Original Article

Comparative Study of Nutritional Status of Children and Adolescents with Sickle Cell Anemia in Enugu, Southeast Nigeria

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ABSTRACT

Background: Poor growth and nutritional status are common features of sickle cell anemia (SCA) in children. The rising trend of obesity in children in developing countries has been reported despite a huge burden of undernutrition in these settings. In SCA, overweight/obesity is being increasingly reported. **Aims:** To evaluate the nutritional status and its determinants in children with SCA and to compare the same with hemoglobin AA (HbAA) controls of similar age, gender, and socioeconomic status. **Methods:** The study was a cross-sectional analytical study involving 175 subjects and controls aged 1–18 years who met the inclusion criteria. Weight and height were measured and body mass index (BMI) was calculated. *Z* scores were computed for the anthropometric measurements using the World Health Organization (WHO) standard reference. Hemoglobin concentration was determined using HemoCue Hb201$^+$ Analyzer. **Results:** Subjects had significantly lower *Z*-scores for weight, height, and BMI compared with controls. Stunting, wasting, and overweight/obesity were observed in 10.9%, 24.6%, and 5.1% of subjects compared with 2.3%, 5.7%, and 9.7% respectively in controls. Wasting, stunting and overweight/obesity in SCA were significantly associated with age while overweight/obesity was significantly associated with upper social class (P = 0.001). **Conclusions:** Poor growth and nutritional status are still prevalent while overweight and obesity are emerging comorbidities among children with SCA in our environment. Regular nutritional assessment of children with SCA should be encouraged while those at risk of under/over-nutrition should receive adequate nutritional rehabilitation to prevent possible complications.

Keywords: *Children, nutritional status, physical growth, sickle cell anemia*

Introduction

Sickle cell anemia (SCA) is a chronic hemolytic disorder and the commonest genetic disorder affecting Nigerian children.[1] SCA affects many systems, causing derangements in function and structure.[2,3] Historically, poor growth and nutritional status are common effects in children and adolescents with SCA.[4-7] In the general pediatric population, recent studies on the anthropometric profile of population suggest an increasing incidence of obesity and the co-existence of undernutrition and obesity in transitional countries and in some developing countries like Nigeria[8-10] and children with SCA do not live in isolation. The co-existence of under and over nutrition in the same population is postulated to bring about a potentiation of their adverse health effects, translating to rising morbidities and premature mortalities from diet-related chronic diseases.[8-12] Among SCA population, the co-existence of the two comorbidities is rising in certain subpopulations. Halpern *et al*.,[13] in a retrospective study carried out in the USA obtained a prevalence of overweight and obesity of 12% and 13% respectively in pediatric and young adult patients with SCD. Similarly,

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Akodu *et al*.[14] in Lagos Nigeria, reported a prevalence of 2.5% and 3.8% for obesity among Hemoglobin SS subjects (SCA) and HbAA controls, respectively.

Generally, it has been established that growth retardation from SCA is complex and may be due to the child's nutritional status, hematological and cardiovascular state, social factors, metabolic, and or altered endocrine function.[7] The role of steady-state hemoglobin (Hb) and social class in the growth and nutritional status of SCA subjects is still unclear. While some authors reported no association between hemoglobin and nutritional status[15,16] others have reported an association between hemoglobin and nutritional status; with the overweight or obese status being associated with higher baseline hemoglobin levels.[13,17] Among SCA patients, social class has been reported to have a modifying influence on growth and nutritional status in SCA, with the children in the upper social class having a better growth status than those of lower social class.[18] On the contrary, some researchers found no association between growth status and social class.[19,20]

This study was therefore undertaken to document the prevalence of stunting, wasting, overweight and obesity in SCA children and adolescents aged 1 to 18 years in Enugu, southeast Nigeria using the World Health Organization (WHO) growth reference standards.[21,22] In addition, the association, if any, of their steady-state hemoglobin, socioeconomic class, age, and gender with their nutritional status was assessed. We hypothesized that poor growth and nutritional status would still be prevalent among children and adolescents with SCA.

