Original Research Article

Prevalence of Albumin/Total Protein Deficiency and Micronutrients Correlates in Apparently Healthy Children in Southwest Nigeria

Abstract

Aim: To assess the prevalence and pattern of total protein, albumin and micronutrient status among school-age children.

Study design: This study was a cross-sectional descriptive design

Methodology: The study was carried out among four hundred pupils aged 6 to 12 years. A semi-structured questionnaire was adopted to obtain relevant data. Each recruited pupil was examined clinically for signs of nutritional deficiencies. Blood samples were collected and microelements levels were estimated using ELISA kits, while total protein and albumin were by colorimetry methods. Data were analyzed using SPSS version 21.

Results: The majority of the study population belongs to the high and middle socioeconomic class. The prevalence of micronutrient deficiencies was 9.5% and 36.5% for Zinc and selenium respectively. While the prevalence of 27% and 15.1% were recorded for albumin and total protein respectively. There were positive correlations between micronutrient (Zn&Se) levels and sociodemographic data and anthropometric data.

Conclusion: The early diagnosis of micronutrient deficiencies, prompt management of protein energy malnutrition and its complications can prevent the development of permanent physical and mental retardation.

Keywords: Albumin, Protein-energy malnutrition, Zinc deficiency, Selenium deficiency, Total protein

1.0 Introduction

Malnutrition is a common nutritional problem facing developing countries; an important cause of childhood mortality and morbidity leading to life-long impairment of physical and mental growth.[1] In cases of severely malnourished children, serum total protein and albumin are reduced.[2,3]

Protein-energy malnutrition is marked by low plasma protein concentration. The use of serum protein measurement is widespread for the assessment of nutritional status. The circulating concentration of transport protein, traditionally albumin, has been used to define protein deficiency.[4]

Micronutrients are essential components of a good quality diet and have a profound impact on health. They are required in minute quantities[5] but are essential building blocks for healthy body tissues including brains and bones. Micronutrient deficiency remains a huge problem with its enormous consequences on economic growth and human development[6]. It is a hidden aspect of malnutrition for which comprehensive data are lacking in school-aged children.[7]

Micronutrient deficiency affects at least 2 billion people worldwide[8] with every one in three people being deficient in developing nations,[9] resulting in approximately 7.3% of the global burden of disease.[10] It has been found to be a significant cause of morbidity and mortality in children.

The primary school age is a dynamic period of physical growth as well as mental development of the child.[11] Hence poor nutrition, including micronutrient deficiency, at this age, will negatively affect the overall development of the child. The negative effects on cognition will produce young adults with subnormal mental development, increasing the number of dependents in the community. Deficiencies of some trace elements like zinc, selenium, iron, vitamin A 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.[5,12]

Most studies focus on iodine, iron and vitamin A while zinc and selenium are less studied. Zinc and selenium play critical roles in biological processes including growth and development. They also function as antioxidants and are required for immunity.[13] Their deficiencies can affect all age groups, but young children are most at risk, particularly in the developing world,[10] resulting in disease states like diarrhea, pneumonia and malaria.

Morbidity pattern in school children was not found but according to a hospital-based study,[14] malaria, diarrhea diseases, sepsis, pneumonia and protein energy malnutrition were the commonest cause of morbidity and mortality in children,[14] with both zinc and selenium deficiencies linked to these disease conditions.[15]

Factors like gender, age, family size, socio-economic class and geographical locations have been shown to influence zinc and selenium levels in children. These trace elements were found to be higher in males due to higher lean body mass and growth rate, as well as in younger children and those from high socioeconomic class,[16–18] as a result of increased access to balanced and nutritious diets. Hence, the study aimed to estimate serum total protein, albumin levels and micronutrient status to evaluate the nutritional health of apparently well-school children.

2.0 Materials and Methods

2.1 Study Design

This study was a descriptive cross-sectional design carried out among four hundred primary school pupils in Ogbomoso North Local Government Area of Oyo State, South-Western Nigeria. The local government is one of the 33 in the State with headquarters in Ogbomoso town. It has an area of 187.36km^2 and a population of 198,859 inhabitants according to the 2006 census.[19] Ogbomoso North Local Government Area is one of the five local government areas under Ogbomoso Educational Zone.

