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Prevalence of iron and zinc deficiencies among preschool children ages 3 to 5 y in Vhembe district, Limpopo province, South Africa

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ABSTRACT

Objectives: Children under the age of 5 y constitute the most vulnerable group for iron and zinc deficiencies and their nutritional status is a sensitive indicator of community health and nutrition. The aim of this study was to determine the prevalence of zinc and iron deficiency among preschool children aged 3 to 5 y in Vhembe district, Limpopo province, South Africa.
Methods: This study included 349 preschool children recruited from two municipalities of Vhembe district, Limpopo province, South Africa. Municipalities were purposively selected and simple random sampling was used to choose children. Body weight and height were measured using standard techniques. Serum zinc, iron, ferritin, transferrin saturation, transferrin and C-reactive protein levels were also assessed, as were hemoglobin levels.
Results: The prevalence of wasting, stunting, and underweight was 1.4%, 18.6%, and 0.3%, respectively; whereas 20.9% of the children were overweight and 9.7% were obese. The prevalence of zinc deficiency was 42.6% and anemia was 28%; both were higher in girls than in boys. When using serum ferritin and transferrin saturation 7 (2%) of the children had iron-deficiency anemia. Combined iron and zinc deficiencies using ferritin was found in 8 (2.3%) of the children; when using transferrin saturation these deficiencies were found in 42 (12%) of the children.
Conclusions: Iron and zinc deficiencies as well as anemia, accompanied by high prevalence of stunting; and overweight and obesity, were common in preschool children. The results observed here call for interventions to combat the escalating problem of child malnutrition in the form of nutritional education for mothers and food handlers at preschools to ensure food diversification in these children.

Introduction

Despite the legislated fortification of staple foods in South Africa [1], there is a general shortage of iron and zinc in a large part of the population's diets [2]. Furthermore, iron and zinc deficiencies still appear to be important public health problems in many low-income countries [2], as iron deficiency has an effect on psychomotor development, cognitive function, and growth [3]. On the other hand, zinc deficiency has been associated with poor growth, depressed immune function, increased susceptibility to and severity of infections, and neurobehavioral abnormalities [3]. The diets of many people in rural communities of South Africa consist of plant sources with very minimal amounts of animal sources that are rich in both iron and zinc [4].

Iron deficiency is particularly prevalent in infants and young children. These age groups have a higher risk for developing iron deficiency because of the high demand of iron during the period of rapid growth. Iron deficiency exists in all countries, but its magnitude is higher in South East Asia (57%) and Africa (46%) [5].

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The cause of nutritional anemia may be due to inadequate iron intake from food and low iron bioavailability.

Recently, there has been heightened interest in the role of zinc in humans, as it plays an indispensable role as a key component of a host of enzymes crucial for optimal metabolism and body functioning [6]. Additionally, zinc is an antiinflammatory and antioxidant agent and also functions in cell-mediated immune responses. In childhood, zinc is required for optimal growth and development, as well as brain functioning [7].

In developing countries, for instance, poor nutrition (especially micronutrient deficiencies) is not only responsible for >10 million preventable child deaths annually [8]. It is also a risk factor preventing an additional estimated 200 million children <5 y from attaining their full cognitive developmental potential [3]. Like many other developing populations, a recent national survey conducted among South African children revealed that 27.9% were anemic and 45.3% were zinc deficient [9]. Although large nutritional national studies [5,9,10] have been conducted among South African children, there is paucity of data concerning the prevalence of iron and zinc deficiency in rural preschool children in particular. In view of this, we conducted this study to evaluate iron and zinc status in preschool children residing in a rural area of Limpopo province, South Africa.

Methods

Study population

The study was conducted in Vhembe District, which is one of five municipal districts of Limpopo province. The district is divided into four local municipalities, namely, Thulamela, Makhado, Musina, and Mutale.

Simple random sampling was used to select two municipalities (Mutale and Makhado). Mutale had an estimated population of 91 870 and 148 villages; Makhado had an estimated population of 516 031 and 290 villages [11]. A list of preschools was obtained from the Department of Education, Vhembe District, and each preschool was assigned a number from which 16 were randomly selected for study inclusion. The same procedure was used to select 380 children (ages 3–5 y) to participate in the study. Children who were ages 3 to 5 y and whose parents consented and were present on the day of data collection were included in the study. The children were required to be free from infection, not taking any medication, and present on the day of data collection. Children whose parents or guardians did not give consent were excluded from the study.

Anthropometric assessments were performed according to standard procedures as described by the International Society for the Advancement of Kinanthropometry [12]. The following measurements were taken in duplicate using calibrated equipment with the children wearing light clothing and no shoes: standing height and weight. Height was measured to the nearest 0.1 cm using a calibrated portable stadiometer; and weight was measured to the nearest 0.01 kg on a portable Seca solar scale (model 0213) (Seca, Hammer Steindamm, Hamburg, Germany). The solar scale and stadiometer were calibrated before measurements using a calibration weight and steel tape, respectively.

