AJFAND ONLINE
Volume 10 No. 5
May 2010
ISSN 1684 5374
AFRICAN JOURNAL OF FOOD AGRICULTURE NUTRITION AND DEVELOPMENT

ASSESSMENT OF ANAEMIA AND IRON STATUS OF SCHOOL AGE CHILDREN (AGED 7-12 YEARS) IN RURAL COMMUNITIES OF ABIA STATE, NIGERIA

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AJFAND ONLINE
Volume 10 No. 5
May 2010
ISSN 1684 5374
AFRICAN JOURNAL OF FOOD AGRICULTURE NUTRITION AND DEVELOPMENT

ABSTRACT

The objective of this study was to investigate iron status of school children aged 7-12 years in some rural communities in Nigeria as well as identify factors associated with anemia in the children. A total of 249 school children, 120 males and 129 females aged between 7-12 years were used in the study. Haemomoglobin (Hb), haematocrit (PCV) and serum ferritin were used to determine anaemia and iron status in 208 children. The subjects were also screened for malaria parasites and worm infection to determine their impact on anaemia. C-reactive protein (CRP) was used as an indicator of inflammation or infection. Socioeconomic, anthropometric and body composition information were collected from the children, while dietary iron intake was determined using a combination of 24 hour dietary recall, food frequency questionnaire and weighed inventory technique. The values obtained for energy and nutrient intakes were compared with RDA recommendations. Anaemia was defined as Hb < 11.0mg/dl and iron deficiency was defined as serum ferritin levels below 12ug/dl. Correlation coefficient was used to evaluate association between anaemia and nutritional as well as health factors. The results showed that the prevalence of anaemia was 82.6%, while iron deficiency was 77.8%. The average daily iron intake was 30% below the recommended allowance. There was a high prevalence of inflammatory disorders as indicated by CRP. Malaria parasite and worm infestations were high in the children (93.2% and 41.8%, respectively). Anaemia was significantly associated with helminth infestation, malaria parasite and CRP. The children had a mean weight and height below the recommended standards. Of all the children in the study (n=249), 77% were both stunted and underweight while 56% were wasted. The body composition values of normal children (body fat, triceps, subscapula skinfold thicknesses and abdominal circumference) were significantly higher than those of the malnourished children ($p<0.05$). The percentage of children having low BMI (<14.59) was 23.69%.The need for malaria and helminth control in these communities is recommended.

Key words: Anaemia, stunting, school, children, rural

INTRODUCTION

Anaemia is a worldwide problem that is highly prevalent in developing countries of the world with the highest incidence reported in Asia and Africa [1]. Anaemia prevalence is high in children and its cause is frequently multifactorial. It has been estimated that about 40% of the world's population (more than 2 billion individuals) suffer from anaemia with a prevalence of 48% in school-aged children [2,3]. Anaemia occurs as a result of abnormally low haemoglobin due to pathological conditions. Iron deficiency is one of the most common causes of anaemia, other causes include chronic infections such as malaria, worm infestation, hereditary haemoglobinopathies and other micronutrient deficiency particularly folic acid [4].

The prevalence of iron deficiency is usually detected by low serum ferritin concentrations while iron deficiency anaemia is typically diagnosed by haemoglobin concentrations, accompanied by biochemical evidence of iron deficiency such as low serum ferritin concentration [5]. Anaemia among school-aged children (5-14 years) is defined as haemoglobin levels of 11g/dl or PCV of 34% [6]. Studies have shown low iron status and iron deficiency anaemia to be prevalent in African populations. A study of 8 African and Asian countries found that 40%-60% of school aged children in Mali, Tanzania, Mozambique, Ghana, Malawi and Kenya and 12% and 30% of those in Vietnam and Indonesia suffered anaemia [7]. Poor nutrition especially iron deficiency in school-aged children is associated with retardation of growth and poor cognitive development [8]. The school age children are at risk of iron deficiency because of an expanding red cell and muscle mass [9].

AIM OF THE STUDY

Information on the assessment of anaemia and iron status of school age children (7-12 years) has not been well documented in Nigeria. Therefore, this study sought to find out the major causes of anaemia in school children in some selected rural communities of Abia State, Nigeria.

