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Anthropometry, serum zinc and socio-economic status of children attending a private secondary school in Nigeria in COVID-19 era

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ABSTRACT
Introduction: Pandemics have been known to influence many markers associated with socio-economic status. This is especially true of micronutrients, including zinc. Yet despite the importance of zinc in the human body, there is a paucity of data on the zinc status of Nigerian children.
The aim of this study was to determine serum zinc levels, anthropometry, dietary zinc content and socioeconomic status (SES) of school-aged children in the cities of Osogbo and Ogbomoso in South West Nigeria during the COVID-19 pandemic.
Materials and methods: One hundred and forty-one children (aged 9–17) were recruited for the study, 76 children from Osogbo and 65 children from Ogbomoso. Serum zinc levels were determined using atomic absorption spectrometry. Information on SES and dietary zinc content were obtained using a structured questionnaire. Anthropometric indicators – height, weight, body mass index (BMI), and mid-upper arm circumference (MUAC) were also measured. Data were analysed statistically using Student's t-test and Pearson's correlation coefficient $p < 0.05$ was considered significant.
Results: Results of the study showed that there were no significant differences in the values of zinc, BMI, and MUAC, when both groups were compared. Majority of the students in each group were of medium SES. Sixty percent (Ogbomoso) and 43% (Osogbo) did not consume food rich in zinc, although calculated BMI-for-age percentiles revealed that 89.23% (Ogbomoso) and 71.05% (Osogbo) were of normal weight. Mid-upper arm circumference of <22.0 cm for both groups suggests moderate acute malnutrition despite the fact that a correlation was observed between MUAC and BMI.
Conclusions: The results of the study indicate that moderate zinc deficiency is still prevalent among school-aged children in South West Nigeria and this requires urgent intervention from different stakeholders.
Keywords: serum zinc; dietary zinc; school-aged children; anthropometry; socio-demography; urban setting.

INTRODUCTION

Zinc, an essential trace element vital for the development of the reproductive organs and brain, is also required for the normal growth and optimal immune response. The function of zinc in cells and tissues is dependent on metalloproteinase and these enzymes are associated with reproductive, neurological, immune, and dermatological systems, as well as gastro-intestinal tract [1]. Zinc deficiency is associated with poor growth, depressed immune function, hair loss, increased susceptibility to infection, delayed sexual development in adolescents, loss of appetite, weight loss, problems with wound healing etc. [2, 3].

So far plasma/serum zinc concentration, dietary intake and stunting prevalence are the best-known indicators of zinc deficiency. Zinc affects growth hormone (GH) and zinc deficiency may result in reduced GH production and/or insulin-like growth factor-1. Zinc deficiency may also affect bone metabolism and gonadal function [4]. In many lower-income countries, zinc deficiency is common because the diets are composed primarily of:

- cereals and legumes which contain a substantial amount of phytate, a compound known to inhibit zinc absorption,
- a few animal-source foods that are rich sources of zinc and are free of phytate [5, 6].

Anthropometric measurements are a series of quantitative measurements of muscle, bone and adipose tissue that are used to assess the composition of the body. The core elements of anthropometry are height, weight, body mass index (BMI), body circumferences (waist, hips, and limbs), and skinfold thickness. They are used as a measure of nutritional status in children as well as baseline for physical fitness [7]. Body mass index is a number calculated from a child's weight and height, and is a reliable indicator of body fatness and nutritional status for most children and adolescents [7, 8]. Mid-upper arm circumference (MUAC) is a rapid method of assessing nutritional status that does not require extensive training or supervision [9].

Social economic status refers to the social and financial level of individuals in society. An individual's socio-economic status (SES) from before birth and through the early years of life is based on that of their parents [10]. The present pandemic has significantly altered socioeconomic situations of people, and according to Woods et al. lower income predisposes people to consume diets composed primarily of cereals and legumes, instead of zinc-rich animal-source foods [11]. Therefore the aim of this pilot study was to carry out a comparative assessment of anthropometric parameters, serum zinc level and socio-economic status of children in private schools in 2 urban settings (Ogbomoso, Osogbo) in Nigeria.

