East African Medical Journal Vol. 81 No. 1 January 2004
HAIR ZINC STATUS AND ITS CORRELATION WITH HEIGHT INDICATOR IN PRE-SCHOOL AND SCHOOL CHILDREN FROM A MIXED INCOME, LOW DENSITY (MILD) COMMUNITY IN SOUTHERN GHANA
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# HAIR ZINC STATUS AND ITS CORRELATION WITH HEIGHT INDICATOR IN PRE-SCHOOL AND SCHOOL CHILDREN FROM A MIXED INCOME, LOW DENSITY (MILD) COMMUNITY IN SOUTHERN GHANA

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## ABSTRACT

***Objectives:*** **To determine and assess the chronic zinc nutritional status of pre-school and school children living in a mixed-income, low-density (mild) community in southern Ghana and determine if zinc deficiency was implicated in growth stunting of the children.**
***Design:*** **Prospective/comparative study.**
***Setting:*** **A cluster of schools, made up of a nursery, two primary schools and two Junior Secondary School pupils living in Kwabenya, a village recently transformed into an urban community.**
***Subjects:*** **Three hundred and fourty four pupils, aged two and half to eighteen years.**
***Main outcome measures:*** **Levels of hair zinc were determined in three hundred and fourty four pupils, aged two and half to eighteen years, using Atomic Absorption Spectrophotometer. Age was assessed from birth baptismal certificates while height was determined using stainless steel stadiometer. The socio-economic status of the children was also assessed using pretested, weighted and structured questionnaires.**
***Results:*** **The chronic zinc nutritional status was generally good. Out of 344 pupils, 72% (248/344) had adequate status, while 11% were zinc deficient and 9.5% marginally deficient. Excess zinc status was found in 7.5% (26/344) of the children. It appears that growth stunting was not associated with zinc deficiency neither was zinc status affected by the socio-economic status of the children's families.**
***Conclusion:*** **Nutritional education should be mounted to families of children with deficient, marginally-deficient and excess zinc status and to encourage those with adequate status to maintain their zinc status.**

## INTRODUCTION

The United Nations has urged that priority attention be given to programmes in developing countries for the prevention of micro-nutrient deficiencies-termed hidden hunger. The micro-nutrients that have been emphasised are iodine, vitamin A, iron and more recently, zinc(1). It has been documented that zinc is involved in many biological processes including growth, enzyme function, protein synthesis, sexual maturation, wound healing and host defense reactions(2-6). Thus, features of zinc nutritional deficiency in man include anorexia, hypogonadism (under-development of the sex organs), lethargy, behavioral changes, increased susceptibility to infection, impaired development of the immune system and growth retardation.

The etiology of growth retardation in zinc deficiency is unknown but it is suggested to be related to nutrition and/or genetics or both; however it is believed that in the pre-school age, nutritional factors predominate over genetic factors(7). Diminished height (stunting) has been described in infants and children with poor zinc nutriture(8). In fact zinc deficiency was described as the cause of pronounced growth retardation, dwarfism and impaired sexual maturation in young people living in Egypt and Iran who consumed diets of low zinc bioavailability(9). A milder form of zinc deficiency with slight growth retardation, poor appetite and impaired taste acuity was described over two decades ago in children of middle and upper income families in Denver, Colorado, USA. These children were presumed to be of a good nutritional status(10). Since then, more studies have identified marginal zinc deficiency in pre-school and school children in several countries(11-13). Thus, zinc deficiency could be common in both developed and developing countries, albeit to different degrees.

The current study was undertaken to determine the chronic zinc nutritional status of pre-school and school children of various socio-economic classes, living in a suburb of Accra, and to determine the correlation between zinc and height status. Chronic zinc status was measured using head hair zinc levels while Height/Age Z score was used as indicator to assess height. This would indicate whether zinc deficiency was involved to stunting in the subjects.

## MATERIALS AND METHODS

*Project Sites/design:* The project was carried out in Kwabenya, a recently transformed community from a village setting to a mixed-income, low-density urban community. This community is part of the Accra municipality about 20 km from the city center. Details of the community as well as study details were reported earlier(14). Head hair was collected from the occipital region of the head. The hair was first cut low (1-2 mm) and then cut to the root using sterilised stainless steel pair of scissors. About 20 mg of hair was cut from each child. Hair was obtained from three hundred and fourty pupils. Treatment of hair samples and subsequent determinations of zinc levels were done as reported earlier(15).

Weighted, structured and pre-tested questionnaire were then administered to the children to determine the socio-economic status of their families based on these, the children were grouped into three socio-economic classes of low, medium and high, and the following age groups: <3; 3-5; >5-8; >8-15 and >15 yrs. Thus the study was both descriptive and comparative. For Socio-economic status, the presence of modern amenities of life, such as refrigerator, and the general standard of living, such as presence of a car and others were weighted and used. A cut-off point of <100 marks was regarded as Low, 100-<200, as Middle while >200 as High class.

Age was obtained from birth baptismal certificates. Height was determined using stainless steel stadiometer. The Institutional Review Board of Noguchi Memorial Institute for Medical Research approved the study.

