The influence of socioeconomic status on the hemoglobin level and anthropometry of sickle cell anemia patients in steady state at the Lagos University Teaching Hospital

BA Animasahun, EO Temiye[1], OO Ogunkunle[2], AN Izuora[3], OF Njokanma[4]

Department of Paediatrics and Child Health, Lagos State University College of Medicine, Ikeja, [1]Paediatrics, University of Lagos College of Medicine, Idi-Araba, [2]Paediatrics, University College Hospital, Ibadan, [3]Department of Paediatrics and Child Health, Isolo General Hospital, Isolo, [4]Paediatrics and Child Health, Lagos State University College of Medicine, Ikeja, Lagos, Nigeria

Abstract

Background: Sickle cell anemia (SCA) has multisystemic manifestations and is associated with severe morbidity and high mortality. It commonly affects growth leading to wasting and stunting.

Aims and Objectives: This study aimed to determine the influence of socioeconomic status on the nutritional status using anthropometric measurements and steady-state hemoglobin, of children with homozygous SCA, aged 1 year to 10 years in steady state at the Lagos University Teaching Hospital.

Materials and Methods: This is a cross-sectional study involving 100 children with SCA and 100 age-, sex-, and social class-matched controls that fulfilled the inclusion criteria. Social class was assessed using educational attainment and occupation of parents. Hemoglobin concentration was determined using the oxy-hemoglobin method.

Results: This study demonstrated a significantly lower mean weight and weight-for-height in the SCA patients than those of controls ($P < 0.001$). By contrast, this study did not demonstrate any statistical significant difference in the mean height and mean body mass index of SCA patients and controls ($P = 0.06$) and ($P = 0.12$), respectively. The mean weight, height, and body mass indices of the subjects and controls were consistently below those of the NCHS standards. The magnitude of the difference from the NCHS standard was also more pronounced in the subjects, increased with advancing age and affected male subjects more than females. Progressive declines in the anthropometric attainment and hemoglobin concentration were observed from social class 1 to 4; this was statistically significant in controls ($P = 0.00$) but not in subjects ($P > 0.1$). However, SCA patients had significantly lower values than controls in each of the social classes.

Conclusion: Poor socioeconomic status has an adverse effect on the nutritional status and hemoglobin of SCA patients.

Key words: Hemoglobin level, sickle cell anemia, socioeconomic class

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Introduction

Sickle cell anemia (SCA) is a chronic hemolytic disorder caused by homozygous inheritance of an abnormal hemoglobin called "hemoglobin S". It is an example of a single point mutation resulting in a qualitative defect in hemoglobin synthesis.[1] The resultant hemoglobin is structurally different from the normal as valine replaces glutamic acid in the sixth position of the β globin.[2]

Address for correspondence:
Dr. BA Animasahun,
Department Of paediatrics, Lagos State University college of Medicine/Teaching Hospital, IkejA-Nigeria.
E-mail: deoladebo@yahoo.com

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Sickle cell mutation is believed to have initially emerged in a tropical climate with many adverse environmental factors such as malaria, infections, other infestations, and malnutrition.[3] The sickle cell gene is known to be widespread, reaching its peak incidence in Equatorial Africa, and also occurring in parts of Sicily, Southern Italy, Northern Greece, Southern Turkey, the Middle East, Central India,[4] and mainly among people of African descent in North and South America. The gene for heterozygous sickle hemoglobin is carried by about 25% of Nigerians, while the incidence of its homozygous state is about 2–3%.[1]

SCA is the commonest hemoglobinopathy affecting people of Negroid race.[5-8] It has multisystemic manifestations and potentially affects growth leading to wasting and stunting.[9,10] Emodi and Kaine[11] found that SCA patients weighed significantly less when compared with normal healthy children. Lesi[12] found that the height and weight of SCA patients whose parents were non-elites fell below those whose parents were elites. Olanrewaju and Adekile[13] in a later study documented a similar finding.

