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ZINC NUTRITIONAL STATUS AND ANTHROPOMETRIC INDICES OF PRESCHOOL CHILDREN LIVING IN A RURAL COMMUNITY IN EDO STATE, NIGERIA

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ABSTRACT:

Zinc deficiency impairs growth and development but epidemiological data for zinc nutrition status among preschool children living in rural areas of Nigeria is lacking. The aim of the present study was to assess the zinc status and anthropometric indices of children aged between 6 and 60 months, living in a rural community in Edo State, Nigeria. In this community-based cross-sectional study, five out of the nine political wards (quarters) in the community were randomly selected; all the households with children aged between 6 and 60 months were included the study. A total of 252 children were selected to participate after obtaining informed consent from their parents. Steps were taken to avoid exogenous zinc contamination of the blood samples which were collected in the mornings. The serum zinc levels of the subjects were determined, using flame atomic absorption spectrophotometry. The weights, heights, head and mid-upper arm circumferences of each child were measured, using standard procedures. Z-scores of anthropometric indices of height-for-age, weight-for-age and weight-for-height were computed to assess the nutritional status of the children. The mean age of the study population was 32.7±17.0 months. The prevalence rates of stunting, underweight and wasting among the children were 18.2%, 14.7% and 11.1%, respectively. The overall mean serum zinc concentration was 4.77±3.02μmol/L, with a range of 1.0-16.52μmol/L. Of the 252 children, 220 (87.3%) had mean serum zinc concentration below 7.65μmol/L, representing severe zinc deficiency. The highest mean serum zinc concentration was found among children aged 6 to 12 months and this was followed by a progressive decline in serum zinc concentration from the age of 13 months up to 48 months. Correlation between the serum zinc concentration of the children and their age and social class of the parents were as follows: age, $r = 0.09$, at $p = 0.15$; social class, $r = 0.08$; at $p = 0.21$. The children with wasting had the lowest mean serum zinc concentration compared with either the group with underweight or stunting. The zinc nutritional status of preschool-age children in this community clearly indicates a suboptimal zinc status at the time of this study. According to the IZiNCG criteria, this should be considered as a public health problem among preschool-age children in this community. To effectively address the issue, social mobilization, intensive education and awareness campaign, with all target groups and policy makers are urgently required. Public health measures aimed at improving their zinc nutritional status should also be considered.

Keywords: Zinc status, rural community, preschool children, stunting, underweight, wasting.

INTRODUCTION:

Zinc is an essential micronutrient which is ubiquitous in human biological systems and vital for protein synthesis, cellular growth, cellular differentiation, immune function and cognitive development [1]. The zinc content of foods which is the major source of zinc in an individual's body, varies widely. Some of the good sources of dietary zinc include red meats (especially organ meats) and sea foods (especially oysters and shellfish), poultry, pork, fish and dairy products [1]. Vegetables are good plant sources of zinc [1]. Zinc intake from breast milk varies during lactation as the breast milk content decreases from approximately 12mg/L in colostrums to 1.6, 1.1 and 0.5mg/L at 3, 6 and 12 months, respectively [2]. After the age of six months, older breast feeding infants depend on complementary food for a substantial part of their zinc requirements and this represents the period of special concern regarding zinc nutrition [3]. Complementary foods containing phytates are not only low in zinc content but some also, reduce bioavailability of zinc from breast milk [4]. Processing of certain foods may affect availability of zinc for absorption. For example, heat treatment can cause food zinc to form complexes that are resistant to hydrolysis, thereby making zinc unavailable for absorption [1]. In preschool children, suboptimal zinc nutrition constitutes a significant health risk with regard to growth and cognitive development [1,3]. Attained height is the result of interaction between genetic endowment and both macro- and micronutrient consumption and bioavailability during the growth period. Linear growth occurs through a process of cell proliferation, the addition of new cells to growth plate of the bone and hypertrophy, resulting in expansion of growth plate [5]. Some micronutrients affect the insulin-like growth factor-I (IGF-I) system. For example, animal studies show that zinc deficiency in rats causes not only growth retardation but also a decrease in both IGF-I plasma concentration and growth hormone (GH) receptors, which return to normal after zinc repletion [6]. In addition, through its influence on the GH/IGF-I system, zinc deficiency has been observed to affect bone metabolism [7]. The role of zinc in growth also may be explained in part through its participation in DNA synthesis [8]. In many developing countries, including Nigeria, growth disorders among children are under-diagnosed because weights and particularly, heights are not routinely measured and recorded during visits to healthcare institutions for other ailments. Studies have shown conclusively that zinc supplementation improves linear growth in infants, preschoolers and older prepubertal children [9, 10], confirming the requirement of adequate zinc intake for normal growth. In some developing countries, zinc deficiency is common and represents a major public health problem [11-15]. The report of a study in Cameroon revealed a zinc deficiency prevalence of 82.6% in children [16]. The major aetiologic factors of childhood zinc deficiency in developing countries include low intake of zinc-rich foods, poor bioavailability of zinc, and the presence of parasitic infections of the gastrointestinal tract [17-19]. In the paediatric age group, nutritional status is classified as underweight (Weight-for-Age; WAZ: less than minus 2SD, Z-score); Wasting (Weight-for-Height; WHZ: less than minus 2SD, Z-score); and Stunting (Height-for-Age, HAZ: less than minus 2SD, Z-score) [20]. Stunting (HAZ) results from chronic undernutrition which retards linear growth; whereas wasting (WHZ) results from inadequate nutrition over a shorter period and underweight (WAZ) encompasses both stunting and wasting [20]. Nigerian complementary foods consist mainly of starchy tubers (yam, cassava, cocoyam) and cereal-based gruels made from maize, millet, guinea corn [21, 22]. These food items may have inadequate zinc content [22]. The results of some Nigerian studies have revealed high prevalence of zinc deficiency, ranging from 41.5% to 63.3% [12, 15]. The purpose of the present study was to assess the zinc nutritional status and anthropometric indices of children aged between 6 and 60 months, living in a rural community in Edo State, Nigeria.

SUBJECTS AND METHODS:

This descriptive cross-sectional study was conducted over a period of 3 months, from January to March, 2013. Ethical approval for the study was obtained from the Ethics and Research Committee of the University of Benin Teaching Hospital. The details of the study were explained to the chief of Udo community (the Uwague) with his subordinates (heads of the political wards) in attendance. Each of the heads of the political wards informed the heads of every household within his domain. Informed consent was also obtained from the parents of the children who participated in the study.

Study area location:

The study was conducted in Udo, a rural community in Ovia South West Local Government Area (LGA) of Edo State, Nigeria. The community is made up of 9 political wards (quarters), namely Ogbe, Efa, Ihogbe, Oliha, Ikpema, Igbesanwan, Ido, Ebo and Aragua. Each of these wards is headed by a chief. These chiefs in the wards are subordinate to the Uwague, the overall chief of Udo community. The major occupation of the inhabitants is subsistent farming. Some of the men and women are also engage in hunting and petty trading, respectively. In a nearby community (Okomu), there is Palm Oil Extracting Factory which process palm nuts into palm oil and where some of the men are employed as unskilled workers.

Sampling and recruitment of study population:

The study population consisted of children aged between 6 and 60 months who were residing with their parents at Udo community during the study period and whose parents gave consent. The houses in the community were numbered and labelled. The members of each of the households were interviewed to determine the number and ages of persons in each household. Direct head counts carried out revealed that children aged between 6 and 60 months were 1,028 in the study area. The minimum sample size for the study population was obtained, using the minimum sample size determination table by Bartlett et al [23]. Based on this table, the minimum sample size obtained was 213. To accommodate losses of blood samples (e.g., haemolysis) and unforeseen laboratory problems a high attrition rate of 35% was built-in, resulting in a final sample size of 292. An interviewer-administered questionnaire was used in obtaining socio-demographic information. Fifty percent of the 9 wards (approximately 5) in Udo community were selected, using a table of random numbers. The political wards selected were Efa, Ogbe, Ihogbe, Ikpema and Aragua. Due to the uneven population size in these political wards, an appropriate random sampling technique was used in selecting the subjects from the selected political wards. The number of children between the ages of 6 to 60 months in each of these political wards was known and so, the number to be selected from each of the wards was allocated proportionately, using percentages as follows: Efa 28% (82 children), Ogbe 36% (103 children), Ihogbe 18% (53 children), Ikpema 5% (16 children) and Aragua 13% (38 children). The number of households in each ward was known. Some of the households did not have the category of children of interest in this study. In addition, some parents refused to give consent. Thus, the number of households available for study was reduced. The households with children aged 6 to 60 months and whose parents gave consent were included in the study. To ensure adequate spread, a maximum of two children from each household were recruited. The socio-economic status of the parents was determined [24]. This was analyzed via combining the highest educational attainment of the mother and father's occupation. In this social classification System, classes I and II represent the high social class, class III represents middle social class and class IV and V represent low social class. In this way, the subjects were categorized into high, middle and low socio-economic classes. The family size was categorized into small size (no sibling or one to two siblings); medium size (3 or 4 siblings); large size (5 or more siblings).

