ISSN: 2714-4674 (Online)
ISSN: 2714-4666 (Print)

Annals of Clinical and Experimental Medicine

(ACEMedicine)

This Journal Is A Publication of
ASSOCIATION OF SPECIALIST MEDICAL DOCTORS IN ACADEMICS SOKOTO STATE CHAPTER

Volume 2, No. 1, January - June 2021

In this issue

www.acemedicine.asmeda.org

A comparative study of Vitamin A and Zinc levels of Preschool Age Children with Malnutrition and Well-nourished children in a tertiary Health Facility in North-Western Nigeria.

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Abstract

Background: Micronutrient deficiencies constitute a devastating form of malnutrition whose consequences can be crippling or fatal. In developing countries where malnutrition is prevalent, children usually have multiple micronutrient deficiencies. There is increasing evidence that zinc and vitamin A interact in several ways. Zinc is a component of retinol binding protein (RBP), a protein necessary for transporting vitamin A in the blood.

Objective: To compare mean serum levels of vitamin A and zinc between preschool age children with malnutrition and age matched well-nourished children at Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto.

Methodology: Study was descriptive cross-sectional, carried out at the Department of Paediatrics of UDUTH, Sokoto from April 2013 to June 2014. It was conducted among 275 malnourished children aged 6 – 60 months and age matched well-nourished controls. Five mls of venous blood was taken for serum vitamin A and zinc analysis.

Result: The mean serum levels of vitamin A and zinc in children with malnutrition were 23.4±13.2μg/dl and 13.5±3.3μmol/L respectively, which were significantly lower when compared to that of the controls 54.1±22.8μg/dl and 15.8±1.9μmol/L respectively. Mean serum vitamin A and zinc levels were significantly low across all age groups of study subjects compared to age matched controls (p=<0.05). Lowest mean serum vitamin A level was observed among children with severe wasting (18.6±10.2μg/dl) when compared with that of the controls (54.0±22.8 μg/dl): the difference was significant (p=0.0001). Similarly, the lowest mean serum zinc level was observed among children with oedematous malnutrition (12.8±3.0μmol/L) when compared to that of the controls (15.8±1.9μmol/L): the difference was also significant (p=0.0001).

Conclusion: Children with malnutrition had significantly lower mean serum vitamin A and zinc levels especially among children aged 2 to 3 years. For effective management of children with malnutrition, vitamin A and zinc supplementation should be part of the treatment.

Keywords: Vitamin A, Zinc, Preschool Children, Malnutrition, Well-nourished children, North-Western Nigeria.

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ACCESS TO THIS ARTICLE ONLINE

DOI: 10.47838/acem.26011977.127122021.asmeda.1.6

Website
https://www.asmeda.org/acemedicine

Introduction

Micronutrient deficiencies constitute a devastating form of malnutrition whose consequences can be crippling or fatal (1). In developing countries where malnutrition is prevalent, children usually have multiple micronutrient deficiencies (2). These deficiencies are common in those with severe forms of malnutrition like kwashiorkor, marasmus, and marasmic kwashiorkor (3). In Africa it is estimated that approximately 20 million preschool children are at risk of VAD (4). In Nigeria, six million preschool children may be at risk of VAD (4). The blinding form of severe VAD affect 350,000-500,000 young children annually, most of them residing among the poor in the developing countries (5). Improved vitamin A nutrition would be expected to prevent approximately 1-2 million deaths annually among children aged 1-5 years (6). While severe micronutrient deficiency is easily recognized as a result of its clinical manifestation, detecting subclinical deficiency states in humans is yet to receive a similar attention among clinicians (7). Early detection of low serum Zn level in the serum and it's correction is important in malnourished children and it has been shown to halve mortality rate (7, 8).

Factors contributing to micronutrient deficiencies in malnourished children include low dietary intake, poor bioavailability, malabsorption, lack of breastfeeding, and increase losses due to diarrhoea. Hypoalbuminemia in severe PEM can also contribute to lower plasma zinc (9). There is increasing evidence that zinc (Zn) and vitamin A interact in several ways. Zinc is a component of retinol binding protein (RBP), a protein necessary for transporting vitamin A in the blood (2). Therefore, deficiency of Zn limits the body's ability to mobilise vitamin A stores from the liver (9). Zinc deficiency can contribute to vitamin A deficiency even in the presence of adequate hepatic reserve of vitamin A (2). Zinc is also required for the synthesis of the enzyme that converts retinol to retinal. The later form of vitamin A is necessary for the synthesis of rhodopsin, a protein in the eye which absorbs light and thus involved in dark adaptation (9). Hence zinc deficiency has been implicated in retinal dysfunction including night blindness and abnormal dark adaptation despite adequate vitamin A nutritional status (10).