Both cities were chosen because of similarities in ethnic distribution as well as social/educational markers. Moreover, the comparison became necessary because of differences in measures adopted by Oyo and Osun states at the early stage of COVID-19 pandemic. Total lockdown was strictly enforced and for a longer time in Osun than Oyo state. Moreover, COVID-19 pandemic has been recognized to impact many aspects of adolescence life. Daniunaite et al. observed a significant negative impact of the COVID-19 pandemic on mental health in the majority of adolescents recruited for a study, but the impact of pandemic is not limited to adverse psychological functioning, it has been reported to adversely affect SES also [12, 13]. Whether its impact on SES is severe enough to alter anthropometry has not been determined among Nigerian adolescents, but in other parts of the world, for example Poland, COVID-19 caused a significant weight gain among children, as found by Koletzko et al. [14].

MATERIALS AND METHODS

Chemicals

All chemicals used for the study were of analytical grade and were obtained from reputable companies – British Drug House (Poole, England) and Sigma – Aldrich (MO, USA).

Ethical consideration

Ethical clearance was obtained from the Ministry of Health, Osun State, Nigeria. Informed consent was obtained from parents/guardians. The assent of children 9 years and above was sought. The anonymity of the obtained information was maintained.

Study design

Cross-sectional comparative study.

Study site

Private secondary schools in Ogbomoso, Oyo state and Osogbo, Osun state (Nigeria).

Study population, sampling technique, sample size

Research participants consisted of respondents male and female between the ages of 9–17 years. Secondary school students in Ogbomoso (Oyo state) and Osogbo (Osun state) were recruited. Multi-stage random sampling technique was employed for the selection of study participants. Sample size for this pilot study was based on Hertzog who suggested that a sample size of between 10–30 per group is adequate for a pilot study [15].

Inclusion criteria

Apparently healthy participants were allowed to partake in the research. Participants were of both genders: male and female.

Exclusion criteria

All children known to have chronic medical conditions such as human immunodeficiency virus, tuberculosis and chronic diseases were excluded from the study. Also excluded were all children with postural deformity that affect height, those on zinc supplementation or with disorders related to zinc metabolism as well as those on dietary restriction because of gastrointestinal diseases or allergy.

Sample collection and trace element estimation

Laboratory wares used were cleansed according to standard procedure as described in Elemental Analysis Manual of United State Department of Health and Human Services. Four mL of venous blood was collected from all participants into anti-coagulant free bottles. Each sample was centrifuged at 1500 revolution/min for 5 min. Serum samples were kept at –20°C until required for analysis. Serum trace metal was estimated with Atomic Absorption Spectrophotometer – AAnalyst model 400.

Anthropometric measurement

For each child, weight in kg was taken with his/her clothes made of light fabric, barefoot, using a normal bathroom standing scale (AL HanaMedical weighing equipment, JafeiyaMankhool Road, Dubai). Measurements were taken to the nearest 0.5 kg. Using a stadiometer supplied by Indo Surgicals Private Limited (New Delhi, India), standing height in cm was taken. This was carried out without shoes, both feet flat on the ground and apposed at the medial malleoli. Measurements were made to the nearest 0.5 cm.

The BMI was calculated by the formula: BMI = weight (kg)/height (m^2). World Health Organization and Centers for Disease Control classification was employed to classify BMI into underweight as BMI less than the 5th percentile, healthy weight as BMI of 5th up to the 85th percentile, overweight as BMI of 85th to less than the 95th percentile and obese as BMI equal to or greater than the 95th percentile for age and gender [16]. Mid-upper arm circumference was obtained using a measuring tape.

Instrument of data collection

Pre-tested, structured questionnaire was administered by a trained person. For a child below the age of 10 years the assistance of the parent/guardian was employed to carry out the interview. The structured questionnaire consisted of different sections. The 1st section collected demographic data (age, gender, parents' occupation and education). Stratification of the children into socio-economic classes was done with the classification by Oyedeji [17] and Oredugba and Savage [18], based on the parent's level of education and occupation. The mean of 4 scores (one each from the father's educational level and occupation and also from the mother's educational level and occupation) to the nearest whole number was the social class assigned to the child on a 5-point scale, with class 1 representing the highest level of socio-economic status, and 5 the lowest.