MATERIALS AND METHODS

Location/study sites

This cross sectional study was carried out from April-July, 2007 in two local government areas (LGA) of Abia state; Umuahia North and Ikwuano local government areas. Three rural schools each were randomly selected from 17 LGAs that make up the state. The rural schools were located at Okwuta and Ahiaeke for Umuahia North; while rural schools from Umudike and Oboro make up that of Ikwuano LGA. The communities designated by sampling device were characterized by low to medium income earners and has majority of its inhabitants as farmers, traders, artisan, students, pensioners and civil servants. In these areas, the staple foods are cereals, legumes, roots and tubers.

Subjects
The study population consisted of primary school children aged 7-12 years living in the selected communities. Inclusion of subjects for the study was on voluntary basis, prior to acceptance. A total of 249 children were enrolled in the study. Only 208 participated in the collection of blood and stool samples for determination of iron status, malaria and helminthic parasites. Permission to conduct the study was obtained first from the LGA chairman, secondly from the headmaster/mistress of the schools, thirdly from the village heads and chiefs and lastly from the parents through the PTA meetings. The ethical committee of the Abia State University Teaching Hospital, Aba, reviewed the protocol and approved the study.

Blood sampling and biochemical measurements
Finger prick blood sample was collected from 208 children to measure haemoglobin in the field. An additional 5 ml venous blood sample was drawn into tubes with and without anticoagulant for the determination of serum ferritin and haematocrit. Blood samples were kept on ice during transport to the laboratory.

Iron status indices
Iron status was determined by measurement of hemoglobin, PCV and serum ferritin. Since hemoglobin, PCV and serum ferritin may be altered in the presence of infection, C- reactive protein (CRP) was used to identify individuals with inflammation.

Haemoglobin concentration (Hb)
Haemoglobin concentration was determined from finger prick blood sample using "Hemocue globinometer (HemoCue, Angelholm HB, Sweden). This apparatus is a portable battery-operated Hb meter and was used for haemoglobin determination in the field.

Serum ferritin
Venous blood sample was collected from the subjects and centrifuged at 5000rpm for 5 minutes after clotting. The sera were transported frozen at 20^0C to the University Biochemistry laboratory where analyses were done within one month of blood collection. The serum ferritin concentration was determined with Elegance Amplified Enzyme Linked Immuno Sorbent Assay (ELISA) system using kits from Bioclone Australia Pty. Ltd.

Haematocrit (PCV) determination.
Heparinised capillary tubes filled with blood up to two third of their capacity from the EDTA treated tubes were used. They were sealed and centrifuged at 1,500 rpm for 10 minutes on a micro haematocrit centrifuge [10].

C- Reactive Protein
CRP concentration was determined also with ELISA system based on the method developed by Naik and Voller [11].

PARASITOLOGICAL TESTS

Stool Samples

Containers were given to each child and they were asked to bring a sample of their faeces to school the next day. Stool samples were microscopically examined for helminthic infection within one hour of staining using a modification of formol-ether and ethyl acetate concentration technique [12]. Hookworm, Taenia and Ascaris ova were counted.

Malaria screening

Thick blood smears were prepared on glass slides within 12 hours of blood collection for the determination of malaria parasites. The slides were fixed and stained with Field stain (A and B), allowed to dry and observed under a microscope for malaria parasite using oil immersion objectives [13]. The presence or absence of malaria was reported as well as malaria parasite count.

Definitions

Anaemia was defined as haemoglobin below 11.0g/dl and further categorized as severe (Hb < 7.0g/dl), moderate (Hb between 7 and 10g/dl) and mild (Hb between 10 and 11g/dl) anaemia [14]. Haematocrit/PCV value below 34% was indicative of anaemia [15]. Iron deficiency anaemia was defined as serum ferritin below 12ug/dl [15]. CRP concentration was used as an indicator of the presence of a possible inflammation. CRP concentration above 20mg/l shows high risk of infection, mild risk was 10-20mg/l while CRP below 10mg/l indicated low or no risk of infection [16]. Malaria infection was defined as any parasitaemia (any species) detected in the blood smear. Malaria parasite count (MPC) indicates the level of severity of malaria infection as indicated by one plus (+), two pluses (++) and three pluses (+++). The worms most identified in the stool were counted and reported.