Whereas zinc participate in the absorption, mobilisation, transport and metabolism of vitamin A, there is also evidence that vitamin A affects zinc absorption and utilization (10). Thus, fluctuations in the status of one or both micronutrients may alter the metabolism of the other (10). Therefore, it is necessary for clinicians to consider nutrient- nutrient interaction whenever deficiency symptoms are found (11).

Airede *et al* (12) in Maiduguri, North Eastern Nigeria evaluated serum vitamin A levels of PEM children matched with controls. The authors observed 100% inadequate serum retinol levels in children with kwashiorkor and in only 6% of those with marasmus on the first day of admission. Following Vitamin A supplementation by Day16, only 13.9 % of the kwashiorkor group and none in the marasmic group had inadequate serum retinol (12). A study done in Jos, North Central Nigeria showed that children with Marasmus, Kwashiorkor, and Marasmic Kwashiorkor had lower mean serum zinc levels of 13.01±0.17umol/L,14.99±0.20 umol/L and 12.6±0.15 umol/L respectively when compared to the controls with mean serum zinc levels of 15.15±0.19umol/L (13).

Though some studies (12,13) have evaluated the status of vitamin A and Zinc in malnourished Nigerian children, these studies assessed these micronutrients separately. Current interest in nutrition has shifted from isolated concern with individual micronutrient to interaction between and among nutrients and the functional consequences of combined deficiency (10).

There is limited data on joint vitamin A and zinc status of preschool age children with malnutrition in our region. The study is therefore relevant as it seeks to provide local data on this subject, which will enable comparison with other studies. It will also help to sensitise clinicians within the study area on the burden of joint vitamin A and zinc deficiencies and the need for simultaneous supplementation of these micronutrients among children with malnutrition. This will go a long way in improving the quality of care for such patients and in reducing overall childhood morbidity and mortality.

MATERIALS AND METHODS

Study area

The study was carried out at the Paediatric department of the Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto. The hospital is a tertiary health facility located in Sokoto, the Sokoto state capital, North -Western Nigeria. It serves as a referral centre for more than 10 million people from Sokoto, Zamfara, Niger, Katsina and Kebbi states of Nigeria and the neighbouring Niger and Benin Republics in the West African sub-region (14).

Study design and duration

The study was a descriptive cross-sectional, conducted from April 2013 to June 2014.

Study population

The study was carried out on children aged 6 to 60 months that presented to the department of Paediatrics with malnutrition and those that were well nourished as controls. Controls were apparently healthy non-stunted well-nourished children that were > -1Z score of the WHO child growth standards reference values for Weight- for -length / height and length / height -for –age (15) without clinical signs of malnutrition that attended paediatric outpatient department (POPD) clinic for follow up after discharge from the hospital for other Illnesses. Children that have received vitamin A and zinc supplements in the preceding 3 months before the study were excluded in the study, as well as those with normal weight and height but presented with acute diarrhoea, features of respiratory tract infection, and sickle cell anaemia, preceding history of measles 3 months before the study.

Sample size determination

The minimum sample size was determined using the formula (16).

$$N = \frac{z^2pq}{d^2}$$

Where

N= desired sample size needed for meaningful statistical analysis

z = the standard normal deviate usually set at 1.96 which corresponds to 95% confidence interval.

p = the proportion in the target population estimated to have a particular characteristic

In this study, prevalence of vitamin A deficiency in PEM children was calculated using a *p* value of 7.8% (0.078), based on previous study by Akinyinka *et al* (17).

q=1-p

= 1.0 – 0.078 =0.922

d = degree of accuracy desired. This was taken as 5% or 0.05

$$N = \frac{(1.96)^2 \times 0.078 \times 0.922}{0.05^2}$$

= 110

The minimum calculated sample size was 110

For estimating minimum sample size for zinc deficiency in PEM children, for this study taking the prevalence of zinc deficiency in under five Nigerian children as 20% (18), *p* value =0.2

$$N = \frac{(1.96)^2 \times 0.2 \times 0.}{0.05^2}$$

= 246

Therefore, the minimum sample size that was used for both vitamin A and zinc estimation in PEM children was 246

10% attrition = 25

246 +25 =271 approximated to 275

275 subjects each were selected for the study and control groups with a total of 550 participants enrolled into the study.