*Data analyses:* Data were analysed using either EPINFO 6 or SPSS statistical package. Excel statistical package was used to determine correlation coefficient (r) values. Multiple comparison test of Least Square Difference (LSD) was used to determine significant differences between means of different groups. F values having p<O.05 were regarded as significant, while p> 0.05 were regarded as not significant.

## RESULTS

The present work was carried out to determine and evaluate the chronic zinc nutrition status of school children (aged 2.5 to 18 years, n=344) living in a mixed income, low density (mild) community in southern Ghana. It was also to determine whether zinc deficiency was implicated in stunting in the children. The results are shown in Tables 1-5.

Table 1 indicated that there was no significant difference (p>0.05) between the zinc level for the entire population and on sex basis. There were however significant differences (p<0.05) between the respective mean and median values. This indicated that the hair zinc levels did not follow a normal Gaussian distribution curve. There was also no significant difference (p>0.05) in the hair zinc levels in the various age groups (Table 2). The zinc nutrition status for the entire cohort is shown in Table 3. Using a cut-off point of < 70 for chronic zinc deficiency, 70-100 for marginal zinc deficiency, >100-500 for adequacy and >500 as possible excess, l1% (38/344) of the cohort were zinc deficient and 9.5 % (33/344) marginally deficient while at 7.5 % (26/344) could have excess zinc status. This meant that about 72% of the children had adequate chronic zinc status, with 40% of this figure having 100 -200 µg/g.

The breakdown of zinc status according to age is shown in Table 4. Based on children whose ages were definitely known (n= 288), two of the three children in less than three year group had adequate zinc status. In the three to five year group, ten out of the 13 had adequate status with a child probably having excess (>500 µg/g). The values for >5 - 8, >8 -15 and >15 year age groups were, 71% (24/34). 71% (60/223) and 67% (10/15) respectively. A few (8.5%, 19/223) possibly had excess zinc level in the >8-15 year group.

**Table 1**

*Hair zinc levels of school children - for the total population and by sex*

| Subject | Zinc level (µg/g) Mean | Median | SD |
|---|---|---|---|
| Total population n=344 | 240.5 | 172.4 | 250 |
| Boys n= 166 %=48.25 | 270.1 | 176.5 | 260 |
| Girls n=178 %=51.74 | 212.6 | 166.9 | 205.2 |

Each value is a mean of triplicate determinations. There was no significant difference (p>0.05) between the mean hair zinc levels.

**Table 2**

Hair zinc levels of children, by age groups (μg/g)

| Age (years) | Zinc Levels Mean | Median | SD |
|---|---|---|---|
| <3 n=3 % =1.04 | 192.7 | 208.0 | 84.0 |
| 3-5 n=l3 %=4.51 | 253.4 | 220.2 | 160.8 |
| >5-8 n=34 %=11.8 | 172.4 | 156.6 | 97.9 |
| >8-15 n=223 %=77.43 | 267.6 | 173.7 | 150 |
| >15 n=15 %=5.2 | 178.9 | 180.6 | 101.6 |

No significant difference ($p>0.05$) between the mean HZ value in the different age groups

**Table 3**

*Zinc status for the entire population*

| Zinc level (μg/g) | Zinc status | no | % | Details of Zinc Levels Mean | Median | SD |
|---|---|---|---|---|---|---|
| <70 | Deficient | 38 | 10.95 | 39.1 | 38.0 | 19.1 |
| 70- 100 | Marginal deficiency | 33 | 9.51 | 85.0 | 83.0 | 8.8 |
| >100-200 | Adequate | 139 | 40.06 | 152.6 | 156.7 | 25.8 |
| >200-300 | Adequate | 76 | 21.90 | 243.9 | 242.4 | 27.4 |
| >300-400 | Adequate | 21 | 6.05 | 350.5 | 351.4 | 27.8 |
| >400-500 | Adequate | 14 | 4.03 | 433.1 | 428.6 | 26.0 |
| >500 | Excess? | 26 | 7.49 | 999.7 | 780.2 | 686.0 |

**Table 4**

*Hair zinc status by age groupings*

| Hair Zinc Level (μg / g) | Zinc Status | Age groupings <3 | 3-5 | >5-8 | >8-15 | >15 |
|---|---|---|---|---|---|---|
| <70 n=36 | Deficient | 0 | 0 | 3 | 32 | 1 |
| 70- 100 n = 26 | Marginal Deficiency | 1 | 2 | 7 | 15 | 1 |
| > 100-200 n=110 | Adequate | 0 | 4 | 12 | 89 | 5 |
| >200-300 n=65 | Adequate | 2 | 4 | 8 | 47 | 4 |
| >300-400 n=19 | Adequate | 0 | 2 | 2 | 14 | 1 |
| >400-500 n=l2 | Adequate | 0 | 0 | 2 | 10 | 0 |
| >500 n=20 | Excess? | 0 | 1 | 0 | 19 | 0 |

The figures under age groups represent number of pupils in each category. The smaller sample size of 288 which is different from sample size of 344 indicated that the ages of 56 children were not definitely known.