This study aimed to determine the influence of socioeconomic status on the nutritional status using anthropometric measurements and steady-state hemoglobin, of children with homozygous SCA, aged 1 year to 10 years in steady state at the Lagos University Teaching Hospital (LUTH).[14]

Materials and Methods

This was a prospective, cross-sectional, and analytical study carried out at the LUTH in Idi-Araba between October 2005 and January 2006. LUTH is a tertiary care health facility in Nigeria's foremost metropolitan city.

The subjects were 100 pediatric patients aged 1–10 years attending the SCA clinic who were consecutively recruited. They had hemoglobin genotype "SS" on hemoglobin electrophoresis and were in steady state at the time of recruitment. Steady state was defined as absence of any crisis in the preceding 4 weeks, no recent drop in the hemoglobin level, and absence of any symptoms or sign attributable an acute illness.[15] Patients with any form of acute illness, congenital heart disease or acquired heart disease, renal disease, or hypertension were excluded from the study. Healthy controls were of genotype "AA," from the Community Health Outpatient and Well-baby clinics. They were matched for age, sex, and socioeconomic class one for every SCA patient.

A complete history was obtained from the parents/caregivers and the children, if old enough. All relevant information including the name, age, sex, and social class were recorded in a proforma. A thorough physical examination was performed on each child.

Height was measured to the nearest centimeter with the aid of a graduated wooden panel fixed to a vertical wall with the child barefoot, standing erect with the heels together against the wall, and looking straight ahead with the back against the wall. The head was held in such a way that the subject was looking forward with the lower border of the eye sockets in the same horizontal plane as the external auditory meatus. The wooden panel had a perpendicular (horizontal) projection built in to slide up and down which rested on the head of the subject.[16] Subjects were weighed in light underwear to the nearest 0.1 kg using a Seca® scale or basinet scale as appropriate for the patient's age. The scales were checked for accuracy with standard weights after every 10th measurement, or whenever it was moved from place to place.[16] Weight-for-age, height-for-age, and weight-for-height were based on NCHS standards. Body mass index (kg/m^2) was calculated using the formula weight kg/height^2 m^2. Hemoglobin concentration was determined using the oxy-hemoglobin method. Social class was assessed using the methods described for Nigerian families based on educational attainment and occupation of parents.[12]

Ethical clearance for the study was obtained from the Research and Ethics Committee of the Lagos University Teaching Hospital. Informed consent was sought from parents or caregivers of potential subjects and the controls before enrolment into the study.

The data were recorded on a self-designed proforma and later analyzed on a standard IBM compatible computer. The data were analyzed using Microsoft Excel Statistical Software supplemented by Mega Stat Statistical Package. The mean, median, standard deviation, and other parameters of statistical location were generated as necessary for continuous data. Tests of statistical significance between subjects and controls included Student's *t*-test for continuous data and chi-square analysis for discrete data. Regression and correlation models were set up and analyzed as necessary. Level of significance was set at $P < 0.05$.

Results

A total of 200 children aged 1 year to 10 years were recruited into the study. Of this number, 100 were test subjects confirmed to have hemoglobin genotype SS and the other 100 were healthy controls of hemoglobin genotype AA.

The sex distribution consisted of 65 males and 35 females each in subject and control groups having male:female ratio in both subjects and controls as 1.9:1, with 35 being less than 5 years and 65 being above 5 years in each subject and control groups. The mean age in months was comparable

between subjects and controls (75.1 ± 30.3 vs 74.8 ± 29.4: $t = 1.02$, $P = 0.15$).

The socioeconomic class distributions of subjects and controls are shown in Figure 1. The majority of the subjects and controls were in social classes 2, 3, and 4 with no one in social class 5.

Table 1 compares the mean values of anthropometry of the SCA group and matched controls. The mean height and body mass index of the subjects were comparable with those of the controls. Controls, however, were significantly heavier ($P = 0.00001$) and also had significantly higher mean weight-for-height ($P = 0.0005$).