Sampling Technique

All consecutive admissions into the Emergency Paediatric Unit (EPU), paediatric medical ward (PMW) and children that attended paediatric outpatient department (POPD) clinic of UDUTH, Sokoto during the study period with diagnosis of malnutrition based on the World Health Organisation classification of malnutrition that fulfilled the inclusion criteria were enrolled for the study. Controls were well-nourished non-stunted apparently healthy children that attended the POPD clinic.

Instrument of data collection

A structured pretested questionnaire using interview method was used to obtain information from recruited subjects and controls on: Socio-demographic characteristics, such as age, gender, socio-economic class of both parents using Oyedeji's classification (19), nutritional and breastfeeding history. All the children recruited for the study had detailed clinical examination for ocular signs of vitamin A deficiency, presence or absence of oedema of the feet, dehydration, pyrexia, skin and hair changes. Relevant information was recorded using the study questionnaire. Anthropometric indices such as the weight and length were measured and recorded for all recruited children by the researcher and trained six resident doctors in the department of Paediatrics.

Anthropometric measurements and classification of Malnurition

The length was measured for the recruited children that were less than 24 months and height for those above 24 months of age to the nearest 0.1cm. Measuring board (infantometer) was used to measure the length of the recruited children. Length was measured in recumbent position with the feet and heels at right angle to the foot board (fixed vertical surface), with the heads of the children supported at right angle to the head piece so that the inner and outer canthi of the eyes were in horizontal plane (20). Gentle traction was applied to the neck to straighten excessive lumbar lordosis (21). The position of the vertex was read off with a movable vertical platform (20). Height was measured while the children were standing erect with heels, buttocks, upper part of the back against the stadiometer, with the heels close together and arms hanging naturally by the sides (21), shoes and caps were removed prior to measurement (20).

The weight of the recruited children aged less than two years was measured using Wunder Beam balance weighing scale for infant, while the weight of those above two years was measured using Wunder Beam balance weighing scale for preschool children in kilograms to nearest 0.1kg. The pointers on the scale were at zero point before commencement of weighing (20), each child was weighed in light clothing without shoes (20). Standard deviation of weight- for- length/height for each recruited child was obtained by plotting the measured weight on WHO growth chart against the length/height and gender. Reference values were taken from the WHO child growth standards (15). Height for age Z score for each recruited child was obtained by plotting the measured length/ height against age on the WHO growth chart for gender (15). Nutritional status of the recruited subjects was assessed using the World Health Organisation (WHO) classification of malnutrition (15). The subjects were classified as mild wasting (weight- for- height ratio between <-1 to ≥-2SD), moderate wasting (weight- for height- ratio between <-2 to ≥-3 SD) and severe wasting (weight- for-height ratio <-3 SD) (15), children that presented with bilateral oedema of the feet were categorised as oedematous malnutrition (15). Controls were apparently healthy non-stunted well-nourished children that were $>$ -1Z score of the WHO child growth standards reference values for Weight- for -length / height and length / height -for –age (15).

Blood sample collection and laboratory analysis

Five millilitres of blood were collected from each child by venipuncture after taking aseptic measures and immediately placed into a well-labeled specimen bottle without anticoagulant. The blood samples were immediately transferred to the chemical pathology laboratory for centrifugation at 200 revolutions per minute for 5 minutes. Serum was relabeled and then frozen at -20^{0}C until time for the analysis. Serum retinol was analysed using colorimetric method (22), and serum zinc using Atomic Absorption Spectrophotometric method (AAS), using Buck Model 205 Atomic Absorption Spectrophotometer; Buck Norwalk, CL by direct method as described by Kaneko *et al* (23). The researcher carried out the laboratory analysis for serum vitamin A and zinc under the supervision of a laboratory scientist after undergoing satisfactory six months training in Chemical Pathology laboratory of UDUTH, Sokoto.

Ethical Consideration

Approval for the study was obtained from the Ethics Committee of UDUTH, Sokoto and written consent from the parents/care-givers of the recruited children.

Data analysis

Data was analysed using the Statistical Package for Social Sciences (IBM SPSS) version 20.0 software, comparison of mean values of subjects and controls was done using Student's *t* test, while comparison of proportions was done using Chi-square test. A p value of <0.05 was regarded as statistically significant.

