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RESEARCH ARTICLE

Nutritional and micronutrient status of adolescent schoolgirls in eastern Sudan: A cross-sectional study [version 1; referees: awaiting peer review]

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v1 First published: 13 Oct 2017, 6:1831 (doi: [10.12688/f1000research.12721.1](https://doi.org/10.12688/f1000research.12721.1))
Latest published: 13 Oct 2017, 6:1831 (doi: [10.12688/f1000research.12721.1](https://doi.org/10.12688/f1000research.12721.1))

Abstract

Background: Adolescents, especially girls, are susceptible to malnutrition and their diet must be adequate to support their very rapid growth and development. Currently, there is little published data on the nutritional state amongst adolescent girls in Sudan.

Methods: A cross sectional study was conducted to assess the nutritional and micronutrient status of adolescent schoolgirls in eastern Sudan during the period of January-February 2015. Weight and height were measured using standard methods. Haemoglobin and ferritin levels were measured using blood samples, and blood films for malaria and stool samples for *Schistosoma mansoni* were investigated. Nutritional status was assessed according to the WHO 2006 reference values. Copper and zinc concentrations were measured by atomic absorption.

Results: Twenty-five (13.7%) out of 183 girls were stunted. Seventy (38.3%) were thin; 17.5, 9.3 and 11.5% had mild, moderate and severe thinness, respectively. Only 10 (5.5%) and six (3.3%) girls were overweight and obese, respectively. The prevalence of anaemia was 77.0%. While there was no significant difference in the haemoglobin, ferritin, copper levels and thinness; thin children had significantly lower zinc ($P=0.007$).

Conclusions: There is a high rate of stunting, thinness and anaemia among adolescent schoolgirls in eastern Sudan. More care has to be taken in order to provide a better nutrition status in the area.

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Author roles: **Mahgoub HM:** Data Curation, Investigation; **Fadleseed OE:** Investigation, Writing – Original Draft Preparation; **Khamis AH:** Data Curation, Formal Analysis; **Bilal JA:** Formal Analysis, Writing – Original Draft Preparation; **Adam I:** Conceptualization, Validation, Writing – Original Draft Preparation, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

How to cite this article: Mahgoub HM, Fadleseed OE, Khamis AH *et al.* **Nutritional and micronutrient status of adolescent schoolgirls in eastern Sudan: A cross-sectional study [version 1; referees: awaiting peer review]** *F1000Research* 2017, 6:1831 (doi: [10.12688/f1000research.12721.1](https://doi.org/10.12688/f1000research.12721.1))

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Grant information: The author(s) declared that no grants were involved in supporting this work.

First published: 13 Oct 2017, 6:1831 (doi: [10.12688/f1000research.12721.1](https://doi.org/10.12688/f1000research.12721.1))

Introduction

Adolescents (individuals aged 10 to 19 years) make up approximately one fifth of the world's population¹. During adolescence there is an increase in nutrient demand that is needed for intense growth, where individuals can gain 15% of their ultimate adult height and half of their adult weight²⁻⁴. Adolescents are vulnerable groups and their diet must be adequate to support their very rapid growth and development⁵. Well-nourished adolescents can have optimum cognitive and learning skills, and energies, as well as be healthy for future parenthood¹. Unfortunately, the required optimum nutrition remains unmet for a vast numbers of adolescents, who are thus unable to achieve their full genetic developmental potential². In particular, adolescent girls in developing countries are at risk, since they may become pregnant at an early age and have a greater risk of pregnancy-associated morbidity and mortality^{6,7}. Furthermore, malnourished adolescent girls are at a higher risk of being stunted mothers, who are likely to suffer obstetric complications, such as delivering low birth weight babies⁸.

Research on the nutritional status of adolescent girls is of paramount importance to health planners, as well as to practicing physicians. There is little published data on the nutritional status of adolescent girls in countries with few resources, including Sudan, where malnutrition is a major health problem⁹⁻¹⁴. Consequently, the current study was conducted to assess the nutritional and micronutrient status of adolescent schoolgirls in eastern Sudan.