Figures 2 to 7 show the mean height, weight, and body mass index of male and female subjects and controls superimposed on NCHS standards. The mean height of male subjects and controls was comparable with those of the NCHS standards until 8 years of age when a fall in the graph of subjects and controls was observed. On the other hand, the mean height of female subjects and controls was fairly comparable with

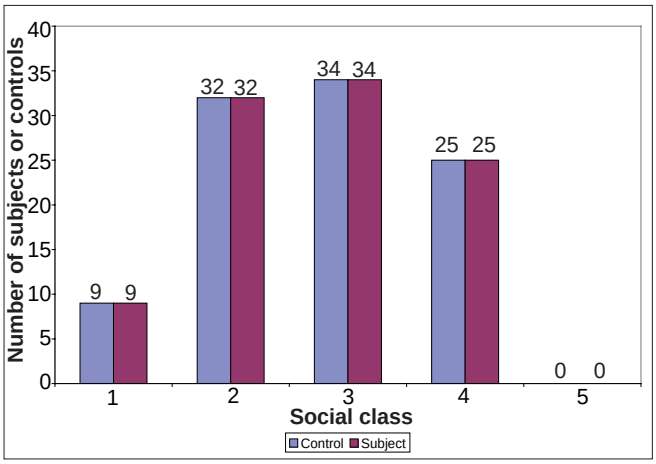

Figure 1: Socio-economic class distribution of subjects and controls

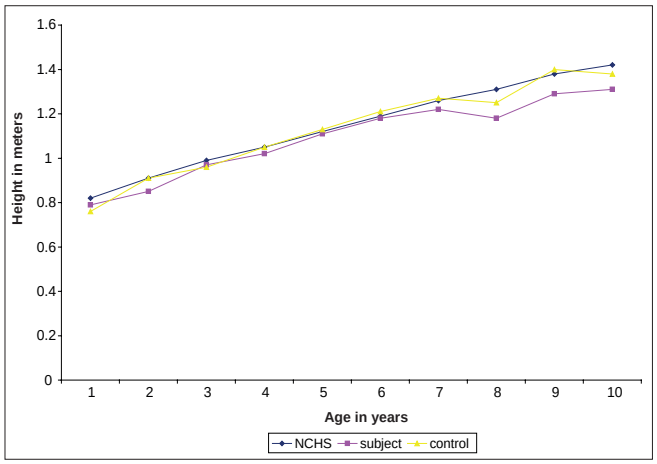

Figure 2: Chart comparing mean height of male subjects with controls and NCHS standards at various ages

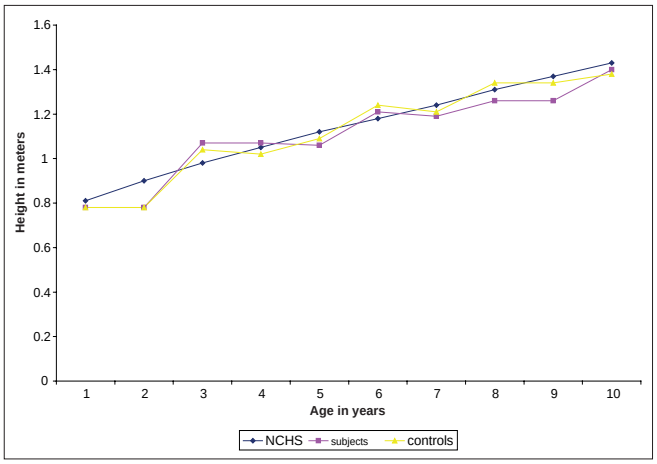

Figure 3: Chart comparing mean height of female subjects with controls and NCHS standards at various ages

