs				
Males	1.12(0.34)	1.06(0.05)	-0.629	0.536
Females	1.06(0.70)	1.07(0.10)	0.377	0.709
>10yrs – 15yrs				
Males	1.03(0.18)	1.06(0.17)	0.400	0.693
Females	0.93(0.08)	1.07(0.13)	3.143	0.005*
All				
Males	1.22(0.28)	1.24(0.23)	0.557	0.578
Females	1.17(0.23)	1.21(0.23)	0.993	0.323

SD = standard deviation

Table 5: Mean arm span among study subjects

Age Group	SS Mean (SD)	AA Mean (SD)	t-value	p-value
≤2yrs				
Males	87.5(9.7)	86.4(5.4)	-0.335	0.741
Females	81.0(7.7)	80.1(7.1)	-0.298	0.769
>2yrs – 5yrs				
Males	108.3(10.0)	101.5(11.3)	-1.628	0.117
Females	102.6(7.4)	109.1(8.1)	2.006	0.058
>5yrs – 10yrs				
Males	126.5(10.2)	136.7(11.7)	2.265	0.034*
Females	129.9(5.7)	135.7(13.0)	1.402	0.175
>10yrs – 15yrs				
Males	148.6(14.8)	162.5(14.4)	2.342	0.029*
Females	149.5(10.4)	161.2(13.3)	2.414	0.025*
All				
Males	117.5(25.1)	120.7(31.9)	0.544	0.587
Females	115.8(27.5)	121.8(32.5)	0.979	0.330

SD = standard deviation

Arm span to height/length ratio

The comparison of the arm span/height or length ratio distribution among the SS and AA subjects is shown in Table 6. Ratios of arm span to height/length varied from 1.02 to 1.09: this showed an increasing trend with age among controls but no consistent pattern among haemoglobin SS subjects. There was no significant difference between haemoglobin SS subjects and controls at any age irrespective of gender.

Table 6: Mean Arm span/Height or length ratio among study subjects

Age Group	SS Mean (SD)	AA Mean (SD)	t-value	p-value
≤2yrs				
Males	1.05(0.05)	1.02(0.04)	-1.721	0.099
Females	1.01(0.03)	1.02(0.04)	1.075	0.294
>2yrs – 5yrs				
Males	1.04(0.04)	1.02(0.03)	-1.889	0.071
Females	1.02(0.03)	1.03(0.05)	0.963	0.347
>5yrs – 10yrs				
Males	1.03(0.11)	1.04(0.1)	0.335	0.741
Females	1.02(0.03)	1.04(0.04)	1.931	0.066
>10yrs – 15yrs				
Males	1.06(0.08)	1.09(0.08)	1.032	0.313
Females	1.02(0.03)	1.07(0.07)	1.930	0.067
All				
Males	1.04(0.07)	1.04(0.06)	-0.235	0.815
Females	1.02(0.03)	1.04(0.05)	2.891	0.005*

SD = standard deviation

Discussion

In the present study, the mean upper body segment increased with age among both primary SS subjects and AA controls, consistent with expected age-related increase in body size. Among the oldest males and females, mean upper body segment was significantly higher in controls than SS subjects. This is comparable to the findings in a study of Indian children with sickle cell disease.[3] The lower mean upper body segment in sickle cell anaemia patients implies that they have shorter trunks. The reason for this finding is beyond the scope of the current report but it is consistent with the finding of narrowed inter-vertebral disc spaces and deformities of vertebral bodies.[12, 13] These abnormalities have been previously reported in older patients who expectedly would have had repeated episodes of vaso-occlusive crisis.[12, 13]

In absolute figures, the mean upper body segment of 60.1cm and 59.5cm in male and female children with sickle cell anaemia observed in the present study was higher than 59.2cm and 58.7cm reported by Mukherjee et al[3] in a group of children with sickle cell anaemia of comparable age. This comparison is in spite of the fact that the Indian patients were slightly taller than the subjects of the current study. The likely explanation is that the Nigerian patients were less severely affected by their primary disease than the Indians.

One consequence of relatively short upper segments is a reduction in upper segment to lower segment ratio. Thus the haemoglobin AA controls in the current study had higher ratios than haemoglobin SS subjects. The same phenomenon was observed in the Indian study.[3] However, in comparison, the ratio herein reported is somewhat higher than 1.0 reported for both Indian male and female subjects with sickle cell disease, again suggesting differences in severity of primary disease.

It was also observed that in both haemoglobin SS and AA subjects, the upper body segment to lower body segment ratio decreased as the age increased. Once again this is a natural trend, in keeping with reference values of 1.7 at birth, 1.3 at 3years, and 1.0 after age 7years.[7, 14] This indicates that in the prepubertal years growth occurs more in the limbs than in the trunk while thereafter growth occurs more in the trunk than in the limbs.

It is physiological for mean arm span to be longer than height.[15, 16] This was reflected in the current study among both sickle cell anaemia subjects and controls. A further finding in the present study is mean arm span of subjects older than 10years was significantly longer in AA controls than SS subjects in both males and females. The finding is not unexpected as sickle cell anaemia is a chronic disease with potential adverse effect on growth. It is attractive to argue that the arm span of older children with sickle cell anaemia would be more adversely affected because they have had the disease for a long enough periods for adverse effects on growth to be noticed.

Overall, change in body proportions are frequent findings in subjects with sickle cell anaemia. Routine body proportion measurements during follow-up clinic attendance by children with sickle cell anaemia should be encouraged to aid evaluation of stunting and subsequent intervention to correct the growth deficit. Age-related physiologic trends and pathologic findings were observable in the patterns of linear measurements of children with sickle cell anemia. Some of the physiological trends were increase in upper segment length, lower segment length, height and arm span. Pathological observations were shorter upper segment and smaller upper segment to lower segment ratio.

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