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Original Research Article

Relationship between zinc levels, anthropometric parameters and socio-demographic status among primary school pupils in a semi-urban community in Nigeria

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ABSTRACT

Background: Zinc plays important roles in many biological processes in the body such as acting as a catalyst for numerous enzymes involved in nucleic acid metabolism cellular replication tissue repair and the growth of tissues hence, the study was aimed to determine the relationship between zinc levels, anthropometric parameters and socio-demographic status among primary school pupils.
Methods: The study was a cross-sectional descriptive design carried out among four hundred primary school pupils between the ages 6-12 years in Ogbomoso. Questionnaires were distributed to obtain socio-demographic information from pupils and blood was collected for serum zinc analysis using ELISA technique. The data obtained were analyzed using Statistical Package for Social Sciences (SPSS) version 21
Results: The level of serum zinc deficiency in the study population was 9.5%. Serum zinc levels are significantly higher among younger age groups compared to older age groups (F=6.913, p value=0.001). The family size and socio-economic class are significantly associated with zinc levels. Zinc level was significantly lower in underweight children (0.389±0.25) compared to normal weight (0.819±0.39), overweight (0.991±0.62) and obese children (0.654±0.41), F=7.264, p=0.001
Conclusions: Zinc deficiency is an important component of nutritionally related morbidity worldwide. Zinc supplementation or food fortification among school children will have beneficial effects on the incidence and outcome of serious childhood infectious diseases.

Keywords: Zinc deficiency, Nutritional status, Anthropometric parameters, Socio-demographic status, Primary school pupils

INTRODUCTION

Zinc is an essential component of a high-quality diet and has a profound impact on health. It is required in minute quantities and is an essential building block for healthy brains and bones, especially the immune system. Zinc plays important roles in many biological processes in the body such as acting as a catalyst for numerous enzymes, involvement in nucleic acid metabolism, cellular replication, tissue repair and growth.[1-4]

Deficiencies of some trace elements like zinc, selenium and iodine, are important public health challenges in developing countries like Nigeria due to inadequate nutritional supply or inefficient utilization as a result of parasitic infestation.[5,6] Zinc deficiency develops over time with a devastating impact that is usually not seen until irreversible damage is done. Its deficiency affects all age groups, but young children are most at risk, particularly in the developing world, where they are at increased risk of diseases such as diarrhea, pneumonia and malaria. Excessive intake of these trace elements is uncommon except in environmental exposure or supplement overuse.[5,7]

Primary school period is a period of dynamic physical growth as well as mental development of the child hence poor nutrition, including micronutrient deficiency, at this age will negatively affect the overall development of the child and the community as a whole.[8,9] Children are especially susceptible to deficiency states because rapid growth creates an increased demand for these elements. Some vital organs, like the brain, are more vulnerable to sustaining permanent damage due to micronutrient deficiency during childhood.[5] Also, in developing countries, children are more prone to gastrointestinal infestations that may cause malabsorption of these elements. Many children suffer from stunted growth, cognitive delays, weakened immune systems and diseases as a result of these deficiencies. There has been increasing evidence over the years that the prevalence of zinc deficiency is on the increase among school children.[10–12] Hence, this study aimed to determine the serum zinc level and associated factors that influence its level among a cohort study of school pupils in a semi-urban community in Southwestern Nigeria.

METHODS

Study design

The study was a cross-sectional descriptive design carried out among four hundred primary school pupils in Ogbomoso North Local Government Area of Oyo State, South Western Nigeria. The sample size was determined using the formula:

$$n = z^2pq/d^2$$

Which generated approximately 400 participants after the addition of a 10% attrition rate. The study was conducted between April to October 2021.

Study technique

Multi-stage sampling method was used. Four hundred apparently healthy children aged 6-12 years in Primary (public and private) schools, in Ogbomoso North Local Government were studied. Children on zinc supplementations and multivitamins were excluded. Children with chronic conditions such as sickle cell disease and renal diseases were also excluded from the study.