Subjects and Methods

Study area

This was a cross-sectional analytical study conducted over a 6-month period at a tertiary hospital in southeastern Nigeria; Study participants were recruited from the Paediatric Haematology clinic and the Children Outpatient Clinic of the Department of Paediatrics. The Paediatric Haematology clinic runs once weekly (every Monday) and attends to children below 18 years. The hemoglobin genotype of all the children attending the clinic had been previously documented and they were all found to be homozygous hemoglobin (HbSS). All patients attending the clinic are routinely placed on malarial prophylaxis as well as folic acid and multivitamin supplement. Our routine treatment for the patients does not include chronic transfusion program, hydroxyurea therapy, or penicillin V prophylaxis. The children's outpatient unit of the hospital (CHOP) is the point of entry of most children coming to the hospital except the acutely ill ones who are seen in the emergency room. Children are seen at the pediatric outpatient unit comprised of those attending the well-baby clinic/immunization clinic, school children for medical certification for school enrolment as well as children who need a referral to specialist clinics like ophthalmology and dermatology.

Sample size determination

The sample size for this study was 175 subjects and 175 controls. The sample size was determined for each of the study populations using the formula for comparing two proportions[23]

$$N = \frac{(Z\alpha + Z\beta)^2[P_1(100 - P_1) + P_2(100 - P_2)]}{(P_1 - P_2)^2}$$

With the level of significance ($Z\alpha$) and the power of a test ($Z\beta$) set at 5% and 80% respectively.

P_1 = 54% proportion of stunted Yemeni SCA children and adolescents[16] while P_2 = 38% proportion of stunted Nigerian children.[24] (stunting being the indicator with the highest prevalence) To compensate for possible attrition or unforeseen errors in completing the study questionnaire or blood sample processing the minimum sample size was increased by 10%.

Ethical approval

The approval of the Health Research and Ethics Committee of the University of Nigeria Teaching Hospital Ituku-Ozalla Enugu was obtained before the commencement of the study. The approval number is NHREC/05/01/2008B with reference number UNTH/CSA.329/VOL. 5. Informed written consent signed or thumb printed was obtained from the parents/guardians and assent obtained from study participants aged 7 years and above after a full explanation of the study was given to them in a language they understand.

Recruitment of study participants

Inclusion criteria for study participants

1. Age 1–18 years
2. Hemoglobin genotype SS
3. In apparent good health with no history of acute illness or hospitalization for at least 4 weeks prior to enrollment.
4. Informed parental and subject consent/assent obtained.

Inclusion criteria for controls were the same as for subjects except that the hemoglobin genotype was AA.

Exclusion criteria for study participants

1. Blood transfusion within 3 months prior to the study.
2. Subjects with any form of acute illness such as acute gastroenteritis

3. Presence of stroke or limb deformity or any other chronic illness which can affect growth such as cardiac diseases and chronic kidney diseases.
4. Subjects on nutritional supplements or medications known to affect growth or nutritional status such as steroids.

Consecutive subjects were SCA patients attending the pediatric hematology clinic who made the inclusion criteria. Healthy controls with hemoglobin genotype AA matched for age, gender, and socioeconomic class (SEC) were recruited from the children outpatient unit. Following the age distribution of the patients attending the pediatric sickle cell clinic, the subject's stratification was done into age groups ≤5 years, 6–10 years and >10 years to ensure an evenly distributed selection using patient's completed ages as at last birthday. Results of the hemoglobin genotype of the subjects were retrieved from their case notes while the controls had their hemoglobin genotypes confirmed by hemoglobin electrophoresis using cellulose acetate paper. SEC was determined using the classification proposed by Olusanya *et al*.[25] scores were awarded to each child based on the occupation of the father as well as mothers' educational attainment. The sum of the 2 scores was the social class assigned to the child and these ranged from 1 to 5. The classes were grouped as follows: the upper class (social class I) consisting of those with scores 1 or 2, middle class (social class II) consisting of those with score 3 while lower class (social class III) represented by those with score 4 or 5.

Anthropometric measurements

All anthropometric measurements were done twice by the principal investigator and the mean of the values obtained recorded on the proforma. If any pair of readings exceeded the maximum allowable difference for a given variable (weight 100 g, length/height 0.7 cm) the variables were measured again, if necessary, the third set of readings for the affected variable was obtained.[26]

Weight: Weight of younger children (≤18 months) was measured using the basinet scale (WAYMASTER, England), which can measure up to 20 kg with 0.50 kg precision. Calibrated weighing equipment with a stadiometer (HEALTH MEDICAL EQUIPMENT, England, RG2-160), which can measure up to 160 kg to the nearest 0.1 kg was used for older children. Subjects weighed were lightly clothed and were without shoes. The scales were calibrated to zero point before use and checked for accuracy with standard weights after every 10th measurement or whenever the scale was moved from place to place.

