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Nutritional status of children with sickle cell disease

A study at the Komfo Anokye Teaching Hospital of Ghana

Tracy Bonsu Osei and Charles Apprey
Department of Biochemistry, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Felix Charles Mills-Robertson
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, and

Agartha N. Ohemeng
College of Basic and Applied Science, University of Ghana, Accra, Ghana

Abstract

Purpose – This study aims to assess the nutritional status of children with sickle cell diseases using anthropometric measurements, biochemical markers and dietary intakes.

Design/methodology/approach – The study was conducted in 100 children of 3-12 years of age with sickle cell diseases (SCDs) at the Komfo Anokye Teaching Hospital in the Kumasi Metropolis of Ghana. Weight, height and age of participants were used to calculate body mass index-for-age. The mid-upper-arm-circumference-for-age, weight-for-age (percentiles) and height-for-age (percentiles) were compared with standards growth charts for children. Biochemical measures such as serum albumin and ferritin, as well as full blood count, were assessed. Dietary intake was assessed using 24-h dietary recall and food frequency questionnaire.

Findings – From the study, 73 and 37 per cent of the children with SCD recorded inadequate intake of iron and vitamin E, respectively, when compared to the recommended daily allowance. Out of the 100 participants, 37 per cent were underweight and 22 per cent were stunted. There was significant difference ($p < 0.05$) in underweight (weight-for-age) prevalence by gender. A multiple variate regression showed a significant association between zinc ($r^2 = 0.763$, $p < 0.05$) and haemoglobin levels.

Originality/value – The evidence in this paper is relevant for treatment, health education and nutritional counselling of parents with children who have SCD.

Keywords Nutrition, Children, Sickle cell disease

Paper type Research paper

Introduction

Malnutrition is considered an important risk factor for illness and death in children with a prevalence of 52.5 per cent (Tette *et al.*, 2015). Undernutrition is associated with low immune function and considered as the commonest cause of immunodeficiency (Ashaba *et al.*, 2015). Thus, children who are undernourished have decreased ability to overcome infections and may have high probability of dying from common diseases (Apprey *et al.*, 2014; Tette *et al.*, 2015).

Sickle cell disease (SCD) is a group of inherited red blood cell disorders that affects haemoglobin. It is caused by the exchange of nitrogenous bases in the codon of the beta haemoglobin gene, creating a different haemoglobin S (Hgb-S). Hence, the expression of the disease mainly lies in the presence of Hgb-S, in which there is replacement of glutamic acid

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with valine, resulting in hydrophobic interaction which triggers polymerization molecules when deoxygenated. The red blood cells then form longer and rigid structures which are sickled-shaped (Oliveira *et al.*, 2015).

Globally, SCD is known as one of the leading causes of death and disability (Piel *et al.*, 2014). The global burden of SCD varies across different settings. In the USA, it is estimated that the population affected by SCD each year is about 7,200, of which most are blacks (Piel *et al.*, 2014). In Africa, where dietary intake is inadequate among a significant proportion of the population, it is hypothesised that undernutrition is a key factor that worsens the prognosis of SCD. SCD is associated with 50-90 per cent of childhood mortality in Africa (Ansong *et al.*, 2013). The prevalence is highest in sub-Saharan Africa, especially in West Africa (Hyacinth *et al.*, 2013). In Ghana, SCD is a major contributing factor to childhood morbidity and mortality (Magalhaes and Clements, 2011), and it affects 2 per cent of all babies born (Dennis-Antwi *et al.*, 2008).

In low- and middle-income settings, children with SCD may have increased risk of developing undernutrition due to poor appetite levels, reduced dietary intake and infectious complications. Most children with SCD show reduced growth rate, delayed maturity and poor immunologic functions. These complications are mainly attributable to undernutrition associated with the disease. (Behera *et al.*, 2012; Hasanato, 2006; Jackson *et al.*, 2012).

While adequate nutritional intake is required for effective child development, there is a dearth of evidence on the extent of intake among children, particularly those with SCD. This presents a gap in literature on the nutritional status of children with SCD, something required to develop interventions. This study therefore sought to assess the nutritional status of children with SCD presenting at Komfo Anokye Teaching Hospital, a tertiary hospital setting in Ghana.