Procedure

Five milliliters of venous blood were collected from each pupil for serum zinc analysis. The samples were spun for 15 minutes at 2,200 revolutions/min to separate the serum. The sera were then stored at a temperature of -20ºC until all sample collection was completed. Serum from each participant was analyzed in batches using standards and level 2 and 3 controls for zinc assay. Zinc was analyzed using Human Zinc Finger E-box-binding homeobox 1 (ZEB1) ELISA Kit to assay the Zinc-Alpha-2-Glycoprotein (ZAG) in the participants' serum samples. Other information was obtained via questionnaires which were filled with the aid of trained research assistants. The WHO growth charts and BMI-for-age charts were used to compute Z-score (weight-for-age, height-for-age and BMI-for-age) according to WHO reference standard (WHO, 2007)[14]. These charts were used to convert raw anthropometric data (weight, height and age of the children) into an anthropometric Z-score used to classify children into levels of nutritional status (stunting, underweight, overweight and obesity). Stunting and underweight were calculated as height-for-age and weight-for-age Z-score below-2 Z-score respectively, while overweight was BMI-for-age >2 Z-score and obesity was BMI-for-age >3 Z-score (5-19 years).

Data analysis

The data obtained were analyzed using Statistical Package for Social Sciences (SPSS) version 21 using frequency tables, percentages, and graphical representation in the analysis of categorical variables such as sex, religion, ethnicity, family type etc. while means and standard deviation of continuous variables was obtained. The distribution of zinc in participants was checked using a boxplot. The distribution of zinc in the study population was not normally distributed. Log transformation of zinc values was taken to impose normality. Student t-test and F-test were used where suitable in comparison of zinc concentration across categorical variables. A cut-off value for zinc deficiency was 2 ng/ml. The chi-square test of independence was used to examine the association between zinc and each of the socio-demographic variables and anthropometric parameters. Pearson moment correlation was used to examine the relationship between the concentration of zinc and each of the socio-demographic variables and anthropometric parameters. All decisions were made at a 95% level of confidence and the level of significance of p was set at <0.05.

RESULTS

A total of 400 primary school children aged 6 to 12 years were recruited with a mean age of 8.35±1.61 years. There was a female preponderance with a male-to-female ratio of 1:1.3. Three hundred and seventeen (79.3%) children were from monogamous families, 15.2% from polygamous families and 5.5% had single parents. Forty-seven percent (47%) were from a family size with fewer than 4 persons, 39.8% with 4 to 6 persons, and 12.8% had a family size of 7 and above (Table 1).

Table 1: Socio-demographic characteristics of the study population.

Variables	N	%
Age (years)		
<8	124	31.0
8-10	232	58.0
>10	44	11.0
Mean (SD)	8.35 (1.61)	
Sex		
Male	188	47.0
Female	212	53.0
Religion		
Christianity	225	56.3
Islam	171	42.8
Traditional	2	0.5
Others	2	0.5
Ethnicity		
Yoruba	375	93.8
Igbo	12	3.0
Hausa	10	2.5
Others	3	0.8
Family type		
Monogamy	317	79.3
Polygamy	61	15.2
Single parents	22	5.5
Family size		
<4	190	47.5
4 to 6	159	39.8
7 and above	51	12.8
Socio-economic class		
High	171	42.8
Middle	176	44.0
Low	53	13.3

Table 2: Anthropometric indices of the study subjects.

Parameters	N	%
Height-for-Age (N=400)		
Stunting	35	8.8
Normal	347	86.8
Above +2 Z-score	18	4.5
BMI-for-Age (N=400)		
Underweight	17	4.3
Normal	368	92.0
Overweight	7	1.8
Obese	8	2.0

One hundred and seventy-one (42.8%) children belong to the high socio-economic class, 44% were in the middle socio-economic class, and 13.3% were in the low socio-economic class. The mean weight was 25.71±6.61kg, (range of 13.10 to 53.0kg) whilst the mean height was 125.88±11.22cm (range 95.0 cm to 149.0 cm). Eighty-six percent (86.8%) of the children had normal height, 8.8% were stunted and 4.5% had height above +2 Z - score. Three hundred and sixty-eight (92%) children had normal weight, 4.3% were underweight, 2% were obese and 1.8% were overweight (Table 2).