Length/Height: For children under 2 years of age, recumbent (crown–heel) length was measured with the help of a nurse, using an infantometer (Rigid Length board) (Seca mod. 416) measuring up to 100 cm. The child's head was held by the nurse assistant against the rigid headboard in such a way that the lower borders of the eye sockets were in the same horizontal plane as the external auditory meatus (Frankfurt plane). The ankles were gently pulled to stretch the child, the legs were straightened, and the feet turned up vertically; a sliding foot-piece was then brought against the feet and the crown–heel length was read twice to the nearest 0.1 cm.

Standing height was measured in children over 2 years of age using a stadiometer (HEALTH MEDICAL EQUIPMENT, England, RG2-160) with a well-calibrated vertical measuring rod 200 cm in length to the nearest 0.1 cm. The child was asked to stand on the footplate portion of the stadiometer barefooted with the legs together, knees not bent, arms hanging loosely and with buttocks, shoulders, and the back of the head touching the upright rod and the head in Frankfurt plane. The metal head-piece was then lowered to touch the top of the crown. The height was recorded twice to the nearest 0.1 cm.

Body mass index (BMI) was calculated for each subject using the formula: BMI = Weight (Kg)/Height (M^2).

LABORATORY INVESTIGATIONS: Hemoglobin concentration and hemoglobinopathy diagnosis (for controls) were determined on venous blood using HemoCue Hb201$^+$ Analyzer and electrophoretic techniques using cellulose acetate at pH 8.6 respectively.

Definitions

With reference to WHO multicenter growth reference, stunting was defined as height for age <-2SD while wasting was defined as weight for height (for <5 years) or BMI for age (for ≥5 years) <-2SD.[26] For children <5 years overweight was defined as weight-for-height >+2SD whereas obesity was defined as weight-for-height > +3SD. For children ≥5 years overweight was defined as BMI for age > +1SD whereas obesity was defined as BMI for age > +2SD.[26]

Data Analysis

The data were analyzed using statistical package for social sciences, version 19 (SPSS Inc., Chicago, IL, USA). Mean and standard deviation were calculated for each anthropometric index. Height for age (HAZ), weight for age (WAZ), weight-for-height (WHZ), and BMI (BMIZ) z-scores were computed from the WHO multicentre growth reference[21,22] using WHO anthro and anthroplus software version 3.2.[27] WHO growth reference does not have WAZ for children above 10 years due to variability in the age of the

pubertal growth spurt, thus, weight for age (WAZ) was not calculated for children above 10 years of age.[22] For *Z*-score analysis, study participants were grouped into <5 years and ≥5 years with respect to WHO standards reference.[21,22] Comparisons between calculated mean values were made using the Student t–test while Chi-square or Fisher's exact tests were used to compare proportions. Logistic regression analysis was used to assess the likelihood of an association between growth deficits and other factors. The adjusted odds ratios were estimated with 95% confidence intervals. Variables included in the model were gender, age, social class, hemoglobin concentration and hemoglobin genotype. They were selected for regression analysis using a backward multiple logistic regression model. The dependent variables (HAZ and WHZ or BMIZ) were coded 1 if their value fell below -2 *Z*-score but coded 0 otherwise. This implies that if the variable receives a value of 1 then the child had growth failure. Similarly, with respect to overweight/obesity, WHZ was coded 1 if above +2 *Z*-score for children aged under 5 years while BMIZ was coded 1 if above +1 *Z*-score for children aged five years and above otherwise it was coded 0. Data for subjects with overweight and obesity were combined for regression analysis given the small sample size and the similarity in age and social class among the affected subjects. All statistical tests were two-tailed with $P < 0.05$ considered significant.

Results

A total of 350 children (202 boys and 148 girls) divided into 175 subjects and 175 controls were studied, with ages ranging from 1 year to 18 years. The mean age was comparable between subjects and controls (9.7 ± 4.8 vs 9.8 ± 4.8 years: $t = -0.069$, $P = 0.95$). The male to female ratio in both subjects and controls was 1.4:1. The social class distribution showed that 46 (13.1%), 106 (30.3%) and 198 (56.6%) of the study participants belonged to the upper, middle, and lower SECs, respectively.