Methods

Participant sample

A cross-sectional study was conducted in the New Halfa area in eastern Sudan during the period of January–February 2015. Adolescent schoolgirls aged from 11 to 18 years were selected through a two-stage random (using computer generated number) cluster sample of adolescent girls attending three primary schools (AlHara Aloula, Tania and AlHara Althalta) in the area. Stage one, simple random sampling of the schools to randomly identify classes within the specific age range; stage two, random sampling of the class in identify individuals.

Those with chronic illnesses were excluded.

A sample size of 183 subjects was calculated using the assumption of the prevalence of stunting (9.45%) and thinness (23.7%) that was recently reported among school children in Northern Sudan⁹. This sample would provide 80% power to detect a 5% difference at $\alpha = 0.05$, with an assumption that complete data might not be available for 10% of participants.

Data collection

Nutritional status. Age of the adolescent schoolgirls was taken and double checked with that in the school records, which had been completed using the birth certificate.

Weight was measured using a digital scale to the nearest 0.1 kg. Height was measured using a stadiometer with a moveable headboard to the nearest 0.1 cm, while the participant was barefoot.

Body mass index (BMI) was computed as weight (kg) divided by the square of height (m²).

Height-for-age (HAZ) and BMI-for-age z-scores (BAZ) were calculated according to the WHO reference¹⁵. Stunting was defined by HAZ <−2 z-scores. Overweight was defined by BAZ between 1 z-scores and 2 z-scores, and obesity by BAZ >2 z-scores. The WHO defines mild, moderate and severe thinness by z-scores: −2, −1; −3, −2; and <−3, respectively¹⁵.

Micronutrient status. Venous blood (5 mls) was collected from each participant and allowed to clot in plain tubes, and serum was stored at −20°C until analysed in the laboratory in Khartoum for measurement of serum ferritin, copper and zinc. Concentrations of ferritin were determined by immunofluorescent assay using IMMULITE1000 (SIEMENS, CA, USA), according to the manufacturer's instructions.

Copper and zinc concentrations were measured by atomic absorption spectrophotometry (SOLAAR 2.0, atomic absorption spectrophotometer (iCE 3000), Thermo Fisher Scientific, Cambridge, UK, 3000 Serie), according to the manufacturer's instructions.

Haemoglobin level was measured by HemoCue haemoglobinometer (HemoCue AB, Ängelhom, Sweden), according to the manufacturer's instructions. Anaemia and severe anaemia were defined as haemoglobin <12 and <8 /dl g/dl, respectively. Iron deficiency was defined as serum ferritin <12 µg/l; iron deficiency anaemia as haemoglobin <12 g/dl and s-ferritin <12 µg/l.

Parasite status. Blood films for malaria (*Plasmodium falciparum*) were prepared and Giemsa-stained.

Schistosoma mansoni infection was investigated in a single stool sample that was collected from each participant, and a Kato-Katz slide prepared and used to determine the infection intensity, if any¹⁶.

Statistical analysis

Data were entered using EpiData 3.4 and then exported to SPSS 20 for analysis. Anthropometric indices (HAZ and BAZ) were calculated using WHO child growth references for Z score¹⁵. Haemoglobin, ferritin, zinc and copper were tested for normality using Kolmogorov–Smirnov test. Mann-Whitney and Kruskal–Wallis tests were used to compare the continuous non-parametric data between two and more than two groups, respectively. Age was normally distributed and compared between two and more than two groups with t-test and ANOVA, respectively. Spearman's (non-parametric) correlation was used to investigate the correlations between the different variables. A P value of < 0.05 was considered significant.

Ethical statement

The study received ethical clearance from the Research Board at the Faculty of Medicine University of Khartoum (approval# 2012,18). After explaining the purpose of the study, written permission to perform the study was obtained from the local health

and education office (New Halfa Head Office for Education). Written informed consent was obtained from the parents/guardians of the school girls before data collection.