RESULTS

Socio-demographic characteristics of the subjects and controls

A total of 275 children with malnutrition were studied while 275 well-nourished apparently healthy children served as controls. The mean age of the children with malnutrition was 26.214.6 months (range of 6-60 months) compared to 28.217.0 months (range 6–60 months) in the controls, the difference was not significant ($p=0.15$). Of the 275 children with malnutrition, 137(49.8%) were males and 138(50.2%) were females, with a male to female ratio of 1:1. when compared to the control group with 152(55.3%) males and 123(44.7%) females, the difference was significant ($p=0.0001$) (Table 1). Two hundred and thirty-three (85%) of the children with malnutrition were from lower-socio-economic class (SEC), 34(12.0%) in the middle SEC, and only 8(3.0%) were from upper SEC, while for the controls 53 (19.0%) of the children were from the lower SEC, 151 (55.0%) from the middle SEC, and 71(26.0%) were from the upper SEC. The subject's parents were of a lower-socio-economic class compared to the controls ($x^2=503.4$, $p=0.0001$), (Table 1).

Figure 1 shows the age distribution of the subjects and controls. Two hundred and twenty-five (81.8%) of the children with malnutrition were between the ages of 6 and 36 months.

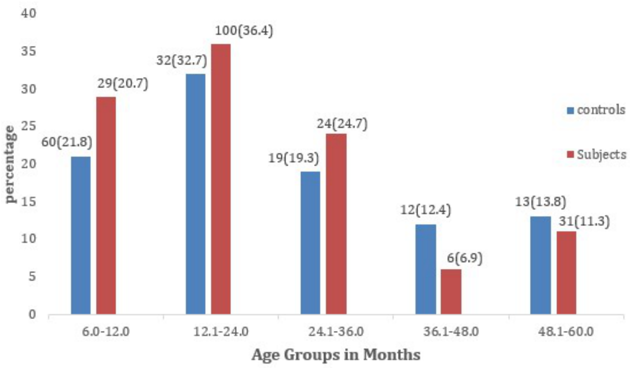

Figure 1. A bar chart showing the age distribution of the subjects and controls.

Distribution of clinical types of malnutrition according to age groups.

Ninety-three (33.8%) of the children with malnutrition had oedematous malnutrition, 82(29.8%) had severe wasting, while 30(10.9%) and 70(25.5%) of the children had mild and moderate wasting respectively.

Oedematous malnutrition and severe wasting were more common among children aged 12 to 24 months, except for mild wasting which predominates at 48.1 – 60.0 months age group, (Table 2).

Mean serum vitamin A levels of the subjects and controls.

The mean serum vitamin A levels for the subjects and controls were 23.4±13.2μg/dl and 54.0±22.8μg/dl respectively. There was significant difference between the mean serum vitamin A levels of the subjects and controls (t=19.50, df=548, p=0.0001).

Comparisons of mean serum vitamin A levels between children with malnutrition and controls according to age.

When children with malnutrition were segregated into age groups, the mean serum vitamin A levels were observed to be low among all the age groups compared with age matched controls. The differences were significant (p=<0.05 each, (Table 3). Malnourished children in the age range 24.1-36.0 months have the lowest mean serum vitamin A levels (21.0±11.2μg/dl) compared with age matched controls (47.8±22.6μg/dl), the difference was significant (p=0.0001). Children with malnutrition in the age group 48.1-60.0 months have the highest mean serum vitamin A levels (26.0±17.5μg/dl), (Table 3).

Mean serum vitamin A levels of children with malnutrition and controls according to age and gender.

The mean serum vitamin A levels of male controls (54.5±23.8 μg/dl) was higher than that observed among the male subjects (23.7±14.1μg/dl). The difference was significant (p=0.0001). There was also significant difference between the mean serum vitamin A levels of female controls (51.7±24.3μg/dl) and that of the female subjects (23.1±12.1μg/dl) (p=0.0001) (Table 4). However, no significant gender difference was observed in the mean serum vitamin A levels across all age groups between malnourished males and controls males as well as in malnourished females and controls females (p>0.05), (Table 4).

The mean serum vitamin A levels of malnourish males (23.7±14.1μg/dl) were similar to that of malnourished females (23.1±12.1μg/dl), the difference was not significant (p=0.195). Similarly, no significant gender difference was observed in the mean serum vitamin A level across all age groups (p>0.05), (Table 5).

Table 1. The socio-demographic characteristics of the subjects and the controls.