Socio economic data

A questionnaire was developed to obtain information on the family's socioeconomic and demographic status such as marital status of parents, household size, number of siblings, mother's educational status, and mother's level of education and position of index child in the family.

Anthropometry

Anthropometric measurements of height, weight and arm circumference were measured with children in light clothing. Weight measurement was taken using a bathroom scale (HANSON Model) to the nearest 0.1 kg. A fixed base portable wooden constructed scale carefully calibrated was used for height measurement to the nearest 0.1 cm. All measurements were taken following standard procedures [17, 18]. Other measurements taken included: head circumference, chest circumference and skinfold thickness measurement (triceps, biceps, subscapular and suprailiac). Chest/head circumference ratio was calculated by dividing the chest by head circumference. BMI was calculated as weight in kg divided by height in m^2. Height-

for-age (stunting), weight-for-age (underweight), and weight-for-height (wasting) were calculated using <-2S.D NCHS reference data [19].

Dietary Assessment

Twenty-four (24) hour dietary recall in combination with individual weighed inventory technique and FFQ were used to obtain food intake data from the children and their caregivers/parents according to methods previously described 20]. During the 24-hour dietary intake interviews, various food models, local kitchen utensils, such as plates, cups, spoons, and slices commonly used in Nigeria were used to quantify foods consumed. The utensils were later used to determine the equivalent weights of various food portions in grams. All the interviewers were nutritionist/dietitians working in the Human Nutrition Department of the University. For individual weighed inventory, food portions were weighed for breakfast, lunch and dinner in the house of the respondents; remnants were subtracted from the original weight of the food. Also, samples of food were collected from each household for the determination of iron, protein and other nutrient (specify all the nutrients) content of some common foods consumed in the communities.

STATISTICAL ANALYSIS

Data entry and management were done using SPSS statistical software version 10.0 [21]. Descriptive statistics of means, standard deviations and percentages were calculated. Differences in variables between sexes were examined using student's t-test. Pearson's correlation coefficient (r) was used to determine the association between anaemia and nutritional and health factors. Backward stepwise multiple regression analysis was performed to evaluate the independent relationship of haemoglobin concentration with various socioeconomic and biochemical factors. Level of significance for acceptance was p-value < 0.05.

RESULTS

A total of 249 children were originally included in the study, but only 208 participated in the collection of blood samples. Participation rate in females was 51.8%, while in males it was 48.2%. Table 1 and 2 show the anthropometric and nutritional status indices of the school children. The children had a mean weight and height below the recommended standards [22]. Of all the children in the study (n=249), 77% exhibited stunted growth and underweight respectively while 56% were wasted. There were significant differences in the triceps, subscapular, suprailiac and abdominal circumference of the children, with the females having higher values. Comparison of the body composition of normal children and malnourished children based on nutritional status indices (stunting, wasting and underweight) revealed that the normal children had significantly higher body fat, triceps, subscapular and abdominal circumference than the malnourished children ($p<0.05$). When body composition was compared based on age, there was significant difference with children aged 10-12 years having higher values than their counterparts (7-9 years). The percentage of children having low BMI (<14.59) was 23.7%.

The biochemical and iron status indicators of the children are presented in Table 3. The mean haemoglobin and PCV were 9.8g/dl and 28.16%, respectively. Using a cut off value of 12 µg/dl for serum ferritin concentration, 77.8% of the children were iron depleted or had iron deficiency. There was a high prevalence of inflammatory disorders (69.1%) as indicated by CRP. The average values of the iron status indicators were in all cases below the respective cut offs. Mean haemoglobin concentration and serum ferritin levels in wasted, stunted and underweight children were not significantly different from children with normal values ($p<0.05$).

Table 4 shows the children's mean daily energy and nutrient intakes. The energy and nutrient intake suggests the general nutrition of the children to be unsatisfactory. The mean dietary iron intake was 6.8 mg. In this study, more than two third of the children had a total iron intake below the RDA. Protein intake was lower than the recommended intake. The main foods consumed by these rural children were rice, beans and cassava processed into *garri* or *foofoo*. These foods contain non-heme iron as well as several iron inhibitors like tannins, poly phenols and phytates.