Results

Two hundred adolescent schoolgirls were initially screened; 183 had complete data and were analysed. The nutritional status of the girls is shown in [Table 1](#). Twenty-five (13.7%) out of the 183 girls were stunted. Seventy (38.3%) were thin, 17.5%, 9.3% and 11.5% had mild, moderate and severe thinness, respectively. Only 10 (5.5%) and six (3.3%) children were overweight

and obese, respectively. The prevalence of anaemia, iron deficiency and iron deficiency anaemia was 77.0%, 18.0% and 17.5% respectively. Four children (2.2%) had severe anaemia.

There was no significant difference in the mean (SD) age between girls with a normal anthropometric status (14.2 [1.3] years), and girls who had mild (13.7 [0.9] years), moderate (13.4 [1.3] years) and severe thinness (13.8 [1.3] years), overweight (13.7 [1.4] years) and obese (13.6 [1.2] years) girls ($P=0.161$). Likewise the mean (SD) age was not significantly different between stunted and non-stunted girls (14.2 [1.0] vs. 13.9 [1.3] years; $P=0.318$).

Table 1. Anthropometric status of the adolescent schoolgirl, eastern Sudan.

Status	N	%
Normal	97	53.0
Mild thinness	32	17.5
Moderate thinness	17	9.3
Severe thinness	21	11.5
Overweight	10	5.5
Obese	6	3.3
Total	183	100.0

Only two girls had *P. falciparum* infections. Eleven girls had *S. mansoni* infection, but the rate was not significantly different between the stunted and non-stunted group (3/25 (12.0%) vs. 8/158 (5.1%); $P=0.167$).

While there was no significant difference in the haemoglobin, ferritin, copper levels and thinness, thin children had a significantly lower zinc level compared to normal, overweight and obese children ($P=0.007$; [Table 2](#)). No significant difference was found between age, haemoglobin and micronutrient levels, and stunting ([Table 3](#)).

While there was no correlation between BMI, height, ferritin, zinc and copper, a significant positive correlation was found between haemoglobin, zinc and copper ([Table 4](#)).

Table 2. Anthropometric status and micronutrient levels in adolescent schoolgirl, eastern Sudan. Values show the median (interquartile range).

Status	Haemoglobin, g/dl	Ferritin, µg/l	Zinc, µg/ml	Copper, µg/ml	Zinc/copper
Normal ($n=97$)	10.8 (10.1–12.1)	44.2 (16.6–88.8)	113.1 (99.8–130.0)	124.5 (104.7–144.75)	99.7
Mild ($n=32$)	10.8 (10.1–11.6)	45.4 (24.3–87.6)	114.2 (105.4–127.3)	97.1 (119.0–138.2)	1.07
Moderate ($n=17$)	9.4 (9.8–11.1)	84.3 (8.0–124.9)	106.0 (97.9–120.5)	118.5 (102.2–150.7)	99.9
Severe ($n=21$)	10.8 (10.1–12.2)	31.8 (14.4–100.5)	96.1 (83.7–102.6)	108.5 (88.5–140.0)	1.1
Overweight ($n=10$)	10.2 (9.6–11.3)	43.4 (31.9–182.4)	116.9 (103.1–135.9)	144.2 (115.0–149.7)	0.7
Obese ($n=6$)	10.8 (10.6–11.2)	113.8 (31.5–182.0)	130.1 (109.2–137.3)	137.0 (121.1–149.7)	0.9
P value	0.649	0.597	0.007	0.191	0.014

Table 3. Stunting and micronutrient levels in adolescent schoolgirl, eastern Sudan. Values show the median (interquartile range).

Micronutrients	Stunted ($n=25$)	Not stunted ($n=158$)	P value
Hemoglobin, g/dl	10.8 (10.2–11.9)	10.8 (10.2–11.7)	0.925
Ferritin, µg/l	31.4 (20.3–88.0)	46.1 (17.8–96.9)	0.436
Zinc, µg/ml	108.4 (99.5–124.7)	112.0 (99.2–129.2)	0.560
Copper µg/ml	118.5 (104.0–144.7)	123.5 (103.–144.0)	0.796
Zinc/copper	0.955	1.055	0.521

Table 4. Spearman correlation between height, BMI and micronutrients among adolescent schoolgirls in eastern Sudan.