Variable	Subjects (N=275)	Controls (N=275)	Test of Significance
Age (months) Mean±S.D	26±14.6	28.4±17.3	**t-test**=1.57, ***P***=0.115
Gender			
Male	137(49.8%)	152(55.3%)	x^2=566.2, ***P***= 0.0001
Female	138(50.2%)	123(44.7%)	
Socio-Economic Class			
Upper	8(3.0%)	71(26.0%)	x^2=503.4, ***P***= 0.0001
Middle	34(12.0%)	151(55.0%)	
Lower	233(85%)	53(19.0)	
Maternal Educational Status			
None	211(76.7%)	81(29.4%)	x^2=566.2, ***P***= 0.0001
Primary	30(10.9%)	34(12.4%)	
Secondary	19(6.9%)	6(34.95%)	
Tertiary	15(5.5%)	64(23.3%)	

N=Number, t= student t-test, *p=p value*, *X^2= Chi square*

Table 2. Distribution of clinical types of malnutrition according to age groups.

Age group (months)	Mild wasting N (%)	Moderate Wasting N (%)	Severe wasting N (%)	Oedematous Malnutrition N (%)	Total N (%)
6.0 - 12.0	4 (1.5)	10 (3.6)	17 (6.2)	26 (9.5)	57 (20.7)
12.1 - 24.0	5 (1.8)	16 (5.8)	36 (13.1)	43 (15.6)	100 (36.3)
24.1 - 36.0	6 (2.2)	28 (10.2)	16 (5.8)	18 (6.5)	68 (24.7)
36.1 - 48.0	2 (0.7)	5 (1.8)	7 (2.5)	5 (1.8)	19 (6.8)
48.1 - 60.0	13 (4.7)	11 (4)	6 (2.2)	1 (0.4)	31 (11.3)
Total	**30 (10.9)**	**70 (25.4)**	**82 (29.8)**	**93 (33.8)**	**275 (100)**

Table 3. Mean serum vitamin A levels of children with malnutrition and controls according to age.

Age group (months)		Mean serum vitamin A levels (μg/dl) Subjects (N=275)	Controls (N=275)	t	P
6.1-12.0		25.2±14.7	64.9±19.4	12.3	0.0001
	N	57	60		
12.1-24.0		21.4±10.6	52.7±24.3	11.6	0.0001
	N	100	90		
24.1-36.0		21.0±11.2	47.8±22.6	6.6	0.0001
	N	68	53		
36.1-48.0		25.4±14.5	51.1±24.2	3.8	0.001
	N	19	34		
48.1-60.0		26.0±17.5	54.4±17.3	9.4	0.0001
	N	31	38		
Total		**23.4±13.2**	**54.0±22.8**	**19.5**	**0.0001**

Relationship between serum vitamin A levels with types of malnutrition.

The mean serum vitamin A levels were significantly low among all clinical types of malnutrition compared with controls ($p=0.0001$). Children with severe wasting had the lowest mean serum vitamin A levels (18.6±10.2μg/dl), when compared with that of the controls (54.0±22.8μg/dl) the difference was significant ($p=0.0001$). Children with oedematous malnutrition had the second lowest serum vitamin A levels (22.1±11.7μg/dl) while children with mild wasting had the highest value (28.8±19.4μg/dl), (Table 6).

Mean serum zinc levels of the subjects and controls

The mean serum zinc levels for the subjects were significantly lower (13.5±3.3μmol/L) than that of the controls (15.8±1.9 μmol/L) (t=9.42, df=548, $p=0.0001$).

Comparison of mean serum zinc levels between children with malnutrition and controls according to age.

The mean serum zinc levels of malnourished children were significantly lower (13.5±3.3μmol/L) than that of the control group (15.8±1.9μmol/L). The difference was significant ($p=0.0001$). The levels were also observed to be significantly low ($p=<0.05$) across all age categories of malnourished children compared with age-matched controls (Table 7).

It is of note that malnourished children in the age group 24.1-36.0 months have the lowest serum zinc levels (12.8±2.5μmol/L), when compared with controls of the same age group (15.3±2.4μmol/L), the difference was significant ($p=0.0001$). While, those within the age range 48.1-60.0 months have the highest value of serum zinc (14.4±4.0μmol/L), (Table 7).

Relationship between mean serum zinc levels and gender.
Mean serum zinc levels of children with malnutrition and controls according to age and gender.