The overall prevalence of anaemia was 82.6% with rates of mild, moderate and severe anaemia being 9.6%, 71.6% and 1.4%, respectively. Only 17.4% were non anaemic. All the subjects that had severe anaemia (100%) were females while none of the males had severe anaemia. Sex specific anaemia rates were not significantly different for boys and girls. The Pearson's correlation coefficient analysis showed that there was a statistically significant positive correlation between low haemoglobin and serum ferritin. ($r=0.834$, $p<0.05$).

More than 41% of the children had worm infection of various kinds with hookworm being the most common helminthes found (13.9%), followed by ascaris (10.5%). About 58.2% of the children had no worm infection. A backward stepwise multiple regression analysis was used to identify factors influencing haemoglobin levels. The analysis included, socioeconomic data and iron status indicators. Using a p-value >0.05 for inclusion, CRP and helminthes were found to be significant predictors influencing haemoglobin status.

Socio economic and demographic data collected from the children and their mothers are presented in Table 6. The sample comprised 51.8% girls and 48.2% boys aged 7-12 years inclusive. The descriptive data showed a mean household of 5.07 with approximately 5-8 persons per household (49.7%). A higher percentage of mothers of the children were farmers (39.4%) while 41.4% had up to secondary education. Sixty nine percent of the children were staying with their parents at the time of the study. Mother's level of education was significantly but negatively correlated with helminthic infection ($r=-0.226$, $p<0.05$).

DISCUSSION

Few studies have been conducted in Nigeria on the iron status of school age children. This study is thus the first to report on anaemia and iron status in this population group in Abia state Nigeria. The prevalence of iron deficiency as indicated by depleted iron stores (SF < 12ug/dl) was 77.80%. Serum ferritin concentration has been identified as the most specific biochemical test that correlates with relative total body iron store, hence is a precondition for iron deficiency in the absence of infection [3]. In this study, 82.6% of the children were anaemic, suggesting that anaemia is a public health problem among the children in this area. However, low haemoglobin is a non-specific indicator for anaemia because it is also influenced by blood depleting parasites, chronic infections and haematological conditions [23, 24]. It is, however, interesting to note that 1% of the total number of children severely anaemic were all females. When normal and undernourished children (using BMI values) were compared based on iron status indicators, their mean haemoglobin and serum ferritin did not differ significantly. This suggests that anaemia may not only have occurred as a result of low haemoglobin but may have been influenced by other factors. Closely linked to anaemia is helminthic infection, which has been widely documented among children in both, rural as well as urban areas [25]. More than 40% of anaemic children were infested by helminth infections. Helminth infections were found to correlate significantly with anaemia in children. These helminthes have been reported to cause blood loss through stool and urine thereby leading to haemorrhagic anaemia [23]. Similar trends were reported in a study carried out on Tanzanian school age children [15]. Another study conducted by other workers on school age children (10-12 years) in Western Kenya also reported high prevalence of helminthes [26]. However, in contrast to the significant association between helminthes infection and anaemia reported in this study, this relationship was not observed in a study carried out in Zanzibar [27]. Malaria parasite, which, may also contribute to the etiology, and severity of anaemia through several mechanisms including destruction of red blood cells, was confirmed in majority of the children (93.2%) with *Plasmodim falciparium* as the primary cause of severe malaria (39.8%), especially in Nigeria where malaria is endemic. In Africa, it was noted that malaria and anaemia accounts for majority of visits to health centers [28]. In Tanzania, malaria accounts for about 60% of anaemia while iron deficiency is associate with only 30%.

Assessment of dietary intake revealed that iron intake was inadequate; iron intake of the children was about 30% below the RDA [22]. The result of this inadequate intake is reflected on the haemoglobin level of the children. Assessment of the iron content of collected food samples indicated that the iron content of foods consumed in the communities was poor. It was also observed during the food intake interviews that cereals, legumes, roots and tubers were the predominant foods consumed and these types of diet are known to contain high content of iron inhibitors such as polyphenols and provide low amounts of bioavalaible iron [29, 30]. These children consumed meat, poultry and fish, which are also excellent sources of heme iron and are enhancing factors for non-heme iron absorption, in low quantities. The limited economic potential of these rural children using socioeconomic status analysis could

possibly explain why the children have lower consumption of meat, fish and poultry, hence lower intake of highly bioavailable iron. In addition, fruits and vegetables (ascorbic acid sources) were consumed in between meals in an irregular manner. This consumption pattern coupled with the high prices of fresh citrus fruit outside the harvest season, as well as poor nutrition knowledge and practices of rural households did not allow the enhancing effects of vitamin C on iron bio-availability among these children to be effective as it usually the case [24].