2.2 Study Procedure

Multi-stage sampling method was used. All apparently healthy children aged 6 to 12 years in Primary (public and private) schools were recruited. There are 88 registered private and public primary schools in Ogbomoso North Local Government Area with 61 of them being private primary schools and 27 public primary schools in a ratio of 2:1.

The desired sample size was selected by proportional allocation of respondents from different classes in the selected public and private schools. A semi-structured self-developed questionnaire designed for this study was used in suitable venues for physical examination, anthropometric measurements and blood samples were collected into lithium heparin bottles to assay for Zinc and selenium.

Height and weight were measured according to standard techniques. Body mass index was calculated using the weight and the height as; Weight (kg)/Height^2 (m^2)[20] Physical examination was done for signs of malnutrition, including evidence of protein loss and evidence of zinc or selenium deficiency including dryness of the skin or dermatosis, hair loss, whitish discolouration of the nailbed, and angular stomatitis.

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[21]. 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 (5-19years).

2.3 Data Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 21. Summary statistics entailed the use of frequency, percentages, and graphical representation in analysis of categorical variables such as sex, religion, ethnicity, family type etc. All decisions were made at 95% level of confidence and level of significance of p set at < 0.05.

2.4 Ethical Consideration

Ethical clearance was obtained from the Research and Ethics Committee of LTH, Ogbomoso and Approval was also obtained from the Oyo State Ministry of Education. Relevant consent was obtained.

2.5 Consent

The information leaflets and Informed consent forms were given to the selected pupils to take home for their parents to endorse. The Information leaflet explained the reasons and benefits of the research, associated risk and freedom of participation. Only those that gave their written consent/assent were included in the study and were assured of confidentiality.

3.0 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 were from a family size with fewer than 4 persons, 39.7% with 4 to 6 persons, while 12.8% had a family size of 7 and above. One hundred and seventy-one (42.7%) children belong to the high socioeconomic class, 44% were in the middle socioeconomic class, and 13.3% were in the low socioeconomic class. (Table I).

Table I: Socio-demographic characteristics

Variables	No of children	Percentage (%)
Age (years)		
< 8	124	31.0
8 to 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	42.7
Traditional	2	0.5
Others	2	0.5
Ethnicity		
Yoruba	375	93.7
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	39.7
7 and above	51	12.8
Socio-economic class		
High	171	42.7
Middle	176	44.0
Low	53	13.3

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 95.0cm to 149.0cm). Eighty-six percent (86.7%) 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 II).

Table II: **Anthropometric indices of the study subjects**

Parameters	No of children	Percentage (%)
Height-for-Age (n = 400)		
Stunting	35	8.8
Normal	347	86.7
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

Zinc and selenium concentrations among children in the study population were not normally distributed. The median concentration was 5.58 ng/ml and 4.30 ng/ml for zinc and selenium respectively (table III).

Table III: Serum zinc, selenium, albumin and total protein levels in the study population

Variables	**Minimum ng/ml**	**Maximum ng/ml**	**Median ng/ml**
Zinc	0.42	53.77	5.58
Selenium	0.02	98.45	4.30
Total protein	45.2	82.7	62.50
Albumin	20.6	55.5	40.20

Figure 1 shows serum zinc deficiency in the study population. Zinc deficiency was evident in 9.5% of the study population**.**

Selenium deficiency among the children in the study population was 36.5% (Figure 2).

Further, total protein and albumin deficiencies were seen in 15.1% and 27% of children in the study population respectively (Figure 3 and 4)**.**

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

Figure 2: Selenium deficiency among children in the study population

Figure 3: Total protein deficiency among children in the study population.

Figure 4: Albumin deficiency among children in the study population.

Table IV shows the correlation between zinc and selenium levels and the socio-demographic characteristics of the study population. There is a significant negative correlation between age group and serum zinc (r = -0.332, *P* = 0.001) and selenium levels (r = -0.138, *P* = 0.006). The younger the age of the child, the higher the zinc and selenium levels. Children between 8 and 10years and those above 10years have lower levels compared to those below 8years.

Children from a family size of < 4 had a higher concentration of serum zinc and selenium levels while those from a larger family size had lower levels of serum zinc (r = -0.283, *P* = 0.006) and selenium (r = -0.140, *P* = 0.005). There is a significant positive correlation between socio-economic class and serum zinc (r = 0.143, *P* = 0.004) and selenium levels (r = 0.133, *P* = 0.024). Children from high SES have higher levels of both zinc and selenium levels compared to those from lower classes.