Materials and methods

Sampling and sample size

The study was conducted at the Child Health Unit (Sickle Cell Department) of the Komfo Anokye Teaching Hospital, Kumasi, Ghana. Using the Yamane (1967)[1] formula for calculating sample size, where N is the population (the total number of registered children with SCD) and e = 5 per cent (margin of error), the sample size obtained was 98, which was approximated to 100. A consecutive sampling was used to recruit participants. This sampling helped to enrol all SCD children presenting at the facility over the period of a month. All SCD children presenting at the sickle cell unit for review were approached, and all those who agreed to participate were made to sign a consent form. This process was repeated for all the prospective participants until a total of 100 participants were reached.

Ethical consideration

Ethical approval was obtained from Committee on Human Research Publication and Ethics of The School of Medical Sciences, Kwame Nkrumah University of Science and Technology. All participants of the study signed a consent form in accordance with Committee on Human Research Publication and Ethics regulations before participating in the study.

Inclusion and exclusion criteria

All children of 3-12 years of age with SCD who did not have any clinical complications and were in a steady state were included in the study. Participants who did not give consent to the study and those in crisis were excluded from the study.

Dietary assessment

Multiple 24-h dietary recall was used to assess the daily intakes of some macro- and micronutrients. The participants were made to recall all foods and snacks they had taken the previous 24 h. The recall was done on a one weekday and one weekend. Household handy measures were used to help estimate the amount of foods or snacks consumed. Nutrient analysis template was used to determine the nutrient content of the food consumed. A Food Frequency Questionnaire that had been tested on children with similar age were used to assess dietary intake of the participants for the previous three months.

Anthropometric assessment

Weight and height were measured and used to calculate body mass index (BMI)-for-age [kg/height (m^2)] (Silva and Viana, 2002). Weight-for-age (percentile) and height-for-age (percentile) were expressed into percentiles and compared with World Health Organization growth reference standards (de Onis, 2015).

Haematological and biochemical markers assessment

About 6 ml of venous blood sample was collected from the antecubital fossa of the study participants. Of the 6 ml, 2 ml of the blood sample was dispensed into ethylenediamine-tetra-acetic acid anti-coagulated tube and the other 4 ml into a vacutainer plain tube. Assay parameters included serum ferritin, full blood counts, total proteins and albumin. Serum ferritin was performed on Mindray® microplate reader MR 96 A (Shenzhen Mindray Bio-medical electronics Co., Ltd, China), whereas the full blood count was determined using the Sysmex XP300 autoanalyzer.

Data analysis

Data were entered using SPSS version 20. The study was analysed using descriptive and inferential statistics. Descriptive statistics such as frequencies, means and standard deviations were used to present findings. Continuous variables were summarised as means with their standard deviations. Independent Student's *t*-test was used to compare means between boys and girls. Multiple variate regression was used to determine the association

Parameter	$n = 100$
Age (years)	
3-5	35 (35)
6-8	37 (37)
9-12	28 (28)
Gender	
Male	57 (57)
Female	43 (43)
Type Of SCD	
SCD-SS	65 (65)
SCD-SC	28 (28)
SCD-Sβ^0	6 (6)
SCD-Sβ^+	1(1)

Table I.
Demographic characteristics of study participants

Notes: Grouped data are represented as frequency with their corresponding percentage in bracket. SCD: sickle cell diseases; SC: sickle cell anaemia; SS: genotype SS; Sβ^0: beta-zore thalassemia; Sβ^+: beta-zore thalassemia (plus)

Variables	Total	Boys n = (100)	Girls n = (57)	p-value n = (43)
Weigh-for- age				
Underweight	37	17 (29.8%)	20 (46.5%)	
Normal	54	37 (64.9%)	17 (39.5%)	0.030
Overweight	9	3 (5.3%)	6 (14.0%)	
Height-for-age				
Short stature	22	11 (19.3%)	11 (25.6%)	
Normal	71	42 (73.7%)	29 (71.0%)	0.750
Tall stature	7	4 (7.0%)	3 (7.0%)	
BMI-for-age				
Underweight	40	20 (35.1%)	20 (46.5%)	
Normal	50	33 (57.9%)	17 (39.5%)	0.160
Overweight	10	4 (7.0%)	6 (14.0%)	

