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Research Paper

Assessment of nutritional status of preschool children in the Bangang rural community, Cameroon

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Abstract. Malnutrition is a public health problem of significant importance in Cameroon. The aim of this study was to assess the nutritional status of preschool children in Bangang rural community. In this study, 475 children aged 2 weeks to 5 years were randomly selected. The eating habits of children were obtained through a questionnaire. The height and weight of children were measured and anthropometric indices of height/age, weight/age and weight/height were used to estimate children's nutritional status. Blood samples were collected on the children's venous. The blood collected was centrifuged and the serum concentration of albumin, zinc, phosphorus, magnesium, calcium and the C-reactive protein were measured using a spectrophotometer. These children consumed low meat, fresh fish, vegetables and fruits. The prevalence of stunting, underweight and wasting of children was 41.26, 10.52 and 3.58%, respectively. The mean serum levels of albumin, calcium, magnesium, phosphorus and zinc were respectively 36.22 ± 16.87 g/L, 7.73 ± 4.48 mg/dl, 1.95 ± 0.8 mg/dl, 4.09 ± 2.29 mg/dl and 62.16 ± 25.72 µg/dl. The prevalence of deficiencies in albumin, calcium, magnesium, zinc, phosphorus were 49.2, 73.56, 45.96, 62.98 and 62.23%, respectively. The prevalence of malnutrition, essentially stunting with altered biological markers was a problem of children in this community. We identified some risk factors including type of feeding, low fruits and vegetables intake and low education of family. The present results are currently used in developing an educational program using locally available food.

Keywords: Preschool children, nutritional status, stunting, Bangang, Cameroon.

INTRODUCTION

Food has always been a critical need for the survival of the human species (Ake-Tano et al., 2011). Good nutrition helps to improve child survival, to promote healthy growth and development, to contribute to better cognitive and economic development. It also reduces morbidity and mortality rate, and the risk of chronic diseases such as cardiovascular disease, diabetes, kwashiorkor, marasmus, hypertension, even in adulthood (OMS, 2010).

Although food is essential, it has often been lacking, in the qualitative and quantitative point of view resulting in the occurrence of malnutrition. Indeed, malnutrition (undernutrition, overnutrition) is a public health problem of significant importance in developing countries (Asres and Eidelman, 2011). It generally affects everyone in a community, but infants and children are the most vulnerable because of their high nutritional needs for growth and development (Nkuo-Akenji et al., 2008; Asres and Eidelman, 2011; Lioret et al., 2013). Malnutrition plays an important role in more than half of all child deaths worldwide and has adverse effects on the health status of children aged 0 to 5 years (Ake-Tano et al., 2011). It also promotes an increased susceptibility to infection, affects school performance and cognitive development (Sumana et al., 2011; Spolidoro et al., 2012; Van Royen et al., 2013). Malnourished children are therefore at high risk of morbidity and mortality (EDS-MICS, 2011).

Worldwide, nearly one billion people are undernourished and more than two billion are deficient in micronutrients (ACF, 2011). Approximately 115 million children under 5 years suffer from underweight, 178 million suffer from stunting (OMS, 2011) and 43 million are overweight (OMS, 2010). In developing countries, growth retardation affects about one child under 5 years on three, with 90% of all the cases in Africa and Asia (UNICEF, 2009). At this age, the number of children suffering from underweight is estimated at 30 million in Africa and 71 million in Asia (OMS, 2011). In sub-Saharan Africa particularly, 39% of children under 5 years suffer from stunting, 15% underweight and 6% of preschool children are suffering from wasting (Souganidis, 2012).

In Cameroon, the latest nutrition survey conducted by the National Statistics Institute reported high rate and increasing prevalences of stunting (33%), underweight (15%) and wasting (6%) in children under 5 years. It also showed that the height and weight disorders are more common in rural than urban areas (EDS-MICS, 2011). Despite sufficient quantity and diversity of food resources in Cameroon, especially in the Western Region (PAM, 2007), where many foods are produced, malnutrition rates among children under 5 years persist and are at rise (EDS-MICS, 2011). This work was initiated to estimate the prevalence of malnutrition and its specific underlying cause among children aged 0 to 5 years in the Bangang rural community, in order to develop a nutritional education program and planning that will to improve the nutritional situation of children in this locality.

MATERIALS AND METHODS

Study area

The study was conducted in the Bangang rural community. This community is located in the region of West Cameroon, in the department of Bamboutos and in the borough of Batcham. The Bangang's population is estimated at 80,000 people. The climate of this locality is Cameroonians type of altitude with a long rainy season and a short dry season. The main source of income is agriculture (Donhou, 2012). Bangang community produced several food and these foods can be used to reduce malnutrition and allow proper growth of children (Kana Sop et al., 2011).