The mean serum zinc levels of control males (16.1±2.4μmol/L) were higher when compared to that of male subjects (13.7±3.8μmol/L), the difference was significant ($p=0.0001$). Likewise, significant gender difference was observed in the mean serum zinc levels of the control females (15.3±1.5μmol/L) and malnourished females (13.5±2.8μmol/L) ($p=0.0001$). No significant gender differences were observed in the mean serum zinc levels across all age groups between malnourished males and control males as well as in malnourished females and controls females except for age group 12.1-24.0 among the males ($p<0.05$), (Table 8).

Table 4. Mean serum vitamin A levels (μg/dl) of children with malnutrition and controls according to age and gender.

Age (months)	Males Subjects	Controls	T	P	Females Subjects	Controls	t	P
6.0 - 12.0	24.5 ±15.2	26.1 ± 14.2	9.3	0.241	26.1 ± 12.6	27.3 ± 13.0	- 1.07	0.350
12.1 - 24.0	20.5 ± 9.7	22.1 ± 14.8	8.48	0.155	22.3 ± 11.6	23.1 ± 12.0	- 1.01	0.233
24.1 - 36.0	27.7 ± 17.8	27.1 ± 16.3	1.46	0.113	22.1 ± 8.7	24.2 ± 15.0	- 7.11	0.325
36.1 - 48.0	28.6 ± 19.6	30.8 ± 23.1	1.36	0.145	23.7 ± 18.5	23.0 ± 17.3	5.60	0.112
48.1 - 60.0	20.5 ± 10.1	21.8 ± 16.5	1.34	0.174	21.2 ± 12.0	24.3 ± 8.3	0.36	0.675
Total	**23.7 ± 14.1**	**54.5 ± 23.8**	**12.9**	**0.0001**	**23 ± 12.1**	**51.7 ± 24.3**	**13.0**	**0.0001**

Table 5. Mean serum vitamin A levels (g/dl) of children with malnutrition according to age and gender

Age (months)		Gender Males N=137	Females N=138	T	P
6.0 - 12.0	Mean ± SD	24.5 ±15.2	26.1 ± 12.6	0.39	0.69
	N	34	23		
12.1 - 24.0	Mean ± SD	20.5 ± 9.7	22.3 ± 11.6	0.88	0.38
	N	49	51		
24.1 - 36.0	Mean ± SD	27.7 ± 17.8	22.1 ± 8.7	1.41	0.16
	N	36	32		
36.1 - 48.0	Mean ± SD	28.6 ± 19.6	23.7 ± 18.5	0.63	0.54
	N	8	11		
48.1 - 60.0	Mean ± SD	20.5 ± 10.1	21.2 ± 12.0	0.15	0.88
	N	10	21		
Total	**Mean ± SD**	**23.7 ± 14.1**	**23 ± 12.1**	**0.57**	**0.195**

Table 6. The levels of mean serum vitamin A according to the types of malnutrition.

Clinical types of Malnutrition	Number of Children N (%)	Mean Serum Vitamin A Levels (µg/dl)
Controls	275.0 (100)	54.0 ± 22.8
† Oedematous malnutrition	93.0 (33.8)	22.1 ± 11.7
Mild wasting	30.0 (10.9)	28.8 ± 19.4
Moderate wasting	70.0 (25.4)	28.2 ± 12.9
‡ Severe wasting	82.0 (29.8)	18.6 ± 10.2

F=101.5, (p=0.0001), † =t= 13.0, (p=0.0001), ‡=t=13.9, (p= 0.001),F= one way analysis of variance(ANOVA)

The mean serum zinc levels of male subjects (13.7±3.8µmol/L) was similar to that of malnourished females (13.5±2.8µmol/L), the difference was however not significant (p=0.21). There was also no significant gender difference in the mean serum zinc level across age groups (p>0.05) (Table 9).

Table 7: Mean serum zinc levels of children with malnutrition and controls according to age.

Age group (months)		Mean Serum Zinc Levels(µmol/L) Subjects (N=275)	Controls (N=275)	t	P
6.1 – 12.0		13.2 ±2.6	17.1±3.9	6.0	0.0001
	N	57	60		
12.1 – 24.0		13.1±3.0	15.7±1.7	3.0	0.0001
	N	100	90		
24.1 – 36.0		12.8±2.5	15.3±2.4	6.2	0.0001
	N	68	53		
36.1 – 48.0		13.8±3.6	16.1±0.7	3.8	0.0001
	N	19	34		
48.1 – 60.0		14.4±4.0	15.8±1.2	4.7	0.0001
	N	31	38		
Total		**13.5±3.3**	**15.8±1.9**	**10.07**	**0.0001**

Relationship between serum zinc levels with types of malnutrition.