The mean values of weight, height, and BMI for the study population are shown in Table 1. Weight, height, and BMI mean values were significantly lower in the SCA subjects compared to the controls ($P < 0.05$ in each case). Relative to the controls children and adolescents with SCA also had significantly lower *Z*-score for weight, height, and BMI [Table 1], with children above 5 years more affected than children <5 years (WAZ <5 years, -0.20 ± 1.01 vs. ≥5 years, -0.87 ± 0.94, $P = 0.003$, HAZ <5 years, -0.13 ± 1.35 vs. ≥5 years, -0.64 ± 1.23, $P = 0.048$, BMIZ <5 years, -0.26 ± 1.11 vs. ≥ 5 years, -1.50 ± 1.08, $P = 0.001$). The gender specific comparison of *z* scores for children <5 years and those ≥5 years are shown in Tables 2 and 3 respectively. Female subjects <5 years had significantly lower *Z*-score for WAZ and HAZ than the controls ($P = 0.001$ and 0.002 respectively) whereas, male subjects <5 years had comparable values with the controls [Table 2]. Among children ≥5 years, subjects were significantly smaller than controls irrespective of gender in all the selected anthropometric values ($P = 0.001$) [Table 3].

Table 1: Comparison of anthropometry between subjects and controls

Variable	Subjects *n*=175 Mean±SD	Controls *n*=175 Mean±SD	*P*
Anthropometry measure			
Weight (kg)	28.2±12.7	34.1±16.3	0.001*
Height (cm)	131.6 ±24.3	137.6±25.8	0.026*
BMI (kg/m^2)	15.4±2.1	16.8±2.9	0.001*
Z-score			
Weight-for-age *Z*-score[‡]	-0.6±1.0	0.4±1.0	0.001*
Height-for-age *Z*-score	-0.5±1.3	0.5±1.3	0.001*
BMI-for-age *Z*-score	-1.2±1.2	-0.4±1.1	0.001*

*Statistically significant difference in the mean values of selected anthropometry between subjects and controls. [‡]Calculated for <10 years, Kg=kilograms, m=metres, BMI=body mass index, Kg/m^2=kilogram per metre squared

Table 4 shows the prevalence of stunting, wasting, overweight, and obesity among subjects and controls according to gender. Irrespective of gender SCA subjects were more likely to be wasted than controls ($P = 0.003$ in males and *P*0.001 in females). Significantly higher proportion of male SCA subjects than controls were stunted ($P = 0.018$). Overall, stunting, wasting, overweight/obesity were observed in 19 (10.9%), 43 (24.6%), and 9 (5.1%) of SCA subjects, respectively compared with 4 (2.3%), 10 (5.7%), and 17 (9.7%), respectively in controls. Significantly higher proportion of SCA subjects than controls were stunted and wasted [stunting, χ^2 (1, N = 350) =9.12, $P = 0.002$, wasting, χ^2 (1, N = 350) =22.77, *P* 0.001] whereas there was no significant difference in prevalence of overweight/obesity between subjects and controls (χ^2 (1, N = 350) =1.82, $P = 0.17$). The frequency of wasting and stunting was higher in subjects over 5 years (wasting <5 years, 2.2% vs ≥5 years, 32.3%; $P = 0.001$, stunting <5 years, 4.4% vs ≥5 years, 13.1%; $P = 0.02$). The proportion of subjects who were overweight/obese were significantly higher in the younger age group (χ^2 (1, N = 175) = 7.97, $P = 0.005$). The mean hemoglobin concentration of subjects was 7.8 ± 1.5 g/dl and was significantly lower than 11.7 ± 3.2 g/dl recorded for

controls (t = -14.901, P = 0.001). Female subjects were observed to have higher hemoglobin level compared with male subjects though this difference was not statistically significant (8.1 ± 1.7 g/dl vs 7.6 ± 1.2, P = 0.98 g/dl).