Table IV: Correlation between serum zinc and selenium levels and socio-demographic characteristics of the participants

Variables	Zinc r	Zinc *P*	Selenium r	Selenium *P*
Age				
< 8 years				
8 to 10 years				
> 10 years	-0.332	***0.001**	-0.138	***0.006**
Family size				
< 4				
4 to 6				
> 7	-0.283	***0.006**	-0.140	***0.005**
Socio-economic class				
High				
Middle	0.143	***0.004**	0.133	***0.024**
Low				

*r= Pearson moment correlation, *p-value < 0.05 indicate significance.*

Table V shows the correlation between zinc and serum selenium levels and anthropometric parameters of children in the study population. There was a significant positive correlation between zinc levels and weight-for-age (r = 0.140, *P* = 0.008), BMI-for-age (r= 0.183, *P*=0.001) and height-for-age (r= 0.125, *P*= 0.012) of the study population. Children with underweight and stunting had significantly lower serum zinc levels than those with normal weights and heights.

Similarly, serum selenium levels are positively correlated with weight-for-age (r = 0.173, *P* = 0.001) and height-for-age (r= 0.193, *P*= 0.001) of the study population. Stunted and underweight children had significantly low levels of serum selenium concentrations.

Table V: Correlation between serum zinc and selenium levels and anthropometric indices of the subjects.

Variables	Log (Zinc) (ng/ml) r	Log (Zinc) (ng/ml) *P*	Log (Selenium) (ng/ml) r	Log (Selenium) (ng/ml) *p*
Weight for Age	0.140	***0.008**	0.173	***0.001**
BMI for Age	0.183	***0.001**	0.051	0.307
Height for Age	0.125	***0.012**	0.193	***0.001**

*r= Pearson moment correlation, *p-value < 0.05 indicate significance.*

4.0 Discussion

Globally, nearly half of under-five deaths are directly or indirectly attributed to malnutrition. It is associated with a reduction in the synthesis of plasma proteins.[22] This current study recruited four hundred primary school-age children with a female to male preponderance. Most of the children were from monogamous families and more than half of them belong to the high and middle socioeconomic class.

It may be noted that in families of middle socioeconomic status, more attention is given to other house and personnel-related affairs except nutrition, and hence they may have nutritional challenges23. Although from this study, the majority of the children had normal height and 92% of the children had normal weight. Only 8.8% were stunted while 4.3% were underweight these were lower compared to a report from Ethiopia[24].

In spite of the fact that the subjects in this study were apparently healthy yet, total protein and albumin deficiencies were seen in 15.1% and 27% of the study population respectively. There was a paucity of data to relate these findings to similar subjects however, this finding is lower compared to reports from children with malnutrition[3].

Zinc deficiency was evident in only 9.5% of the study population. This is lower compared to 87.3% reported among school children in eastern Nepal[25] however it is comparable with 15.9% reported in China[26]. Selenium deficiency among the children in the study population was 36.5%. The role of selenium in the cognitive development of children has been reported[27]. The brain is one of the organs with high concentrations of selenium. It is the first organ to obtain an adequate level of selenium during dietary intake suggesting the important role of selenium in brain functions[28].

There is a significant negative correlation between the age group and serum zinc and selenium levels. The younger the age of the child, the higher the zinc and selenium levels. Children between 8 and 10 years and those above 10 years have lower levels compared to those below 8 years. Previous reports had it that, the increased need for micronutrients among the growing school-age children may be due to the requirement of the pubertal growth spurt, hormonal influences and co-existing micronutrient deficiencies[29]. Relationships of zinc deficiency, associated with age can be explained on the basis of confounding effects of pubertal status and tanner stage, constraints on growth due to chronic infection and the co-existence of other growth limiting micronutrient deficiencies such as iodine, as described in a previous study[30].

In this present study, children from a family size of < 4 had higher serum zinc and selenium levels while those from a larger family size had lower levels. There is a significant positive correlation between socio-economic class and these micronutrients. Children from the high class have higher levels of both zinc and selenium levels compared to those from lower classes. These findings are based on the fact that an increase in family size decreases not only the standard of living but also, the attention given to children. It reduces the adequacy of meals and the quality of nutritional contents given to them likewise. It is presumed that small family size and or high socioeconomic class may adequately cater to the nutritional needs of their children.