Anthropometric measurements:

We strictly followed the standard procedure recommended by the International Society for the Advancement of Kinanthropometry (ISAK) in the measurement of the height (length if the child was aged below 2 years), weight, mid-upper-arm circumference and head circumference of all the children [25]. To eliminate inter-observer error, all the anthropometric measurements were performed by trained personnel. All the children were physically examined.

Blood sample collection and serum zinc analysis:

Before collection of blood sample, the socio-demographic data of the parents or guardian of each child were obtained, using an interviewer-administered questionnaire. Three to 4mls of venous blood was collected from each child. We followed the recommended steps necessary to avoid exogenous contamination of the blood sample by zinc [26]. To minimize effects of diurnal variation, the blood samples were collected in the mornings. To prevent transfer of zinc from the blood cells to the serum, the blood samples were stored in a cool box at 2 to 10°C until centrifuged to separate the serum from the blood cells. Following centrifugation, the serum was transferred to a screw-top vial for storage at -20°C, until analysis [27]. The serum zinc was analysed by flame atomic absorption spectrophotometer (FAAS); the equipment used was Alpha 4-model, S/No 4200 by Chemtech Analytical, United Kingdom.

Although various cut-off points for zinc deficiency have been used in different studies, in consonance with the report of previous studies [26, 28, 29], serum zinc concentration below 7.65µmol/L (50.03µg/dl) defined severe clinical zinc deficiency in our study.

Data analysis:

The data were collated and entered into an Excel spread sheet. Accuracy of the data entered was double checked. Data were analysed, using Microsoft Excel and SPSS (Statistical Package for Social Sciences) version 20.0. Measures of central tendency and dispersion involving the mean and standard deviation were computed for all quantitative data. Confidence intervals, frequency distribution and percentages were calculated. Correlation and multiple linear regression analysis were employed to evaluate the degree of relationships between variables. Test for significant differences between means of variables was carried out, using the Single Factor Analysis of Variance (ANOVA). The level of statistical significance was set at $p < 0.05$.

RESULTS:

We analyzed the data of a total of 252 children aged between 6 and 60 months. Of this number, 134(53.2%) were males and 118(46.8%) females. The mean age was similar for both sexes and the combined mean age was 32.7±17.0 months. The age distribution of the children indicates that 13 to 24 months age group accounts for the highest (26.2%) proportion.

Table 1: Anthropometric parameters, correlation between serum zinc concentrations and anthropometric indices

Parameters	Mean ±SD	95% Confidence Interval	Correlation coefficient (r) with Zinc conc	p-value
Weight (kg)	12.0±3.0	11.6-12.4	- 0.08	0.2
Height(cm)	88.3±12.4	86.8-89.8	- 0.11	0.07
MUAC(cm)	15.3±1.3	15.1-15.5	- 0.09	0.15
BMI(kg/m2)	15.4±2.1	15.1-15.7	0.08	0.23
OFC(cm)	47.4±2.4	47.4-47.7	0.07	0.34

MUAC = Mid-upper-arm circumference; OFC = Occipito-frontal circumference; BMI = Body mass index; Significant: $p < 0.05$