**Table 5**

*Hair zinc levels in different socio-economic status for the whole group by sex*

| Socio-economic Status | no | % | Mean (µg/g) | Median | SD |
|---|---|---|---|---|---|
| **Whole group** | | | | | |
| Low | 120 | 37.26 | 266.7 | 185.6 | 171.0 |
| Middle | 176 | 54.65 | 238.5 | 176.6 | 217.5 |
| High | 26 | 8.08 | 242.9 | 148.2 | 160.2 |
| **Boys** | | | | | |
| Low | 55 | 17.08 | 311.4 | 182.7 | 120 |
| Middle | 87 | 27.01 | 271.6 | 188.0 | 275.1 |
| High | 13 | 4.04 | 205.7 | 175.2 | 160.2 |
| **Girls** | | | | | |
| Low | 65 | 20.18 | 222.1 | 188.5 | 120.0 |
| Middle | 89 | 27.64 | 205.3 | 166.1 | 160.2 |
| High | 13 | 4.04 | 280.0 | 121.2 | 160.2 |

The smaller sample size of 322 meant that 22 pupils did not respond to the socio-economic questionnaire. There was no significant difference (P>0.05) between hair zinc levels in the various socio-economic groups.

The hair zinc values in the different socio-economic status (Table 5) indicated that there was no significant difference (p>0.05) among the various socio-economic groups. There was a non - significant, weak positive correlation (p=0.744; r= 0.030) between hair zinc in the Low socio-economic class. In the middle class, there was also a non-significant and weak positive correlation between hair zinc and socio-economic class (p=0.426, r=0.060). However in the high socio-economic group, there was a non-significant inverse correlation (p=0.511; r=-0.141). The use of hair zinc as an indicator of chronic zinc nutriture has been discussed by various researches (16-18).

The use of scalp hair has the advantage of non - invasiveness, ease of collection, preservation (needing no refrigeration) and transport (including air mail postage to distant specialised laboratories), ease of samples once the correct reagent is used, and lack of matrix effect when standard solutions are also prepared in the solubilising fluid(19). Besides, zinc hair determination does not suffer from haemolysis, as happens in serum zinc determinations. Flynn et al.(20) have emphasised that hair can be very useful in nutritional assessment if attention is paid to proper sampling technique and appropriate statistical analyses. The disadvantage of using hair zinc has been attributed to its contamination with greasy products that are normally applied to head hair, and the care that is needed in sampling hair samples. Hair samples must be taken nearer the scalp to reflect the true chronic status of zinc and must be washed repeatedly with different types of solvents to get rid of all possible contaminants(19). These precautions were taken in the present work.

Even though the acceptable lower limit for hair zinc is $\geq$ 100µg /g (21,22), the upper limit has not been established. However, literature value of as high as 426 µg/g has been quoted for elderly black Americans(23). It would be expected that hair zinc values of African school children would be higher than the levels found in elderly people, due to the faster growth rate. Thus, using these cut-off points (of $\geq$ 100 µg/g ), 75% of the children had adequate status while those with levels >500 µg/g could be classified as having excess, with 10% and 11% respectively, being deficient and marginally deficient. Due to the involvement of zinc in growth, it is speculated that hair zinc levels might rise with age. This study showed that there was no significant difference (p> 0.05) between zinc levels in the children of different ages, thus zinc status was not age-related in these children (Table 2). Also zinc status was not affected by the socio-economic status of the children's family (Table 5).

While zinc deficiency leads to a myriad of symptoms which impact negatively on an individual, the effect of excess appears to depend on the form in which excess zinc is ingested. Zinc is considered to be relatively non-toxic, particularly if taken orally, however, manifestation of over toxicity symptoms such as nausea, vomiting, epigastric pain, lethargy and fatigue will occur in high intakes(24).At low intakes, but at concentrations well in excess of RDA (i.e 100 - 300mg/day versus an RDA of 10-15mg/day), evidence of induced copper deficiency with attendant symptoms of anaemia and neutropenia as well as impaired immune functions and elevated ratio of high density lipoprotein (HDL) to low density lipoprotein (LDL) have been reported(24). Even low levels of supplementation, close to RDA, have been suggested to interfere with the utilisation of copper, iron and to adversely increase HLD(24). Thus children in the deficient as well as excess group should be encouraged to take remedial steps to normalise their zinc status. Correlation between hair zinc levels and height for age Z-scores indicated that there was a non - significant, weak and positive correlation (p= 0.518; r=0.035)). This perhaps indicated that any growth faltering, particularly stunting, in these children was not strongly associated with zinc deficiency. This is being speculated since zinc deficiency leads to stunting in many instances.

ACKNOWLEDGEMENTS

To Dinah Quansah for the technical assistance and the field study group of Betty Takyi, Vivian Duodo, Dinah Kyi, Mariam Kingston, Aku Anaglatey, Bernice Hammond, Levina Koomson and Rebecca Amin.

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