Classification of zinc content in 24-hour meal recall

Dietary zinc content of each participant was obtained using the method described by Temiye et al. [19]. The zinc contents of 24-hour meal recall and the last meal consumed before blood was taken were classified based on the qualitative status of zinc in food items consumed by the subject.

The qualitative evaluation of zinc content of commonly consumed food items as reported by Balch [20] and Norman et al. [21] was adopted for classification of dietary zinc content of the participants. Each food item was classified as containing high, moderate, or low zinc levels. Meals containing food items such as plantain, red beef, egg, milk, cocoa products, and fish were classified as having high zinc content. On the other hand, beans or cereals made out of maize and rice products were considered to have a moderate zinc content. Cassava products were classified as having traces or low zinc content. Any participant that had more than 2 zinc-rich items with any 3 items with moderate zinc content or all zinc-rich items was classified as having a zinc-rich diet. Meanwhile, a child who had 1 zinc-rich item and less than 3 items with moderate zinc content or all items with moderate zinc content was classified as a diet with a moderate zinc content, while a subject who had 1 item with a moderate zinc content or 1 item rich in zinc and 1 with low zinc content, or only items with a low zin content, was classified as having a diet poor in zinc.

Statistical analysis

The data obtained from the trace elements analysis and anthropometric measurements were analyzed using Statistical Package for Social Sciences. The data was expressed in mean ±standard deviation. The difference between the means was analyzed using the Student`s t-test and Pearson`s correlation coefficient was used to establish a relationship between trace element levels with anthropometric parameters – $p < 0.05$ was considered significant.

RESULTS

Presented below are the results for 141 children enrolled in this study, comprising of 76 and 65 participants attending Private Secondary Schools in Osogbo and Ogbomoso, respectively. Results in Table 1 reveal the mean distribution and comparison of age, serum zinc as well as anthropometric markers between the Osogbo and Ogbomoso groups. There was no significant difference in the mean values of middle upper arm circumference of subjects in Ogbomoso when compared to subjects in Osogbo ($p > 0.05$). Likewise, there were no significant differences in the mean values of age, serum zinc, weight, BMI and height of subjects in Osogbo when compared to those of the participants in Ogbomoso ($p > 0.05$) – Table 1.

Correlations between serum zinc and anthropometric parameters are shown in Table 2. Correlations were observed between serum zinc and age ($r = 0.181$, $p = 0.032$); BMI and MUAC ($r = 0.579$, $p = 0.000$); BMI and age ($r = 0.259$, $p = 0.002$) and MUAC and age ($r = 0.434$, $p = 0.000$). The absolute and relative data on the SES, dietary zinc content and nutritional status of participants are presented in Table 3.

TABLE 1. Comparison of age, serum zinc and anthropometric markers between the Osogbo and the Ogbomoso groups

Parameters (units)	Osogbo group (mean ± SD)	Ogbomoso group (mean ± SD)	p-value
Age (years)	13.3 ±1.5	13.38 ±2.50	0.705
Zinc (ppm)	0.12 ±0.07	0.11 ±0.06	0.604
MUAC (cm)	21.3 ±2.16	21.8 ±10.9	0.187
Height (m)	1.5 ±0.14	1.47 ±0.11	0.642
Weight (kg)	39.4 ±9.3	42.05 ±9.54	0.099
BMI (kg/m2)	18.5 ±2.9	19.29 ±2.59	0.109

Data presented as mean ± standard deviation (SD)

TABLE 2. Correlation between zinc and anthropometric parameters

Correlations		Serum Zn	BMI	MUAC	Age
Serum Zn	Pearson correlation	1	−0.127	0.015	0.181*
	Sig. (2-tailed)		0.132	0.857	0.032
	n	141	141	141	141
BMI	Pearson correlation	−0.127	1	0.579**	0.259**
	Sig. (2-tailed)	0.132		0.000	0.002
	n	141	141	141	141
MUAC	Pearson correlation	0.015	0.579**	1	0.434**
	Sig. (2-tailed)	0.857	0.000		0.000
	n	141	141	141	141
Age	Pearson correlation	0.181*	0.259**	0.434**	1
	Sig. (2-tailed)	0.032	0.002	0.000	
	n	141	141	141	141

*Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
BMI – body mass index; MUAC – middle upper arm circumference