Table 5 shows the logistic regression analysis of the covariates of growth and nutritional status. In the unadjusted model, age had a statistically significant positive relationship with stunting (P = 0.001) and wasting (P = 0.001). After adjusting for hemoglobin genotype (HbSS or HbAA), social class, steady-state hemoglobin, and gender, this factor remained statistically significant. A significant but negative relationship was also observed between age and obesity/overweight (P = 0.004). In the unadjusted model, there were 30% and 26% decrease in odds for stunting and wasting, respectively for each 1 g/dl rise in steady-state hemoglobin. Whereas, for each, 1 g/dl rise in steady-state hemoglobin, there was a 33% increased odds for

Table 2: Gender-specific comparison of anthropometric *Z*-scores between under-5 subjects and controls

	Males		*P*	Females		*P*
	Subjects *n*=24 Mean±SD	Controls *n*=24 Mean±SD		Subjects *n*=21 Mean±SD	Controls *n*=21 Mean±SD	
WAZ	0.23±0.81	0.39±0.91	0.521	-0.69±0.98	0.44±1.09	0.001*
HAZ	0.39±1.13	0.96 ±0.85	0.056	-0.38±1.15	0.48±1.13	0.002*
WHZ	0.04±1.22	-0.30±0.89	0.412	-0.59±0.91	-0.08±1.16	0.122
BMIZ	-0.05±1.26	-0.31±0.96	0.412	-0.51±0.96	-0.06±1.13	0.164

* Statistically significant

Table 3: Gender-specific comparison of anthropometric *Z*-scores between subjects and controls five year and above

	n	Males		*P*	*n*	Females		*P*
		Subjects Mean±SD	Controls Mean±SD			Subjects Mean±SD	Controls Mean±SD	
WAZ[ǂ]	32	-0.73±0.86	0.25±1.14	0.001*	20	-1.11±1.04	0.45±0.82	0.001*
HAZ	77	-0.55±1.49	0.80±1.10	0.001*	53	-0.38±1.15	0.48±1.13	0.001*
BMIZ	77	-1.52±1.10	-0.64±1.12	0.001*	53	-1.45±1.06	-0.27±1.02	0.001*

* Statistically significant, [ǂ]calculated for ≤ 10 years

Table 4: Gender-specific prevalence of stunting, wasting, overweight and obesity among subjects and controls

	Males		OR (CI)	*P*	Females		OR (CI)	*P*
	Subjects *n*=101	Controls *n*=101			Subjects *n*=74	Controls *n*=74		
Stunting	11 (10.9)	2 (2.0)	5.8 (1.2-6.6)	0.018*	8 (10.8)	2 (2.7)	4.1 (0.8-19.8)	0.097
Wasting	26 (25.7)	9 (8.9)	3.2 (1.4-7.1)	0.003*	17 (23.0)	1 (1.4)	18.7 (2.4-142.3)	0.001*
Overweight	3 (3.0)	6 (5.9)	0.6 (0.1-2.5)	0.498	4 (5.4)	8 (10.8)	0.48 (0.14-1.6)	0.367
Obesity	2 (2.0)	1 (1.0)	2.0 (0.2-22.6)	0.999	0 (0)	2 (2.7)	-	0.9996

* Statistically significant Values in parenthesis are % of number in groups

Table 5: Logistic regression of factors associated with nutritional status among subjects and controls

Indicator	Variable	OR	95% CI	*P*	AOR	95% CI	*P*
Stunting	Age	1.176	1.06-1.30	0.002*	1.191	1.07-1.33	0.001*
	Hemoglobin	0.704	0.57-0.87	0.001*	0.743	0.53-1.05	0.089
	Female	1.054	0.45-2.47	0.905	1.070	0.44-2.63	0.884
	Lower Class	1.803	0.40-8.18	0.445	1.520	0.32-7.30	0.601
	HbSS	5.207	1.73-15.64	0.003	1.722	0.31-9.59	0.535
Wasting	Age	1.133	1.06-1.21	0.001*	1.149	1.07-1.23	0.001*
	Hemoglobin	0.740	0.64-0.85	0.001*	0.890	0.70-1.12	0.32
	Female	0.661	0.36-1.22	0.185	0.646	0.33-1.25	0.196
	Lower Class	2.100	0.71-6.26	0.183	1.834	0.58-5.83	0.304
	HbSS	5.375	2.60-11.10	0.001*	3.724	1.15-12.07	0.028
Overweight/Obesity	Age	0.838	0.75-0.94	0.002*	0.844	0.75-0.95	0.004*
	Hemoglobin	1.333	1.00-1.28	0.049	1.110	0.93-1.33	0.261
	Female	1.892	0.78-4.62	0.161	1.170	0.43-3.17	0.757
	Upper Class	8.126	2.52-26.19	0.001*	7.825	2.24-27.29	0.001*
	HbSS	0.479	0.19-1.22	0.122	0.662	0.21-2.12	0.488