Notes: Data presented as number of respondents, with the corresponding percentage in brackets. Proportions were compared using chi-square test. Percentile < 5: short stature/underweight, percentile ≤ 5 and < 95: normal and percentile > 95 underweight/tall stature

Table II.
Prevalence of malnutrition among children with SCD

Variable	Total	Boys n (100)	Girls n (57)	p-value n (43)
Iron				
Low level	73	46 (80.7%)	27 (62.8%)	0.046
Adequate	27	11 (19.3%)	16 (37.2%)	
Protein				
Low level	28	15 (26.3%)	13 (30.2%)	0.666
Adequate	72	42 (73.7%)	30 (69.8%)	
Vitamin C				
Low level	24	13 (22.8%)	11 (25.6%)	0.750
Adequate	76	44 (77.2%)	32 (74.4%)	
Folate				
Low level	70	39 (68.4%)	31 (72.1%)	0.690
Adequate	30	18 (31.6%)	12 (27.9%)	
Vitamin B_6				
Low level	43	24 (42.1%)	19 (44.2%)	0.840
Adequate	57	33 (57.9%)	24 (55.8%)	
Vitamin B_{12}				
Low level	69	41 (71.9%)	28 (65.1%)	0.470
Adequate	31	16 (28.1%)	15 (34.9%)	
Vitamin E				
Low level	84	48 (84.2%)	36 (83.7%)	0.040
Adequate	14	8 (14.0%)	6 (14.0%)	

Notes: Results were compared with age-specific recommended daily allowances (American dietary guidelines) and interpreted as adequate and inadequate with their corresponding percentage in brackets. Proportions were compared using chi-square test

Table III.
Dietary intakes among children with SCD

between nutritional intakes and haemoglobin. Chi-square test and Fisher's exact test were used to compare proportions between genders where appropriate. The analysis was presented at 95 per cent significant level, p-value < 0.05.

Results and discussion

In this study, a total number of 100 children with SCD participated, with a mean age of 7.0 ± 2.7 years. Majority of the participants (57 per cent) were male, a finding that is consistent with a study done by Al-Saqladi *et al.* (2010), whose male participants constituted 54.9 per cent. The most occurring type of SCD found among the study participants was the SS genotype (65 per cent), followed by the SC genotype (25 per cent). Thus, SCD-SS is the most prevalent type of SCD, and this finding is consistent with studies done by Jacob (2011) and Osei-Yeboah and Rodrigues (2011), who reported that haemoglobin-SS is the most prevalent among children with SCD.

In the study, dietary intakes of the SCD children were compared with age-specific recommended daily allowance for normal children (DeSalvo *et al.*, 2016). With the exception of vitamin E and iron, which showed significant difference ($p < 0.05$), all other nutrients showed no significant difference by gender. Contrary to these findings, Cox *et al.* (2011) reported worse nutritional intakes and status in boys compared to girls. Generally, the study found poor dietary intake among the study participants, and this finding is consistent with studies done by Hyacinth *et al.* (2013), who reported that undernutrition in children with SCD in most developing countries is mostly associated with inadequate diet.

Table IV.
Multivariable model of factors associated with haemoglobin levels

Variables	B	95% confidence interval	p-value
RBC	1.722	1.505-1.939	0.001
Protein	0.007	From −0.014 to 0.028	0.515
Folic acid	0.002	0.000-0.005	0.082
Vitamin B_{12}	−0.282	From −0.335 to 0.229	0.001
Zinc	0.320	0.15-0.49	0.001
Age	−0.030	From −0.074 to 0.063	0.876

Notes: Multiple variate regression model showing dependent variable: haemoglobin, $R^2 = 0.763$ and $p < 0.001$