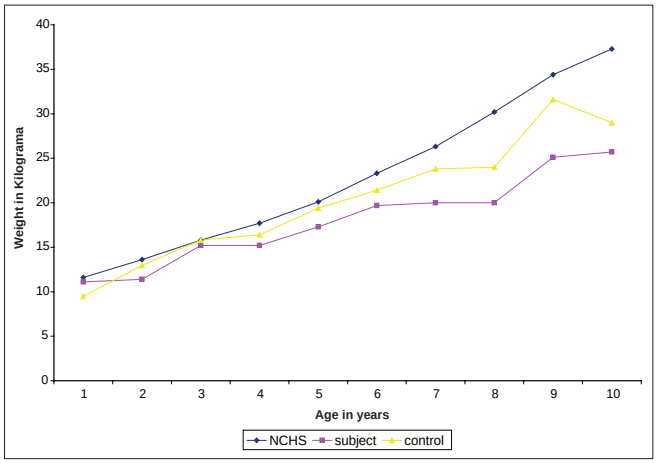

Figure 4: Chart comparing mean weight of male subjects with controls and NCHS standards at various ages

Table 1: Comparison of anthropometry between subjects and controls

Variables	Subjects (n = 100) Mean ± SD	Controls (n = 100) Mean ± SD	t-value	P-value
Height (m)	1.13 ± 0.2	1.25 ± 0.8	−1.52	0.06
Weight (kg)	18.8 ± 5.3	21.3 ± 0.5	−4.77	0.00001
Weighst for height (kg/m)	16.4 ± 3.7	17.7 ± 0.4	−3.49	0.0005
BMI (kg/m2)	14.6 ± 3.2	15.1 ± 0.32	−1.56	0.12

Figures shown are mean ± 1 standard deviation of the mean

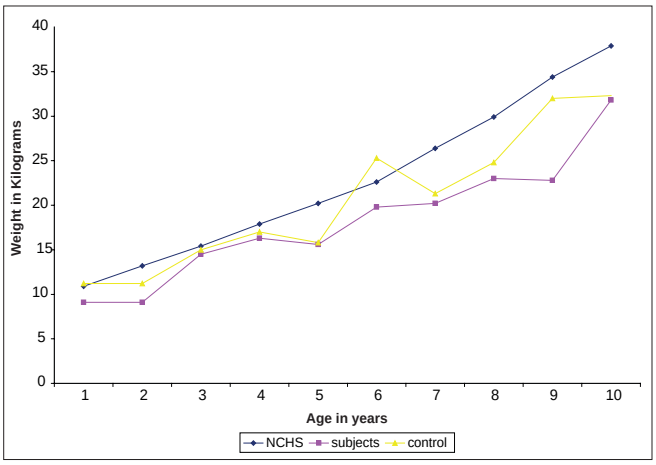

Figure 5: Chart comparing mean weight of female subjects with controls and NCHS standards at various ages

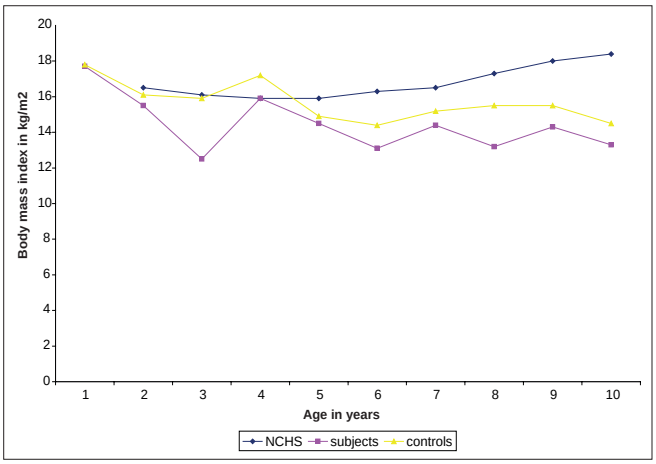

Figure 6: Chart comparing mean body mass index of male subjects with controls and NCHS standards at various ages. (BMI centile for < 2year was not available from the NCHS standard)