* Statistically significant

overweight/obesity. However, this factor lost significance after adjusting for other covariates. The study also showed a statistically significant association between the upper SEC and overweight/obesity (P = 0.001). Adjusting for other factors caused a negligible change in the odds for overweight/obesity [odds ratio (OR) 8.12, 95% confidence interval (CI) 2.52–26.19 vs Adjusted odds ratio (AOR) 7.83, 95% CI 2.24-27.29). A child in the upper SEC was 7.8 times more likely to be overweight or obese when compared to a child in the lower SEC (AOR = 7.82, CI = 2.24–27.29). On the other hand, a child in the lower class was 1.5 times or 1.8 times more likely to be stunted and wasted respectively than a child in the upper SEC (AOR = 1.52 95% CI 0.32–7.30, P = 0.6 for stunting, AOR = 1.8 95% CI 0.58–5.83, P = 0.3 for wasting) though these differences were not statistically significant. Gender was not a significant predictor of stunting, wasting and overweight/obesity (AOR = 1.191% 1.07–1.33 for stunting, AOR = 1.149% CI 1.07–1.23 for wasting, (AOR = 0.844% CI 0.75–0.95 for overweight/obesity).

Discussion

This study has shown evidence of the coexistence of undernutrition and overnutrition among children and adolescents with SCA in our environment. It has further demonstrated as in previous studies[11,16,28] that a significant proportion of children and adolescents with SCA have impaired growth and poor nutritional status. Relative to the controls SCA subjects had significantly lower *Z*-scores for weight, height, and BMI. This observation could be due to chronic ill health, high metabolic rate, and energy wastage often encountered in these subjects.[14]

In this study, the observed prevalence of stunting and wasting (10.9% and 24.6%, respectively) in SCA subjects were far lower than those reported by Al-Saqladi *et al*.[16] in Yemen using the same assessment tool (54% and 35%, respectively) but close to the figures reported by Zemel *et al*.[28] in the USA using National Center for Health Statistics (NCHS) reference (22% and 24% respectively). Thus, the magnitude of growth deficits may vary with geographical location.[16] It is plausible that extrinsic or intrinsic factors in relation to inadequate food intake or increased demands associated with higher energy expenditure and requirements are likely to act together to different degrees against diverse genetic, environmental, and socioeconomic backgrounds.[7] The association between SCA and overnutrition is of interest since it is generally believed that children and adolescents with SCA have impaired growth and poor nutritional status. In this study, overweight/obesity was observed in 5.1% of the subjects. These were lower than those reported by Chawla *et al*.[17] and Halpern *et al*.[13] in the USA (22.4% and 25% respectively) but comparable with the finding of 2.5% by Akodu *et al*.[14] in Western Nigeria among HbSS patients with regard to obesity. Some of the reasons adduced for such observed differences include possibly the effect of sickle hemoglobin variant, chronic transfusion and the use of hydroxyurea[13,17] It has been shown that these SCA-directed treatments, as well as sickle hemoglobin variants are associated with improved growth.[13,17,29,30] Interestingly, the finding of overweight/obesity in the present study is difficult to explain because the reported elevated resting energy expenditure and elevated protein turnover associated with SCA have negative effects on nutritional status.[7]

Considering the impact of age on growth and nutritional status; wasting and stunting were significantly associated with age: with the frequency of wasting and stunting being higher in subjects over 5 years indicating a cumulative long-term deficit. The older the patient the more likely the complications of chronic anemia and ischemia so growth deficits would be more marked in older children. This was similar to the finding of earlier reports.[15,16,31] Overweight and obesity were also associated with age: with the overweight/obese group being significantly younger than the non-obese group. Akodu *et al*.[14] also reported a similar finding. It is possible that the pattern observed in the current study may be because disease episodes in young children may have had less time to affect growth. On the contrary Halpern *et al*.[13] reported that the overweight/obese group in their study was significantly older than the non-overweight group. It is attractive to argue that less severity of illness, hydroxyurea treatment, and chronic transfusion as was the routine practice in the study by Halpern *et al*.[13] may have accounted for the observed difference.