Table V.
Mean values of biochemical variables among children with SCD

Parameter	Total mean	Boys	Girls	p-value
Albumin (g/L)	39.0 ± 3.4	38.6 ± 4.1	39 ± 4.5	0.9
Serum ferritin (ng/ml)	167.0 ± 173.8	117.9 ± 181.3	154.0 ± 164.6	0.5
WBC ($10^3/\mu$L)	10.4 ± 5.2	10.8 ± 4.9	9.8 ± 5.5	0.4
RBC ($10^6/\mu$L)	3.4 ± 1.2	3.3 ± 0.9	3.5 ± 1.4	0.3
Hb (g/dL)	8.6 ± 1.7	8.4 ± 1.8	8.7 ± 1.7	0.6
HCT (%)	27.2 ± 5.9	26.9 ± 5.8	27.4 ± 5.9	0.7
MCV (fL)	80.6 ± 11.3	81.5 ± 12.4	79.2 ± 9.6	0.3
MCH (pg)	25.8 ± 3.3	25.9 ± 3.5	25.5 ± 3.0	0.6
PLT ($10^3/\mu$L)	388.2 ± 155.5	370.1 ± 143.0	412 ± 169.3	0.2

Notes: Data represent Mean ± SD biochemical measures. Mean levels of boys and girls were compared using independent t-test. Hb: haemoglobin; WBC: white blood cell; HCT: haematocrit; MCV: mean corpuscular; MCH: mean cell haemoglobin; PLT: platelet

Children with SCD have higher metabolic rate and resting energy expenditure, and this may increase metabolic and nutrient demands; thus inadequate nutrient intake makes children with SCD susceptible to undernutrition, which increases disease severity (Mandese *et al.*, 2015).

Anthropometric measures reflect the nutritional and growth status of children with SCD. From the study, 37 per cent of the participants had low weight-for-age. Similar observations were made by Lukusa Kazadi *et al.* (2017), who reported that 47.7 per cent of children with SCD were underweight. Again in a longitudinal study, Fung *et al.* (2008) reported lower weight-for-age for male subjects compared to female subjects with SCD. Differences in growth may be attributable to environmental factors, nutritional status and disease severity (Lukusa Kazadi *et al.*, 2017). Prevalence of underweight (37 per cent) in this study was also higher compared to prevalence found among normal children (26.5 per cent) in the Kumasi metropolitan area (Ronald *et al.*, 2006). Underweight and stunting determined by BMI-for-age and height-for-age recorded 40 per cent and 22 per cent, respectively; however, there was no significant difference when gender was compared.

Low anthropometric index has shown significant impact on disease severity in SCD such that underweight increases the number of hospital admissions per year (Cox *et al.*, 2011).

Typically, homozygous SS and heterozygous S/β^0 patients have low red blood cell (RBC), haemoglobin, haematocrit and reticulocyte count due to chronic haemolytic anaemia (Alapan *et al.*, 2016).Total mean haemoglobin levels of the children in the study was 8.6 g/dl, which is a good indicator that the participants were at steady state. Similar studies done by Ballas *et al.*(2012) reported that SCD patients with haemoglobin levels 7.8-8 g/dl may not require blood transfusion. However, mean haemoglobin indicated anaemia when compared with normal reference standard for children (Behera and Bulliyya, 2016). There was no significant difference between haematological markers by gender.

Using multiple variate regression, dietary zinc intake (r^2=0.763, $p < 0.001$) was significantly related to haemoglobin levels. Zinc plays a major role in the absorption of iron, which is needed in the synthesis of haemoglobin, and thus may positively influence haematological parameters such as haemoglobin (Rahfiludin and Ginandjar, 2013). Similar observation was made by Khan *et al.* (2016), who reported that zinc supplementation reduces vaso-occlusion crisis and improves haemoglobin. Direct association between RBC and haemoglobin observed in the study was expected because increase in haemoglobin levels positively influence RBC (Akinbami *et al.*, 2012).

Conclusion

It was observed from the study that SCD is associated with a high prevalence of malnutrition and growth retardation. Also, dietary nutrient intakes among the study participants were inadequate, with significant differences in gender for iron and vitamin E. Nutritional status using anthropometric measures revealed that underweight and stunting were prevalent in the study participants. The study also established a direct association between zinc intake and haemoglobin levels.

It is recommended that macro- and micronutrient supplementation and nutritional education be added as part of the treatment protocol for children with SCD in developing countries.

Note

1. n= N/1 + N (e) ^{2}.

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Corresponding author
Tracy Bonsu Osei can be contacted at: tracob@yahoo.com