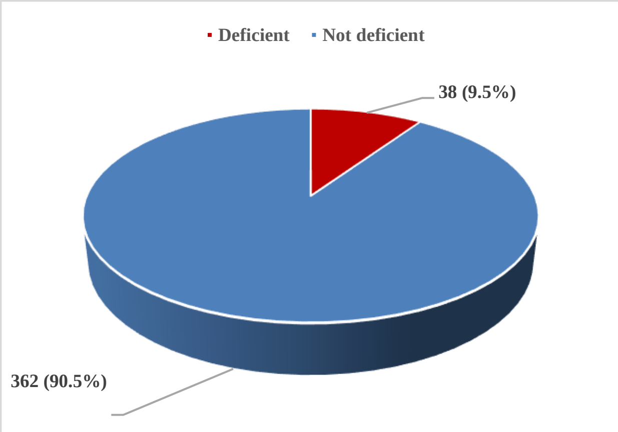

Figure 1: Zinc deficiency among children in the study population.

The mean serum zinc level in the study population was 0.80±0.41ng/ml. It was found to be higher in males than females, but the mean difference was not statistically significant. (Figure 1) shows the level of serum zinc deficiency in the study population. Zinc deficiency was evident in 9.5%.

Table 3: Serum zinc levels across socio-demographic characteristics of the pupils (n=400).

Parameters	Mean±SD (ng/ml)	t/F value	P value
Sex			
Male	0.832±0.42	t = 1.478	0.140
Female	0.771±0.38		
Age groups			
<8	0.974±0.36		
8 to 10	0.754±0.40	F = 6.913	0.001
>10	0.555±0.33		
Family type			
Monogamy	0.825±0.38		
Polygamy	0.746±0.49	F = 4.175	0.016
Single parent	0.589±0.27		
Family size			
<4	0.922±0.41		
4 to 6	0.710±0.34	F=18.541	0.001
>7	0.628±0.44		
Socio class			
High	0.864±0.33		
Middle	0.784±0.44	F= 6.433	0.002
Low	0.643±0.47		

The (Table 3) shows serum zinc levels across the socio-demographic characteristics of the study subjects. There is no significant difference between the serum zinc levels among male and female children, p value=0.140. Serum zinc levels are significantly higher among younger age groups compared to older age groups (F=6.913, p value=0.001).

Table 4: Serum zinc level across anthropometric characteristics of children in the study population.

Parameters	Log (Zinc) (Mean±SD) (ng/ml)	F value	P value
Weight for age			
Underweight	0.659±0.30	3.722	0.024
Normal	0.807±0.41		
Overweight	0.953±0.43		
BMI for age			
Underweight	0.389±0.25	7.264	0.001
Normal	0.819±0.39		
Overweight	0.991±0.62		
Obese	0.654±0.41		
Height for age			
Stunting	0.654±0.27	2.500	0.083
Normal	0.813±0.42		
Above + 2Z scores	0.815±0.20		

The family type is also significantly associated with zinc levels. It was found to be higher in children from monogamous families, and lowest in children from single parents (F=5.063, p=0.016). There is also a significant association between zinc level and family size, as zinc concentration is higher among children from a smaller family size compared to a larger family size (F=18.541, p value = 0.001). Zinc level was also significantly associated with socio-economic class, children from low socio-economic class had lower serum zinc concentration compared to those from high socio-economic class, (F=5.681, p=0.001). The (Table 4) shows the relationship between the anthropometric characteristics of the pupils and their serum zinc levels. There was a significant association between weight for age and zinc level in children. Zinc level was significantly lower in underweight (0.953±0.43), compared to normal weight (0.807±0.41), and overweight children (0.953±0.43), F=3.722, p value=0.024. Similarly, there was a significant association between BMI for age and zinc levels. Zinc level was significantly lower in underweight children (0.389±0.25) compared to normal weight (0.819±0.39), overweight (0.991±0.62) and obese children (0.654±0.41), F=7.264, p=0.001. However, there was no significant association between zinc level and height for age. There was no significant difference in zinc level in children with stunting, normal height and children above + 2 Z scores, p value >0.05.