The mean serum zinc levels were significantly low among all the clinical types of malnutrition (p=0.0001), with the lowest levels observed among children with oedematous malnutrition (12.8±3.0µmol/L), when compared to that of the controls (15.8±1.9µmol/L) the difference was significant (p=0.0001). Children with mild wasting had the highest mean serum zinc levels (14.2±3.3µmol//L) (Table 10).

DISCUSSION

Oedematous malnutrition was encountered in 33.8% of the recruited subjects, and this represents the most prevalent form of malnutrition found in this study, a finding in keeping with that of Madondo *et al* (24) in South Africa. Severe wasting was observed in 29.8 % of the subjects in this study, which was more than mild, and moderate wasting respectively. Similar findings were reported by another researcher (24). Severe wasting is indicative of acute under-nutrition, which may result from a number of factors in the studied population, such as reduced food intake and availability, as well as illnesses (24).

Eighty-five per cent of the children with malnutrition in this study were from lower socioeconomic background. This is similar to findings reported in the literature (19,25-28). This implies that the parents of these children are poor and of poor educational background. Poverty has been identified as one of the leading cause of micro-nutrient deficiency in children in the developing world (29). Animal food products are the best and richest sources of vitamin A and zinc but are unaffordable to many in developing countries (12). Poor households may lack the resources to diversify their diets leading to micro-nutrients deficiency (1). Vitamin A deficiency could result from habitually low intake as well as economic, social and environmental factors which limit access to vitamin A containing foods (30). Significant positive correlation between serum zinc levels and social class is said to exist, with subjects in the high social class having the highest values for serum zinc (31).

The findings of this study are similar to several reports on children with malnutrition and low mean serum vitamin A levels (12,30) and zinc levels (7,13,32,33) when compared to well-nourished children. The mean serum vitamin A level (23.4±13.2µg/dl) of malnourished children observed in this study is lower than 30.91±20.63 µg/dl reported by Akinyinka *et al*. (17) Lowest mean serum vitamin A level was observed among children with Oedematous malnutrition this is in keeping with finding of Airede(12) and Ikekpeazu *et al* (30).

Vitamin A deficiency in malnourished children has been attributed to low intake and mal-absorption of vitamin A rich foods, inadequate hepatic stores of vitamin A and increased utilisation during protein deficiency, which impairs intestinal absorption, transport, metabolism of retinol, as well as depression of conversion of carotene to vitamin A (2).

Reduction in vitamin A levels seen in children with malnutrition in this study may be the result of the effect of malnutrition which

Table 8. Mean serum zinc levels (µmol/L) of children with malnutrition and controls according to the age and gender

Age (months)	Males Subjects	Controls	T	P	Females Subjects	Controls	t	P
6.0 - 12.0	13.2 ± 2.6	14.2 ± 3.4	3.32	0.221	13.3 ± 3.0	15.8 ± 2.2	- 1.07	0.31
12.1 - 24.0	15.0 ± 4.9	14.0 ± 3.0	2.61	0.010	13.3 ± 2.7	15.9 ± 1.5	- 1.01	0.318
24.1 - 36.0	12.5 ± 2.2	13.1 ± 2.6	0.65	0.522	13.6 ± 2.8	15.3 ± 3.2	1.53	0.142
36.1 - 48.0	13.3 ± 2.6	15.2 ± 3.1	1.54	0.155	14.2 ± 4.2	15.6 ± 1.4	1.51	0.163
48.1 - 60.0	13.8 ± 3.0	12.7 ± 2.5	1.01	0.413	12.0 ± 2.8	14.2 ± 2.0	0.41	0.633
Total	**13.7 ± 3.8**	**16.1 ± 2.4**	**14.0**	**0.0001**	**13.5 ± 2.8**	**15.3 ± 1.5**	**13.7**	**0.0001**

Table 9. Mean serum zinc levels (μmol/L) among children with malnutrition according to age and gender.