Overweight and obesity were also significantly associated with social class in the present study. Subjects in the upper social class were more likely to be overweight or obese. This finding conforms to the findings of Akodu *et al*.[14] It is plausible that sickle hemoglobin variant other than HbSS and higher SEC may be responsible for the development of obesity in children with SCA. However, the numbers of cases of obesity in the present study are inadequate to conclude.

After adjusting for other covariates this study showed no significant association between the nutritional indicators and steady-state hemoglobin concentration or gender. Some previous studies have also reported a lack of association between hemoglobin concentration

and growth deficits.[15,16] It is plausible that the chronic anemic state of these subjects may not really contribute to poor growth as seen in other children with chronic anemia due to nutritional deficiencies, because there is a marked shift of the oxygen dissociation curve to the right in SCA subjects, which maintains a near-normal peripheral oxygen delivery.[2] Thus, the hemoglobin level in SCA may not reflect the exact oxygen transport capacity.

This study showed no significant association between nutritional indicators and gender. This finding conforms to the findings of Olanrewaju *et al*.[5] and Halpern *et al*.[13] with respect to overweight/obesity. However, in some studies, males have been reported to have greater growth deficits[31,32] while some have reported that females are more severely affected than males.[33] The causes for this gender difference have been related to differences in the level of hemoglobin, fetal hemoglobin, energy intake, and hormonal changes.[9,12,20,31,33] The lack of correlation between growth index and gender could be explained by the fact that since the growth deficit in SCA is complex and multifactorial, it might be quite difficult to demonstrate a clear cut relationship with some factors.

Conclusions

Stunting and wasting are still prevalent among children and adolescents with SCA in our environment. In addition, overweight and obesity exist among SCA children in the upper SEC in our environment. Regular nutritional assessment of children with SCA should be encouraged while those at risk of under- or overnutrition should receive adequate nutritional rehabilitation to prevent possible complications.

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Conflicts of interest

There are no conflicts of interest.