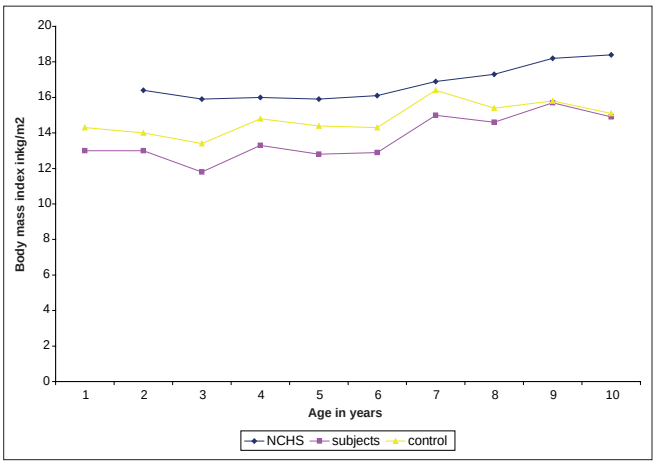

Figure 7: Chart comparing mean body mass index of female subjects with controls and NCHS standards at various ages. (BMI centile for < 2year was not available from the NCHS standard)

NCHS standards throughout the age range. The mean age-related weights and body mass indices of male and female subjects were persistently lower than those of the controls, and both were lower than those of the NCHS standards. There was a tendency for the differences in height, weight, and body mass index to become more pronounced with increasing age, particularly after age 5.

The hemoglobin concentration of subjects was consistently lower than that of controls in both males and females irrespective of age ($P = 0.000$). Also, irrespective of age and gender, the mean hemoglobin of SCA subjects varied within a very narrow range.

The social class and nutritional status (anthropometric measurements) of subjects and controls are shown in Table 2. The anthropometric measurements were found to be reducing progressively from social class 1 to 4 in both subjects and controls.

The weights of the subjects were significantly lower than those of controls in all the social classes ($P < 0.01$). The same pattern was observed in their heights except in social class 3 where the height of the subjects was comparable with those of the controls. With respect to weight-for-height, controls had significantly higher mean values in the upper social classes 1 and 2. In the lower social classes (3 and 4), controls still had higher mean values which did not reach

Table 2: Social class and nutritional status

	Subject	Controls	*P*
Height			
Social class 1	1.15 ± 0.1	1.23 ± 0.03	0.0039
Social class 2	1.15 ± 0.1	1.20 ± 0.02	0.0041
Social class 3	1.08 ± 1.5	1.36 ± 0.6	0.3
Social class 4	1.14 ± 0.1	1.20 ± 0.02	0.02
	$F = 0.04$, $P = 0.99$	$F = 1.48$, $P = 0.22$	
Weight			
Social class 1	20.6 ± 7.6	28.6 ± 2.5	0.0015
Social class 2	19.7 ± 6.2	22.3 ± 1.01	0.013
Social class 3	17.2 2.9	18.4 ± 0.5	0.02
Social class 4	18.8 ± 3.8	20.9 ± 0.8	0.02
	$F = 2.01$, $P = 0.12$	$F = 234$, $P = 0.00$	
Weight-for-height			
Social class 1	17.5 ± 3.9	22.3 ± 1.3	0.0002
Social class 2	16.9 ± 3.9	18.19 ± 0.6	0.04
Social class 3	15.7 ± 3.4	16.0 ± 0.6	0.62
Social class 4	16.2 ± 2.7	17.3 ± 0.6	0.05
	$F = 1.02$, $P = 0.12$	$F = 210$, $P = 0.00$	
Body mass index			
Social class 1	15.1 ± 2.1	18.1 ± 0.7	0.0001
Social class 2	15.7 2.8	15.2 ± 0.5	0.3
Social class 3	14.8 4.0	14.7 ± 0.7	0.9
Social class 4	14.2 2.8	14.7 ± 0.6	0.4
	$F = 1.06$, $P = 0.37$	$F = 82.2$, $P = 0.00$	

statistical significance ($P = 0.12$). The mean body mass index of controls in social class 1 was significantly higher than that of subjects. There was no discernible difference in the other social classes ($P = 0.37$).