	BMI		Height		Haemoglobin		Ferritin		Zinc		Copper	
	r	P	r	P	r	P	r	P	r	P	r	P
Age	0.344	<0.001	0.252	<0.001	-0.092	0.215	-0.106	0.155	0.025	0.738	-0.082	0.271
BMI					-0.045	0.542	-0.016	0.832	-0.093	0.208	0.152	0.040
Height					0.077	0.299	-0.114	0.125	0.141	0.057	0.017	0.821
Haemoglobin	-0.045	0.542	0.077	0.299			0.101	0.175	0.191	0.010	0.194	0.008
Ferritin	-0.016	0.832	-0.114	0.125	0.101	0.175			0.070	0.347	0.115	0.120
Zinc	-0.093	0.208	0.141	0.057	0.191	0.010	0.070	0.347			0.004	0.955

Dataset 1. Raw data collected as the basis for this study

<http://dx.doi.org/10.5256/f1000research.12721.d180824>

Discussion

The current study found a high prevalence of stunting (13.7%), thinness (38.3%) and anaemia (77.0%) among adolescent schoolgirls in this setting. This supports the findings of a previous study where a high prevalence of underweight (41.0%) and stunting (21.4%) was reported among primary school children in Khartoum, Capital of Sudan¹⁷. These two studies should be compared with caution because of the different study techniques used. Unlike the WHO standard used in the current study, weight-for-age, HAZ and skin-fold thickness of triceps muscle was used by the later study. Recently, Sarar and Diab reported⁹ a lower prevalence of stunting (9.4%), thinness (23.1%), and anaemia (29.7%) among 835 school-aged children in Northern Sudan.

The overall prevalence of thinness (38.3%) in the current study was much higher than reports of studies conducted in other neighbouring African countries, e.g. Ethiopia (1.4-8.9%)¹⁸, Kenya (4.5%)¹⁹ and Uganda (10.1%)²⁰.

Wasting, stunting and thinness are indicators of acute nutritional deficiency. Malnutrition in all age groups is caused by inadequate food intake or poor food utilization caused by infections^{15,21}. Six (3.3%) adolescent girls in the current study were obese. Being overweight and obesity have been reported among 10.7% of urban Sudanese adolescents²².

Though there was no significant difference in haemoglobin, ferritin, and copper levels, a significantly lower zinc level among thin adolescent girls was found compared with girls with normal BMIs in the current study. Contrary to our findings, Bemnet and colleagues showed no association between zinc and HAZ. However, they observed a significant positive correlation between HAZ and copper levels¹⁸. Both zinc and copper have an important role in growth, and participate in numerous enzyme systems²³.

Zinc deficiency is common in developing countries and can delay linear growth^{24,25}. Unfortunately, recent research failed to show any benefit of zinc supplement in decreasing stunting in Malawian children²⁶.

In this study, we aimed to assess the nutritional and micronutrient status of adolescent schoolgirls in eastern Sudan. A limitation of this study was that adolescent boys were not investigated, which might have under-estimated the rate of malnutrition among adolescents (both males and females), as adolescent girls have been shown to be less likely to be stunted than boys^{20,27}. In addition, only schoolgirls were investigated, which might have missed the more vulnerable group of adolescent girls who do not attend school. Another limitation of the current study was the lack of puberty history, since the onset of the menarche might have effects on the nutritional status of the adolescent girls. Moreover, there was a lack of dietary intake history, since physical growth of adolescent girls is generally related to their dietary intake. Another point that should be remembered is the lack of investigation of acute inflammatory markers, e.g. C-reactive protein, which has been to be associated with anaemia in eastern Sudan²⁸.

Conclusions

There is a high rate of stunting, thinness and anaemia among adolescent schoolgirls in eastern Sudan. More care has to be taken in order to provide a better nutrition status in the area.

Data availability

Dataset 1: Raw data collected as the basis for this study. doi, [10.5256/f1000research.12721.d180824](http://dx.doi.org/10.5256/f1000research.12721.d180824)²⁹

Competing interests

No competing interests were disclosed

Grant information

The author(s) declared that no grants were involved in supporting this work.

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