References

1. Akinyanju OO. A profile of sickle cell disease in Nigeria. Ann N Y Acad Sci 1989;565:126-36.
2. Serjeant GR. Sickle Cell Disease. 2nd ed. Oxford: Oxford University Press; 1992. p. 358-60.
3. Adekile AD, Adeodu OO. Haemoglobinopathies. In: Azubuike JC, Nkanginieme KEO, editors. Paediatrics and Child Health in a Tropical Region. 2nd ed. Owerri: African Educational Services; 2007. p. 373-90.
4. Ebomoyi E, Adedoyin MA, Ogunlesi FO. A comparative study of the growth status of children with and without SS disease at Ilorin, Kwara State, Nigeria. Afr J Med Sci 1989;18:69-74.
5. Olanrewaju DM, Adekile AD. Anthropometry status of sickle cell anaemia patients in IIe-Ife. Nigeria. Nig Med Pract 1989;18:63-6.
6. Oredugba FA, Savage KO. Anthropometric findings in Nigerian children with sickle cell disease. Pediatr Dent 2002;24:321-5.
7. Al-Saqladi AW, Cipolotti R, Fijnvandraat K, Brabin BJ. Growth and nutritional status of children with homozygous sickle cell disease. Ann Trop Paediatr 2008;28:165-89.
8. Armstrong J, Dorosty A, Reilly J, Child H, Emmett P. Coexistence of social inequalities in undernutrition and obesity in preschool children: Population based cross sectional study. Arch Dis Child 2003;88:671-5.
9. Wang Y, Monteiro C, Popkin BM. Trends of obesity and underweight in older children and adolescents in the United States, Brazil, China and Russia. Am J Clin Nutr 2002;75:971-7.
10. Opara DC, Ikpeme EE, Ekanem US. Prevalence of stunting, underweight and obesity in school aged children in Uyo, Nigeria. Pakistan J Nutr 2010;9:459-66.
11. Popkin BM. The nutrition transition in low-income countries: An emerging crisis. Nutr Rev 1994;52:285-98.
12. Popkin BM. An overview on the nutrition transition and its health implications: The Bellagio meeting. Public Health Nutr 2002;5:93-103.
13. Halpern AB, Welch JJG, Hirway P, Chawla A. Prevalence and complications of obesity in sickle cell disease. Paper presented at 50th ASH Annual Meeting and Exposition; December 6–9, 2008; San Francisco, CA.
14. Akodu SO, Diaku-Akinwumi IN, Njokanma OF. Obesity—Does it occur in Nigerian children with sickle cell anemia. Pediatr Hematol Oncol 2012;29:358-64.
15. Lowry MF, Desai P, Ashcroft MT, Serjeant BF, Serjeant GR. Heights and weights of Jamaican children with homozygous sickle cell disease. Hum Biol 1977;49:429-36.
16. AL-Saqladi AWM, Bin-Gadeen HA, Brabin BJ. Growth in children and adolescents with sickle cell disease in Yemen. Ann Trop Paediatr 2010;30;287-98.
17. Chawla A, Sprinz PG, Welch J, Heeney M, Usmani N, Pashankar F, *et al.* Weight status of children with sickle cell disease. Pediatrics. 2013;131:e1168-73.
18. Lesi FEA. Anthropometric status of sickle cell anemia patients in Lagos, Nigeria. Nig Med J 1979;9:337-42.
19. Okany CC, Akinyanju OO. The influence of socio-economic status on the severity of sickle cell disease. Afr J Med Sci 1993;22:57-60.
20. Singhal A, Morris J, Thomas P, Dover G, Higgs D, Serjeant G. Factors affecting prepubertal growth in homozygous sickle cell disease. Arch Dis Child 1996;74:502-6.
21. World Health Organisation. Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and body mass index-for-Age: Methods and development. Geneva, WHO; 2006. Available from: http://www.who.int/childgrowth/standards/en. [Cited 2019 Mar 11].
22. World Health Organization. Growth Reference Data for Children from 5 to 19 Years. Geneva, WHO; 2007. Available from: www.who.int/growthref/en/. [Cited 2019 Mar 11].
23. Prabhakara GN. Sample Size Determination, Textbook on Biostatistics. New Delhi: Jaypee Brothers Medical Publishers; 2006. p. 110-9.

24. World Bank Nigeria: Health, Nutrition, and Population, Country Status Report, volume 2, Main Report. Washington, DC: World Bank; 2005.
25. Olusanya O, Okpere E, Ezimokhai M. The importance of social class in voluntary fertility control in a developing country. W Afr Med J 1985;4:205-12.
26. World Health Organization. Training Course on Child Growth Assessment. Geneva, WHO, 2008.
27. World Health Organisation. WHO Anthro for personal computers, version 3.2.2, 2011: Software for assessing growth and development of the world's children. Geneva, WHO, 2010. Available from: http://www.who.int/childgro wth/software/en/ cited 2019 March 11.
28. Zemel BS, Kawchak DA, Ohene-Frempong K, Schall JI, Stallings VA. Effects of delayed pubertal development, nutritional status, and disease severity on longitudinal patterns of growth failure in children with sickle cell disease. Pediatr Res 2007;61:607-13.
29. Wang WC, Morales KH, Scher CD, Styles L, Olivieri N, Adams R, *et al*.; STOP Investigators. Effect of long-term transfusion on growth in children with sickle cell anemia: Results of the STOP trial. J Pediatr 2005;147:244–7.
30. Wang WC, Helms RW, Lynn HS, Redding-Lallinger R, Gee BE, Ohene-Frempong K, *et al.* Effect of hydroxyurea on growth in children with sickle cell anemia: Results of the HUG-KIDS Study. J Pediatr 2002;140:225-9.
31. Phebus CK, Gloninger MF, Maciak BJ. Growth patterns by age and gender in children with sickle cell disease. J Pediatr 1984;105:28-33.
32. Silva CM, Viana MB. Growth deficits in children with sickle cell disease. Arch Med Res 2002;33:308-12.
33. Stevens MC, Maude GH, Cupidore L, Jackson H, Hayes RJ, Serjeant GR. Prepubertal growth and skeletal maturation in children with sickle cell disease. Pediatrics 1986;78:124-32.