TABLE 3. The absolute and relative frequencies of socioeconomic status, dietary zinc content and nutritional status of study participants

Parameters	Ogbomoso group		Osogbo group	
	AF	RF (%)	AF	RF (%)
Socioeconomic status				
Low	7	12.31	14	18.42
male	4		7	
female	3		7	
Medium	31	47.69	39	51.32
male	17		17	
female	14		22	
High	27	40.00	26	30.26
male	13		15	
female	14		9	
Dietary zinc content				
Low	14	21.54	14	18.42
male	5		7	
female	9		7	
Moderate	25	38.46	19	25.00
male	10		11	
female	15		8	
High	26	40.00	43	56.58
male	15		22	
female	11		21	
Nutritional status				
Underweight	2	3.08	14	18.42
male	1		10	
female	1		4	
Normal	58	89.23	54	71.05
male	27		28	
female	31		26	
				10.53
Overweight	5	7.69	8	
male	2		1	
female	3		7	
Obesity	0	0.00	0	0.00

AF – absolute frequency; RF – relative frequency

MUAC – middle upper arm circumference; BMI – body mass index

DISCUSSION

The prevalence of a diet poor in zinc at 21.54% (schoolchildren in Ogbomoso) and 18.42% (schoolchildren in Osogbo) is a reflection of how widespread zinc deficiency may be in many African communities. These findings are in line with literature, although most studies used serum zinc as marker of study. Information from past studies included prevalence rates of 72% in Burkina Faso [22]; 47.5% in Sokoto, North West Nigeria [23]; and more recently 32% in Ilorin city, North Central Nigeria [24]. A prevalence of zinc deficiency at 20–25% in food consumption and nutrition surveys obtained by several other authors agrees with our data. Fedele et al. opined that zinc deficiency may limit an individual's readiness to fight any infectious disease, including COVID-19 [25]. Meanwhile, the reasons for low serum zinc level or low dietary zinc intake varies widely in Africa, with socio-economic factors playing the most significant role.

Generally, in our study, low zinc content in the diet was linked to the consumption of a cereal-rich diet and cassava-based diet, as revealed through information obtained from the administered questionnaire. Cereals are rich in phytate which causes the inhibition of zinc absorption in the gastrointestinal tract. Moreover, our survey revealed low consumption of animal-source foods (muscle or organs) which are rich sources of zinc and are free of phytate. It is not surprising that the results revealed that only 40% of participants in Ogbomoso consumed foods with high dietary zinc content. Onyeaka et al. observed that COVID-19 pandemic caused food insecurity occasioned by many factors [26]. The adverse effects of COVID-19 on the socioeconomic parameters of Nigerians as reported by Fatoye et al. [27] and Abay et al. may be a cause of low consumption of animal-source foods. Meanwhile, COVID-19 disruption of school feeding programs [28] must not be overlooked as an important factor that contributed to consumption of a plant-based diet among the studied adolescents.

The SES of both study groups was not so different, with the percentage share of low, medium and high SES at 12.31%, 47.69% and 40.00% in the Ogbomoso group as against 18.42%, 51.32% and 30.26% in the Osogbo group. Mid-upper arm circumference, one of the markers of the study, was not significantly different in both groups, which is in agreement with many past observations in which MUAC has been considered a more appropriate indicator of a child's SES than BMI, and it seems to support the results of the SES of the Ogbomoso and Osogbo groups. According to Nowak-Szczepanska et al. since long-term socioeconomic changes affect MUAC more noticeably than BMI, MUAC may be a more accurate screening tool [29]. The MUAC, not significantly different between the study groups, is useful also in monitoring nutritional status [30]. And since MUAC values obtained for both groups were within WHO acceptable range for moderate acute malnutrition, therefore it can be suggested that the subjects were moderately malnourished. This assumption can be supported by the fact that 47.69% (Ogbomoso) and 51.32% (Osogbo) of the participants were of medium SES. According to WHO the value of ≥18.5 cm is considered normal for children between 10–14 years of age, while moderate acute malnutrition and severe acute malnutrition are set at 16.0–18.5 cm and <16.0 cm respectively. Moreover, children aged 15–17 years are considered normal if MUAC is ≥22.0 cm; but values of 18.5–22.0 cm and <18.5 cm are for moderate acute nutrition and severe acute nutrition respectively.