Age (months)		Gender Males (N=137)	Females (N=138)	t	*P*
6.1 – 12.0	Mean ± SD N	13.2 ±2.6 34	13.3±3.0 23	0.14	0.89
12.1 – 24.0	Mean ± SD N	15.0±4.9 49	13.3±2.7 51	1.58	0.12
24.1 – 36.0	Mean ± SD N	12.5±2.2 36	13.6±2.8 32	-2.36	0.08
36.1 – 48.0	Mean ± SD N	13.3±2.8 8	4.2±4.2 11	0.53	0.61
48.1 – 60.0	Mean ± SD N	13.8±3.0 10	12.0±2.8 21	1.0	0.33
Total	Mean ± SD	**13.7±3.8**	**13.5±2.8**	**2.9**	**0.21**

interferes with hepatic synthesis and release of retinol binding protein (RBP) required for vitamin A transport from the liver (12). Furthermore, other workers linked low serum vitamin A levels in children with malnutrition to acute phase response to infection as antioxidants like vitamin A, and zinc get depleted (34). Also, one of the early consequences of infection is increase vascular permeability with resultant fall in albumin and RBP (36). However the role of infection as a co-morbidity was not part of this study.

Reduced antioxidants status in malnourished children such as vitamin A, C and zinc could also be from oxidative stress from increased generation of reactive oxygen species. As antioxidants are involved in fighting against oxidative stress some amount might be exhausted (37).

The mean serum zinc level (13.5±3.3μmol/L) of malnourished children observed in this study is similar to 13.01±0.17μmol/L, 14.98±0.20μmol/L, 12.66±0.15μmol/L in marasmic, kwashiorkor, and marasmic kwashiorkor reported by Ugwuja *et al* (13) but higher than 7.8±0.17μmol/L, 9.0μmol/L and 9.9±0.96μmol/L reported respectively among malnourished preschool and school age children in Faisalabad in Pakistan (38), stunted Cambodian infants and toddlers (39), and among malnourished children in Ankara, Turkey (35).

Table 10. The levels of mean serum zinc according to the types of malnutrition.

Clinical types of Malnutrition	Number of children N (%)	Mean serum zinc levels (μmol/L)
Control	275.0(100.0)	15.8±1.9
†Oedematous malnutrition	93.0(33.8)	12.8±3.0
Mild wasting	30.0(10.9)	14.2±3.3
Moderate wasting	70.0(25.4)	13.7± 3.7
‡Severe wasting	82.0(29.8)	13.2±3.0

F=25.1,(p= 0.0001),**†** =t= 6.99, (p=0.0001), ‡=t=8.7, (p= 0.001), F=one way analysis of variance(ANOVA)

The low mean serum zinc levels among children with malnutrition as seen in this study has been attributed by some workers, to low dietary intake, poor bioavailability, mal-absorption and increased losses due to diarrhoea, as well as lack of breast-feeding (7,38) as found in this study which showed only 5% of the children with malnutrition were exclusively breastfed.

This study, like several others (32,36,40) has shown that both mean serum vitamin A and zinc levels were significantly lower among children with malnutrition. Low serum vitamin A levels in this study could be attributed to low zinc levels, since zinc influence several aspects of vitamin A metabolism including transport, utilisation and absorption (32).

The present study demonstrated that malnourished children aged 2 to 3 years had both lowest mean serum vitamin A and zinc levels. This is similar to previous finding in which greatest impact of VAD was said to occur among children less than 3 years of age (17). Similar finding was also reported by an earlier researcher in relation to zinc (13). This is because this age coincides with period of weaning and peak age of occurrence of malnutrition (41). After weaning, children derive nutrition from a monotonous habitual diet, depending heavily on cereals with little nutritious accompaniment (13,42).

It was also shown in this study that both mean serum vitamin A and zinc levels were significantly low among the different clinical types of malnutrition when compared to the controls. Lowest mean serum vitamin A levels was observed among children with severe wasting, which is similar to what has been reported previously (29,38). The serum retinol in this study is depressed more in those with severe malnutrition than those with mild and moderate malnutrition. Akinyinka *et al* (17) reported an association between VAD and wasting, but other studies did not show any association between serum retinol and wasting (43,44).

The relationship between serum retinol concentration and wasting is not entirely understood (45). Previous research (44) have confirmed the link between poor vitamin A status and wasting, diarrhoeal morbidities appear to mediate this relationship.

CONCLUSION

Children with malnutrition had significantly lower levels of serum vitamin A and zinc especially among those aged 2 to 3 years. For effective management of children with malnutrition, vitamin A and zinc supplements should be part of the treatment regime.

LIMITATION OF THE STUDY

It was not possible in this study to estimate the cell zinc content of children with malnutrition, which is the most sensitive method of assaying body zinc content.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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