CONCLUSION

Results of the study suggest that the prevalence of anaemia was quite high in the children. It was observed that it was not solely due to iron deficiency, but also as a result of malaria and helminthes infections, which may also have resulted in the high rates of inflammatory disorders in the children. It is suggested that malaria and helminthic control intervention strategies should be intensified in children in these communities. Also mothers should be educated on improving adequate nutritional practices in their homes.

ACKNOWLEDGEMENTS

This research was supported by a grant from Nestle Foundation, Switzerland. We also thank parents, teachers and children in the study area who willingly participated in this study. We especially thank staff members of the Human Nutrition Department of the University who assisted in the study.

Table 1:Anthropometric indices of the school children (n=249)

Parameters	Mean	S.D
Age (yrs)	10.0	1.5
Height (cm)	132.9	9.7
Weight (kg)	28.4	5.8
Arm circumference (cm)	18.6	1.9
BMI (kg/m^2)	16.0	2.0
Head circumference (cm)	51.9	2.0
Chest circumference (cm)	62.9	5.2
Head/chest circumference ratio	1.0	0.1
Abdominal circumference (cm)	4.5	1.8
Triceps (mm)	4.3	1.8
Biceps (mm)	2.8	1.2
Subscapular (mm)	4.3	1.4
Suprailiac (mm)	3.5	1.4
Sum of skinfold (mm)	19.2	6.6
LBM (kg)	18.5	6.2
Body fat (kg)	7.0	2.8

BMI = Body mass index

LBM= Lean body mass

Table 2:Nutritional status indicators in school children (n=249)

Nutritional indicator	Percentage(%)
BMI (kg/m^2)	
<14.59 (malnourished)	76.3
>14.6 (normal)	23.7
Arm circumference (cm)	
<16.0 (malnourished)	91.6
> 16.1 (normal)	8.4
Triceps (mm)	
<5.69 (malnourished)	81.1
>5.7 (normal)	18.9
CRP (n=208)	
<10mg/l (normal)	17.3
10-20 mg/l (At mild risk)	65.4
>20mg/l (At high risk)	17.3
Stunting	77.1
Wasting	56.0
Underweight	77.1

CRP = C-reactive protein

Table 3: Biochemical and iron status indicators (mean ± SD) in school children (n=208)

Iron status indicator	Mean	S.D
Haemoglobin g/dl	9.49	1.3
PCV (%)	28.16	4.0
Serum ferritin (ug/dl)	9.74	1.6
CRP (mg/l)	17.63	8.0

PCV =Packed cell volume

Table 4: Daily nutrient intake of school children

Nutrients	*RDA	All children
Iron (mg)	10	6.8
Protein (g)	34	32.0
Fat (g)	-	32.0
Carbohydrate (g)	-	250.0
Energy (kcal)	1800-2000	1220
Zinc (mg)	10	4.5

* RDA = FNB, NRC, RDA (1989)

RDA= Recommended dietary allowance, FNB= Food and Nutrition Board, National Research Council.

Table 5:Health and nutritional factors and their association with anaemia

Risk factors	Prevalence of risk factors	Correlations (p)
Helminths	41.8	Sf
Malaria parasites	93.3	Ns
Malaria parasite count	90.4	Sf
Underweight	77.1	Ns
Stunting	77.1	Ns
Wasted	56.0	Ns
Iron deficiency	77.8	Ns
Zinc deficiency	63.0	Ns
CRP	69.1	Sf

Sf= Significant

Ns= Not significant

Table 6: Socioeconomic and demographic characteristics of the children (n=249)

Variable	N	%
Sex		
Female	120	48.2
Male	129	51.8
Household size		
1-4	100	40.2
5-8	124	49.8
>8	25	10.0
Mothers level of education		
Primary	79	31.7
Secondary	103	41.4
Tertiary	48	19.3
None	19	7.6
Mothers occupation		
Unemployed	30	12.0
Farmers	56	22.5
Artisan	14	5.6
Trader	57	22.9
Civil servant	50	20.1
Living with parents		
Yes	174	69.9
No	75	30.1

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