Furthermore, this study finds a significant positive correlation between zinc levels and weight-for-age, BMI-for-age and height-for-age in the study population. In line with other report[25] children with underweight and stunting had significantly lower serum zinc levels than those with normal weights and heights.

Similarly, serum selenium levels are positively correlated with weight-for-age and height-for-age of the study population. Stunted and underweight children had significantly low levels of serum selenium concentrations.

4.1 Conclusion

The sociodemographic status has a significant impact on the overall nutritional status of children as demonstrated by our findings. Physically healthy children are equally at risk of salient nutritional problems which could lead to a cognitive deficit, poor academic performance and systemic illnesses. Adequate nutrition is hereby advocated in all school children and fortification of their school meals with necessary nutrients to enrich their macro/micronutrient levels.

However, the early diagnosis of micronutrient deficiencies, prompt management of protein energy malnutrition and its complications can prevent the development of permanent physical and mental retardation.

5.0 References

1. Neumann C, Harris DM, Rogers LM. Contribution of animal source foods in improving diet quality and function in children in the developing world. Nutrition Research. 2002;22(1–2):193–220.
2. Schaible UE, Kaufmann SHE. Malnutrition and Infection: Complex Mechanisms and Global Impacts. PLOS Medicine [Internet]. 2007 May [cited 2022 Jul 2];4(5):e115. Available from: https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.0040115
3. Gupta SS, Gupta PS. Serum albumin and total protein level as plausible marker for diagnosis of protein energy malnutrition in children under age 5 years. International Journal of Contemporary Pediatrics. 2020 Jul 22;7(8):1758.
4. Michael Spiekerman A. Nutritional assessment (protein nutriture). Anal Chem [Internet]. 1995 Jun 1 [cited 2022 Jul 2];67(12):429–36. Available from: https://pubmed.ncbi.nlm.nih.gov/8686865/
5. Greenbaum LA. Micronutrient Mineral deficiencies. In: Kliegman RM. Behrma RE. Stanton BF. Jenson H, editor. Nelson Textbook of Pediatrics. 18th ed. Philadelphia: Elsevier Inc; 2007. p. 265–6.
6. UNICEF. State of the World's Children. [Internet]. https://www.unicef.org/sowc09/report/report.php. 2009 [cited 2017 Aug 12]. Available from: https://www.unicef.org/sowc09/report/report.php.
7. Maziya-Dixon B, Akinyele IO, Oguntona EB, Nokoe S, Sanusi RA, Harris E. Nigeria Food Consumption and Nutrition Survey. 2003. 1–75 p.
8. Akombi B, Agho K, Merom D, Renzaho A, Hall J. Child malnutrition in sub-Saharan Africa: A meta-analysis of demographic and health surveys (2006-2016). PLoS One. 2017;12(5).
9. Madueke NM, Osaronowen EM, Samuel OO. Comparative study of plasma zinc and selenium levels amongst Human Immunodeficiency Virus (HIV) positive and negative subjects. African Journal of Food Science and Technology. 2015;6(8):253–8.
10. Amare B, Moges B, Fantahun B, Tafess K, Woldeyohannes D, Yismaw G, et al. Micronutrient levels and nutritional status of school children living in Northwest Ethiopia. Nutr J. 2012;11(1):1–8.
11. Boma GO, Anthony IP, Mukoro DG, Abaiola E, Andrew F, Daniel MD, et al. Nutritional Status of Children in Rural setting . IOSR Journal of Dental and Medical Sciences. 2014;13(1):41–7.
12. Hesham MS, Edariah AB, Norhayati M. Intestinal parasitic infections and micronutrient deficiency: a review. Med J Malaysia. 2004;59(2):284–93.
13. Negm F F, Soliman D R, Ahmed E S ERA. Assessment of serum zinc , selenium , and prolactin concentrations in critically ill children. Pediatric Health, Medicine and Therapeutics. 2016;7:17–23.

14. Aminu M, Bassey E, Bilkisu G, Muyideen A, Smart A, Sunday O. Pattern of medical childhood morbidity and mortality in a new specialist hospital in Gusau, Nigeria. Annals of Nigerian Medicine. 2014;8(1):15.

15. Gheini S, Kiani A, Sedighi M, Hojabri K. Assessment of serum zinc , selenium and copper in simple febrile convulsions in children aged 6 to 60 months in Mohammad Kermanshahi Hospital. J Kermanshah Univ Med Sci. 2015;19(1):16–23.