Table 3 shows the hemoglobin concentration and socioeconomic class of subjects and controls. A progressive reduction in the hemoglobin concentration is observed in the subject as the social class ranged from 1 to 4, but this was not statistically significant ($P = 0.34$), however that of the controls shows statistically significant difference across the social groups ($P = 0.00$).

Discussion

This study was designed to determine the relationship between the steady-state hemoglobin, nutritional status using anthropometric measurements, and socioeconomic status of SCA patients aged 1 year to 10 years at the LUTH. It was partly based on the premise that repeated and/or severe illness may manifest as suboptimal growth detectable by anthropometry. Also, steady-state hemoglobin level of any index patient may potentially impact on growth because of its direct relationship with oxygen delivery to tissues. Socioeconomic status was investigated because it has direct implications for growth and nutrition, which may be more prominent in the presence of a chronic disease such as SCA.

The study revealed poor nutritional status in children with SCA compared with NCHS standards and with contemporary healthy controls. In turn, both the subject and control groups of this study had demonstrably lower age-specific weight graphs than NCHS standards. This may be due to the fact that NCHS standards were developed in the United States from composite data involving various races, and social classes and the standard of living in the United States of America are higher than in Nigeria. As such it is not surprising that a random selection of Nigerians had poorer growth characteristics. This is in agreement with Janes,[13] and Osinusi and Oyejide[17] who observed similar findings in the growth characteristics in underprivileged and elite children. However, some other authors[18] have documented comparable anthropometric measurements between healthy elite children and those of NCHS standard. The finding in this study may be because the controls in this study are from both high and low socioeconomic classes.

Table 3: Hemoglobin concentration and social class

Social class	Hemoglobin concentration		*P*
	Subjects	Controls	
1	79.1 ± 22.5	124.6 ± 7.5	0.0000001
2	79.0 ± 23.0	119.8 ± 3.8	0.000001
3	77.3 ± 17.8	114.7 ± 3.2	0.000001
4	70.8 ± 13.2	117.3 ± 2.8	0.000000
	$F = 1.13$, $P = 0.34$	$F = 19.7$, $P = 0.00$	

The fact that apparently healthy controls also lagged behind NCHS standards suggests that the effect of SCA alone cannot explain the deficit in anthropometric measurements noticed in the subjects. Furthermore, the differences between the mean weight of subjects in comparison with those of controls and NCHS standards were more obvious with increasing age. This agrees with the observation of earlier workers.[19-22] The explanation is not far fetched as older patients have had the disease for a longer period and therefore the sequel of the disease is likely to be more profound in them.

As was found with mean weight, this study showed that the mean heights of subjects and controls were consistently below NCHS standards. The magnitude of the difference was more pronounced in the older subjects, affecting male subjects more. This is similar to the finding of earlier report[19] and it follows the same explanation given for weight above. Similarly, the trend was more pronounced in SCA patients. This is in keeping with the findings of Whitten[23] and Ebomoyi *et al*.[17]

The subjects expectedly had a mean steady-state hemoglobin concentration significantly lower than that of controls, irrespective of socioeconomic class. This reduced red blood cell lifespan in the subjects is due to premature hemolysis. Furthermore, lower socioeconomic status was associated with significant reduction in mean hemoglobin concentration in controls; the trend was observed but not significant in the SCA group. This observation conforms to the findings of earlier Nigerian workers[24,25]

A similar trend was observed in the relationship between anthropometry of study subjects and social class. The comparable hemoglobin concentration and anthropometry across the different social classes in subjects may be due to the fact that the subjects were hospital patients receiving regular follow-up and good standard of care. It may also be due to the uniform effect of SCA. It is plausible that the quality of care available to them counter-balanced the adverse effects that might have been associated with lower socioeconomic class. Lower hemoglobin values documented in subjects in the lower social classes although not statistically significant. It would therefore be reasonable to suggest that improvement in standard of living and quality of medical care has far reaching effects on health parameters.

Poor socioeconomic status has an adverse effect on the nutritional status and hemoglobin of SCA patients. There is therefore a need for improvement in standard of living through provision of basic amenities, including health services which should be made affordable and available.

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