A nurse checked for clinical signs of zinc deficiency by administering an oral zinc taste test. This was done by placing 10 mL of liquid zinc in the child's mouth, then letting the child hold it in the mouth for 10 to 15 sec while observing facial expressions and taste. The nurse then asked the children what liquid zinc tasted like and recorded the results. Clinical signs that could be identified by the naked eye were also recorded.

Biochemical analysis

Fasting venous blood was collected for blood analysis. Hemoglobin (Hb) was measured by standardized procedures at Ampath laboratories using a STKS analyzer (Beckman Coulter Inc., Brea, CA, USA), using three-level controls provided by the manufacturer, within 2 h of blood collection. Serum zinc was measured using ^{125}I-radioimmunoassay, Enzyme-linked immunosorbent assays were used to measure serum transferrin saturation (TSAT) and ferritin (Ramco Laboratories, Inc., Stafford, TX, USA) and C-reactive protein (CRP; Human Biochemical and Diagnostic Laboratories, South Africa) were analyzed by Synchron LX System(s), UniCel DxC 600/800 System(s) and Synchron Systems CAL 5 Plus by immunoturbidimetric test (Human Biochemical and Diagnostic Laboratories, South Africa). The coefficients of variance for all assays were <10%.

Definitions of iron and zinc deficiencies and anemia

Anemia was defined as Hb levels <11 g/dL for the children and iron deficiency as serum ferritin (SF) <12 μg/L or TSAT <15% [13]. Hb concentrations <7 g/dL were considered as severe anemia, 7 to 9.9 g/dL as moderate anemia, and Hb >10 to <11 g/dL as mild anemia [14], whereas zinc deficiency was defined as serum zinc concentration <9.9 μmol/dL [6]. Iron-deficiency anemia (IDA) was defined as having low Hb levels accompanied by low TSAT or SF or both.

Ethical considerations

Ethical clearance was obtained from the University of Venda Research Ethics Committee (SHS/12/NUT/02) and the study was approved by the Provincial Department of Health Research Committee and the Department of Education. The study was performed in accordance with the principles of the Declaration of Helsinki (2008), Good Clinical Practices, and the laws of South Africa. An oral and written explanation of the study, including possible risks, was provided to the parents and guardians. Parents and caregivers gave written signed consent for their children to participate in the study and the children gave verbal assent.

Statistical methods

The children's weight and height were entered into World Health Organization Anthro-plus version 1.0.2 software (http://www.who.into/nutgrowthdb/into, accessed 03/22/2013) for the calculation of weight-for-age (WAZ), height-for-age (HAZ), weight-for-height (WHZ), and body mass index (BMI)-for-age (BAZ) *z* scores. The data was then exported into Statistical Package for Social Sciences (SPSS, Chicago, IL, USA) version 21 for further analysis along with the biochemical measurements. Descriptive statistics were computed on the data and the median and interquartile ranges were used to describe continuous data as the data were not normally distributed while frequencies were used to describe categorical data. Spearman's correlation coefficients were computed to compare relationships between anthropometric measurements and biochemical measures. For comparison of groups, the Mann-Whitney *U* test was used for continuous data and χ^2-test for categorical data. Logistic regressions were computed to assess biochemical predictors of nutritional status (HAZ, WAZ, WHZ, and BAZ).

Results

We enrolled 380 children into the study, but the number was later reduced to 349 (92% response rate) due to nonresponse from the parents or guardians or the children being absent on the day of data collection. The median age of the children was 4.22 y (4.63 y in boys and 4.54 y in girls). There were no sex differences between the anthropometric and biochemical measurements of the children.

Table 1 provides the median and interquartile ranges of anthropometric and biochemical measurements between the stunted and nonstunted children. Nonstunted children were heavier than the stunted children ($P < 0.0001$), whereas WAZ *z* score values for nonstunted children were higher than those of the stunted children ($P < 0.0001$). BAZ *z* score was higher in the stunted versus the nonstunted children ($P < 0.0001$). There were no differences in biochemical measurements between the two groups.

The prevalence of wasting, stunting, and underweight was 1.4%, 18.6%, and 0.3%, respectively; 20.9% of the children were overweight and 9.7% were obese. Stunting was more prevalent in boys (21.5%) than girls (16.1%), although not statistically significant. Furthermore, 3.1% of boys were wasted although no wasting was found in girls ($\chi^2 = 5.788$; $P = 0.016$). Of the boys, 0.6% were underweight, but none of the girls were found to be underweight. Overweight and obesity levels were virtually the same in both boys (20.9% and 9.8%, respectively) and girls (20.9% and 9.7%, respectively) (Table 2).

Ferritin levels <12 μg/dL were taken as indicative of iron deficiency and 25 (7.2%) of the children were iron deficient. Of the girls, 14 (7.5%) had low SF compared with 11 (6.7%) of the boys. Furthermore, 98 (28%) of the children were iron deficient when TSAT <15% was taken as an indicator of iron deficiency. Additionally, 53 (28.5%) girls had low TSAT compared with 45