Craig et al. [31] and Chaput et al. [32] argue that MUAC is a reliable biological indicator of overweight and obesity, especially among children in resource-limited areas. Zero percent of obesity recorded may be a true reflection of the high/moderate SES in South-Western Nigeria in the period affected by the COVID-19 pandemic. The values varied widely in the pre-COVID-19 period, 0.3% of children were found to be obese in a study conducted in Ile-Ife, a town in Osun state [33], but 8.9% obesity was recorded by Adeniyi et al. [34] and 2.8% by Ene-Obong et al. [35] in 2 other separate studies. That the use of MUAC to investigate nutritional status in these subjects is adequate can be supported by similar submission made by Mazıcıoğlu et al. who highlighted that MUAC, next to the waist circumference and BMI, may be a good indicator of overweight and obesity among children and adolescents [36].

Moreover, the results of MUAC are in agreement with those of BMI, which have been indicated as a common and universally used measurement for screening both underweight and overweight across many populations. Mid-upper arm circumference and BMI of both groups were not significantly different. Several research reports have revealed that MUAC can predict overweight and excess fatness with fairly reasonable accuracy.

Childhood overweight which the WHO considers a serious public health challenge [37], especially in low- and middle-income countries, constituted 7.69% and 10.53% among the participants in Ogbomoso and Osogbo groups, respectively. Therefore, the observation by Hadhood et al. [38] and Taha and Marawan [39], of overweight and obesity in 15% of in a sample population of Egyptian children, are different from the results of the our study. The overweight in Osogbo participants at the level exceeding 10% may be related to multiple causes, such as the modern lifestyle characterized by inactivity and passive overeating [39].

Results of previous studies suggest that the prevalence of overweight and obesity may differ between males and females [40, 41]. Gender-related differences were observed in both Ogbomoso and Osogbo groups. There were more males with high SES, and underweight sub-groups among Osogbo participants than females. In the same vein, among Ogbomoso participants there were more males than females in the sub-group with a zinc-rich diet. In both Osogbo and Ogbomoso participants there were more females than males in the following sub-groups: medium SES (Osogbo), overweight (Osogbo), diet with a low zinc content (Ogbomoso), and a diet with a moderate zinc content.

Although only 30.26% belonged to high SES in Osogbo group, more than 56% consumed food high in dietary zinc content. This probably signifies the fact that SES did not dictate the choice of food in Osogbo participants; moreover, it seems possible that food rich in zinc may be cheaper in Osogbo than Ogbomoso, although there is no evidence to suggest this in literature. On one hand, among the Ogbomoso participants there was complete agreement between the percentage of children in high socioeconomic group and those that consumed a zinc-rich diet. This observation is in line with past observations. Meanwhile, moderate to high zinc containing foods were consumed by 81.58% in Osogbo group and 78.46% in Ogbomoso group. This similarity may be the reason why serum zinc concentrations of both groups were not significantly different.

Although zinc levels were not significantly different between both groups, the fact that only 40% (Ogbomoso) and 56.58% (Osogbo) consumed diet with high zinc content should be a source of concern. Especially, as the MUAC values suggest moderate malnutrition, this means moderate zinc deficiency was prevalent among the studied groups of adolescents. Zinc deficiency may affect cognitive function (especially the ability to learn) and hedonic tone. Moderate and more severe zinc deficiencies are associated with behavioural abnormalities, such as irritability, lethargy, and depression (e.g. involving anhedonia) as well the symptoms of attention deficit hyperactivity disorder.

CONCLUSION

Although there were no differences in the zinc levels of children from the 2 study groups from 2 Nigerian cities and most of the participants were of normal weight, the fact that only about 50% of participants in each group consumed food rich in zinc is an indication of a risk of zinc depletion in both groups. The MUAC results of both groups that indicate moderate malnutrition support this observation.

RECOMMENDATION

The study further supports the persistent call that had been made through several media for stakeholders to make available micronutrient supplementation to children in resource-poor communities. In its absence, they should embark on fortification of some food items to ensure that mild, moderate or severe zinc deficiency becomes a thing of the past.

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