Table 2: Mean serum zinc concentrations by different variables

Variables	Subjects N = 252 (%)	Serum Zinc conc. Mean+SD µmol/L	95% CI	F	p-value
Age (months)					
6-12	37(14.7)	5.43±3.52	4.30-6.56		
13-24	66(26.2)	5.03±3.14	4.27-5.79	0.248	0.29
25-36	57(22.6)	4.78±2.92	4.02-5.54		
37-48	40(15.9)	4.05±2.44	3.29-4.81		
49-60	52(20.6)	4.48±2.95	3.68-5.28		
Gender					
Male	134(53.2)	4.95±3.21	4.41-5.49	0.997	0.33
Female	118(46.8)	4.57±2.80	4.06-5.08		
Social class					
Low	207(82.1)	4.66±2.91	4.26-5.06		
Middle	42(16.7)	5.30±3.48	4.25-6.35	0.800	0.44
High	3(1.2)	5.05±3.97	0.56-9.53		
Family size					
Small	79(31.3)	5.27±3.45	4.51-6.03		
Medium	112(44.4)	4.56±2.89	4.22-5.10	1.55	0.21
Large	61(24.3)	4.53±2.64	3.87-5.19		
Weight-for-age					
Normal	214(84.9)	4.78±3.00	4.38-5.18		
Underweight	37(14.7)	4.70±3.23	3.65-5.74	0.340	0.97
Overweight	1(0.4)	4.14±3.02	0-10.06		
Height-for-age					
Normal	163(64.7)	4.81±3.01	4.35-5.27		
Stunted	46(18.2)	4.85±3.26	3.91-5.79	0.196	0.82
Tall	43(17.1)	4.50±2.84	3.65-5.35		
Weight-for-height					
Normal	217(86.1)	4.92±3.06	4.51-5.33		
Wasted	28(11.1)	3.94±2.86	2.88-5.00	2.176	0.12
Overweight	7(2.8)	3.30±1.20	2.41-4.19		

The distribution of social class of the 252 families was as follows: low 207(82%), middle 42(17%) and high 3(1.0%). The mean weight, height, mid-upper-arm circumference and head circumference of the children are shown in Table 1. Of the 252 children, the weight and height values were within normal limits in 214(84.9%) and 163(64.7%), respectively. Only one (0.4%) child was overweight. Forty three (17.1%) of the children were taller than expected for their age. Of the 252 children, the values of the mid-upper-arm circumference (MUAC) were normal in 249(97.2%), low in 2(0.8%) and elevated in one child.

Based on the head circumferences, eight (3.2%) out of all the subjects had small heads and 2(0.8%) had big heads. As depicted in Table 1, there was a negative correlation between serum zinc concentrations and weight, height or mid-upper arm circumference but these were however, not statistically significant. As shown in Table 2, the prevalence rates of stunting, underweight and wasting were 18.2%, 14.7% and 11.1%, respectively. The overall mean serum zinc concentration was 4.77±3.02µmol/L, with a range of 1.0-16.52µmol/L. Of the 252 subjects, 220(87.3%) had a serum zinc concentration below 7.65µmol/L, representing severe zinc deficiency. As depicted in Table 2, the highest mean serum zinc concentration was found among children aged 6 to 12 months, followed by a progressive decline in serum zinc concentration from the age of 13 up to 48 months. As a group, the children with wasting had the lowest mean serum zinc concentration compared with either the group with underweight or stunting (Table 2). Correlation between the serum zinc concentration and age or social class of the subjects or family size (number of children) were as follows: age, r = 0.09, p-value = 0.15; social class, r = 0.08; p-value = 0.21, family size, r = - 0.07; p-value = 0.25.

DISCUSSION:

We found a generally low mean serum zinc concentrations across all the age groups, gender and social classes with an overall high prevalence rate of zinc deficiency. Such a low mean serum zinc concentration has been reported from Saudi Arabia [29], Nepal [30] and Nigeria [31]. In the study from Saudi Arabia, the mean serum zinc concentration was 5.65µmol/L, with a range of 0.5-13.9 µmol/L among healthy children [29]. The mean serum zinc concentration reported in the study in Nepal was 6.8±3.5µmol/L [30]. Similarly, Atinmo et al reported that among 10 apparently healthy Nigerian children used as control subjects, the serum zinc concentration ranged from 5.6 to 10.5µmol/L [31]. However, the prevalence of zinc deficiency was not reported in both studies [29, 31]. In contrast, the mean serum zinc concentration found in the present study is much lower than 12.50±2.30µmol/L reported among preschool children in Iran [32]. This difference may be a reflection of the regional variation in zinc status, even among developing countries.