16. Ibeawuchi A, Onyiriuka A, Abiodun P. High Prevalence of Zinc Deficiency in Rural Nigerian Preschool Children: A Community-Based Cross Sectional Study. Rom J Diabetes Nutr Metab Dis. 2017;24(1):031–9.

17. Abah RO, Okolo SN, John C, Ochoga MO. Prevalence of Zinc Deficiency Among School Children in a Rural Setting in North-Central Nigeria. International Journal of Public Health Research. 2015;3(5):214–7.

18. Akeredolu IA, Oguntona BE, Okafor C, Osisanya OJ. Iron, Zinc, and Copper Malnutrition among Primary School Children in Lagos, Niagara. Food and Nutrition Sciences. 2011;02(10):1063–70.

19. https://oyostate.gov.ng/ogbomoso-north-local-government/ Assessed on 16/08/2017.

20. Gahagan S. Overweight and Obesity. In: Behrman RE KR, HB J, editors. Nelson Textbook of Pediatrics. 19th ed. Philadelphia: Elsevier Saunders; 2011. p. 179–88.

21. De Onis M. The new WHO child growth standards. Vol. 52, Paediatria Croatica Supplement. 2008. p. 13–7.

22. Asha K, Anil G, Mital G, Parin S, Vikas V, Oza R, et al. Influence of protein energy malnutrition on level Influence of protein energy malnutrition on level of serum zinc in children. Int J Res Med. 2016;5(3).

23. Hameed S, . MTJ, . NB, . HA, . SA. Levels of Serum Total Proteins and Fractions along with Serum Cu, Fe and Zn in Diseased Malnourished Children of 0-4 Years of Age. Journal of Medical Sciences. 2001 Aug 15;1(5):282–7.

24. Gashu D, Stoecker BJ, Bougma K, Adish A, Haki GD, Marquis GS. Stunting, selenium deficiency and anemia are associated with poor cognitive performance in preschool children from rural Ethiopia. Nutrition Journal [Internet]. 2016 Apr 12 [cited 2022 Jul 18];15(1):1–8. Available from: https://nutritionj.biomedcentral.com/articles/10.1186/s12937-016-0155-z

25. Nepal AK, Gelal B, Mehta K, Lamsal M, Pokharel PK, Baral N. Plasma zinc levels, anthropometric and socio-demographic characteristics of school children in eastern Nepal. BMC Research Notes [Internet]. 2014 Jan 9 [cited 2022 Jul 18];7(1):1–6. Available from: https://bmcresnotes.biomedcentral.com/articles/10.1186/1756-0500-7-18

26. Ma G, Jin Y, Li Y, Zhai F, Kok FJ, Jacobsen E, et al. Iron and zinc deficiencies in China: what is a feasible and cost-effective strategy? Public Health Nutr [Internet]. 2008 Jun [cited 2022 Jul 18];11(6):632–8. Available from: https://pubmed.ncbi.nlm.nih.gov/17894916/

27. Gashu D, Stoecker BJ, Bougma K, Adish A, Haki GD, Marquis GS. Stunting, selenium deficiency and anemia are associated with poor cognitive performance in preschool children from rural Ethiopia. Nutrition Journal [Internet]. 2016 Apr 12 [cited 2022 Jul 18];15(1):1–8. Available from: https://nutritionj.biomedcentral.com/articles/10.1186/s12937-016-0155-z

28. Bourre JM. The role of nutritional factors on the structure and function of the brain: An update on dietary requirements. Revue Neurologique. 2004;160(8–9):767–92.

29. Thurlow RA, Winichagoon P, Pongcharoen T, Gowachirapant S, Boonpraderm A, Manger MS, et al. Risk of zinc, iodine and other micronutrient deficiencies among school children in North East Thailand. Eur J Clin Nutr [Internet]. 2006 May [cited 2022 Jul 18];60(5):623–32. Available from: https://pubmed.ncbi.nlm.nih.gov/16391573/

30. Filteau SM, Tomkins AM. Micronutrients and tropical infections. Trans R Soc Trop Med Hyg [Internet]. 1994 Jan 1 [cited 2022 Jul 18];88(1):1–3. Available from: https://academic.oup.com/trstmh/article/88/1/1/1863152