DISCUSSION

The prevalence of 9.5% for zinc deficiency is recorded in this study. This prevalence rate is lower than the 20% prevalence rate set as an indicator of zinc deficiency risk of public health importance, but was within the prevalence rate of 5-30% reported from different countries.[4,15-17] However, it is lower than the prevalence rate of 43% in Nasarawa and 99% in Jos.[10,18] This variation in prevalence rates across many studies may be due to many reasons; probably due to the different methods of zinc assay, for instance, the ELISA kit was used in this study as against the atomic flame spectrophotometry method used in many previous studies, this could give different zinc estimates. Also, the dietary pattern of the subjects may contribute to the low prevalence in this study. The low level of zinc concentration in the present study might be attributable to the different methods of zinc assay, slightly higher sample size and geographical location. Moreover, zinc concentration was found to be higher in males as compared to females in this study, although the difference was not of statistical significance. This agrees with findings from Ethiopia[7] and a local community-based study among preschool children in Edo state[11] who reported increased zinc concentration in boys. These findings might be attributable to preferential parental nutritive care for males in our setting.

The study showed significantly higher serum zinc concentrations in younger age groups compared to older children, although this is only statistically significant in private schools. This agrees with findings from preschool-age children in Edo state, but differs from other studies[9] where no significant difference was found between zinc level and age group.[11,17,19] Increased requirements of zinc in the older age group due to the requirement of pubertal growth spurt may explain the low level of zinc among the older age group. Meanwhile, serum zinc concentration was found to be negatively correlated with family size; this agrees with findings by Ibeawuchi in preschool children of Edo State, while zinc deficiency had a positive correlation with family size, that is, the larger the family size, the more the deficiency, which is comparable to findings from previous studies.[10,11] Findings from this study are in contrast to a cross-sectional study among Chinese preschool children which reported that zinc deficiency was associated with small family size probably due to high maternal education resulting in less traditional lifestyle such as skipping meals and eating fast foods which are deficient of zinc.[19] Zinc concentration was found to be significantly correlated with family type. It is higher in children from polygamous homes, followed by monogamous family type and least in children of single parents. Also, socioeconomic status had an effect on the serum zinc level as those from the lower SES had significantly lower serum zinc concentration than their counterparts from higher classes. This is in agreement with the findings from previous studies.[10,11] In this present study, 91.3% and 92% of the school children had normal height-for-age Z-score (HAZ) and BMI-for-age Z-scores (BMIZ) respectively. Prevalence of stunting, underweight, overweight and obesity in this study were 8.8%, 4.3%, 1.8% and 2.0% respectively. Serum zinc concentration had a negative correlation with underweight and stunting as underweight and stunted children had significantly lower levels of zinc concentration. There was a positive correlation between BMIZ and zinc levels in both public and private schools. The association between zinc level and anthropometric indices is not so clear, with several studies reporting varying findings. For example, among school children in Nepal, zinc concentration was reported to be lower in children with overweight, followed by stunting, thinness, wasting, and underweight respectively.[20] This finding may be due to the increased demand for these micronutrients by the body in this group of children. Low zinc level was also found to be associated with wasting and stunting in older children from Saudi Arabia.[21] In summary, the prevalence of 9.5% for zinc deficiency is recorded in this study. Socio-demographic factors including age, sex, family type, family size and socio-economic class significantly affect serum zinc levels in school-age children. There is a negative correlation between age, family size and socio-economic class with zinc level while a positive correlation exists between BMI-for age and serum zinc level and a negative correlation with underweight and stunting.

Limitations

The study utilized a single micronutrient, Zinc, which is presumed not sufficient alone to grossly and adequately assess the nutritional status of children, although was the element of interest for the study and however does not affect the outcome negatively. It is therefore advised that future research should include other elements alongside zinc.

CONCLUSION

Zinc is an essential trace element that plays a role in growth, tissue repair and wound healing, carbohydrate tolerance, synthesis of testicular hormones, and the immune response. Zinc intake is closely related to protein intake; as a result, zinc deficiency is an important component of nutritionally related morbidity worldwide. Symptoms attributable to severe zinc depletion include growth failure, primary hypogonadism, skin disease, impaired taste and smell, and impaired immunity and resistance to infection. Zinc supplementation or food fortification in populations at risk for zinc deficiency appears to have beneficial effects on the incidence and outcome of serious childhood infectious diseases.

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