With regard to age, the highest mean serum zinc concentration was found among children aged 6 to 12 months but the differences were not statistically significant from the other age groups. This was followed by a trend toward a progressive decline from the age of 13 months up to 48 months. Two separate studies involving preschool children in India and Australia have reported a similar age-related trend in zinc status [13, 33]. The trend towards a progressive decline in mean serum zinc concentration from the age of 13 months up to the age of 48 months could be explained by the challenges of introduction of complementary foods with low zinc content and high phytate. This precarious state of nutrition may be further compounded by high rates of infections. Infections are known to be associated with lower serum zinc concentrations [13]. The high prevalence of intestinal parasitic infections in toddlers (aged 1-to-3-year olds) in some developing countries is a factor that can contribute to the lower serum zinc concentration in this group of children [14, 18, 19, 32]. In children, intestinal parasitic infections is a known cause of poor zinc status [14, 18, 19].

The mean serum zinc concentration varied with social class of the families of the subjects; the mean serum zinc concentration was lowest in the low social class group. Children from families in the low socio-economic class may have reduced access to zinc-rich foods which are more expensive, mostly from animal sources, accounting for the lower serum zinc concentration we observed among them. In addition, higher prevalence and intensity of intestinal parasitic infections has been associated with low socio-economic conditions in children of peasant farmers in Calabar, Nigeria [35]. In that study, the authors attributed the high prevalence and intensity of intestinal parasitic infections to inadequate water supply and poor sanitary disposal of human wastes linked to poor socio-economic conditions [35]. The main occupation of the inhabitants in the rural community, in our present study is subsistence farming, heightening the possibility that this factor may be contributory.

In the present study, differences in the serum zinc concentrations and age as well as gender were not statistically significant, but a trend towards a higher serum zinc concentration in infants, boys, high social class and small family size was observed.

In the present study, we found a low serum zinc concentration in all categories of anthropometric indices. Where a difference existed, it was not statistically significant. This finding is in consonance with some [30, 36] but not other studies [37, 38]. The lack of significant relationship between serum zinc concentration and the anthropometric indices might suggest that other factors capable of limiting growth such as chronic infection and simultaneous existence of two or more micronutrient deficiencies may play a role. Some studies have shown co-existence of deficiency of more than one micronutrient in preschool children [39].

Our data indicate that 18.2% of preschool children in this community were stunted. Although the prevalence rate (18.2%) of stunting was slightly less than the 20% cut-off indicating zinc deficiency of public health importance, it still remains a cause for concern, especially because of the known adverse effects of zinc deficiency on growth, cognitive development and the incidence as well as intensity of bacterial infections in preschool age children [10,13,26]. The prevalence rate of stunting in the present study is similar to 18.6% reported in a study conducted in Vhembe district, South Africa [40] but much lower than 41.26% reported among preschool children in a rural community in Cameroon [41].

The 18.2% prevalence rate of stunting we found is strikingly different from the 0.8% prevalence rate reported in another study in Nigeria [15]. The reason for this difference is not clear. However, it should be noted the National Center for Health Statistics (NCHS) reference standard [42] was used in our present study compared to the World Health Organisation (WHO) reference standard used in the other study for anthropometric classification [15]. Reports show that prevalence of stunting may be higher when WHO 2006 reference standard is used compared with when NCHS reference standard is used [43]. The results of another Nigerian study that used WHO reference standard revealed a prevalence rate of stunting of 12.5% [39]. The prevalence of wasting found in our study was similar to the 11.9% and 14.8% reported in two separate studies among Nigerian preschool children [15, 39]. One limitation of the present study was our inability to assess the dietary zinc intake and its bioavailability in the diets of the children.

In conclusion, the zinc nutritional status of preschool children in this community is suboptimal; public health measures aimed at improving their zinc nutrition status should be considered. Public health measures such as nutrition education (e.g., dietary diversification, improvement in food processing techniques), targeted supplementation, and fortification of staple foods with zinc are suggested.

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