Study population

The study population was the children from the Bangang rural community. In fact, 475 children aged 2 weeks to 5 years were selected. All these children were included in the study informed consent signed by their parents or guardians. Those who were sick or who did not live in this community or whose parent or guardians did not give signed informed consent were excluded in the study.

Sample size

The size of the sample (n) was determined by the following formula (Ake-Tano et al., 2011):

$$n = e^2pq/i^2$$

p: percentage of national preschool children malnutrition.
q: 1-p
e: probability that a sample will fall within a certain distribution (1,96).
i: 5% confidence intervalle.

The minimum sample size obtained by this formula and which allow a reliable result was 340 children.

Ethical approval

Before data collection, the study has been approved by the national ethics committee and ethical clearance was obtained for this purpose. After approval of this study by the National Ethics Committee, various village's authorities have been met and informed of the objectives of our study in order to obtain their consent, solicit their support and assistance. Then seminars awareness was organized to better explain their interest in our study. Informed consent were then handed over and explained to parents. Mothers who signed consent, their children participated in the study and the confidentiality of results was observed.

Data collection

This was a descriptive and analytical cross-sectional study. It took place in 6 health areas represented by 6 health centers. Three categories of data were collected: the food intake, anthropometric measurements and biochemical parameters. To collect these data, 6 sites were identified and arranged in different medical centers and many people were mobilized (6 researchers, 12 nurses, 2 doctors and 15 interviewers). The training of researchers was performed in different university, medical institutions and laboratory. A questionnaire was conducted in order to collect dietary data and information on the identification of the subject (name, age, height, weight, sex).

Dietary data

The eating habits of children were obtained by interviewing their mothers about their diet through a questionnaire.

The questionnaire was designed to recall the food eaten the week (7 days).

Anthropometric data

Weight measurement

Weight measurement was performed using an electronic scale (AEG PW4923, Germany) to reach 150 kg and precision 0.1 g for children who have more than 2 years and weighing scales for the baby (EBSA Kinlee-20, Germany) to reach 20 kg and 5 g precision for children under 2 years. The children were made stand or lying on the scale without touching anything. Shoes and heavy clothing were removed and weight measurement was then read and recorded in the survey form.

Size measurement

Size measurement was performed using the height gauge. The children were made to stand or to lie without shoes on the horizontal or vertical platform. With their feet parallel, their heels, buttocks, shoulders and back of head were made to touch the upright part of the meter. The head was held comfortably erect in the same horizontal or vertical plane as the external auditory meter. Size measurement was then read and recorded in the survey form.

Assessment of the nutritional status of children

Measurements of weight and height allowed us to determine indices height for age, weight for age and weight for height. These indices were determined by z-scores. The overall prevalence rate of malnutrition were obtained by setting the threshold of normality and -2 to -3 Z-scores below the baseline average and 3 to 2 and z-scores above the reference mean. Different indicators were calculated from the WHO software anthroplus 2007 and ENA for SMART. Malnourished children were reported when one of their anthropometric indices were abnormal (-2 z-scores below the average reference). Children were considered wasted if their weight-for-height index was below -2 z-scores below the average reference. Those with severe emaciation had their weight-for-height index below -3 z-scores below the average reference. Children were considered to be underweight if their weight-for-age index was below -2 z-scores below the average reference. Those with severe underweight had their weight-for-age index below -3 z-scores below the average reference. Children were considered to have growth retardation if their height for age index was below -2 z-scores below the average reference. Those who were suffering from severe growth retardation had their height for age index below -3 z-scores below the average reference.

Biochemical and blood collection

Blood samples were collected only on children whose mothers gave their signed consent form. Thus, blood sample of these children were collected by nurses in the morning in different locations. Before each blood collection, wearing gloves and labeling of sample tubes were mandatory. Approximately 2 to 4 ml of blood were collected from the venous of children and introduced into dry labeled tubes. After the collection of blood, needles, cotton and all disposable object used were introduced in a safety box. In the laboratory, after 15 to 30 min of blood collection, the collected blood was centrifuged using a centrifuge (Sigma, Laborzentrifugen, Germany) at a speed of 3600 rev/min for 10 min. The serum obtained was used for determining the serum albumin, zinc, phosphorus, magnesium, calcium and C-reactive protein. The specific volumes of serum, and standard reagent (according to the element to be assayed) were introduced into the tubes with the assay of albumin, zinc, phosphorus, magnesium and calcium. All the solutions of each tube was mixed and incubated at 37°C during 2 to 10 min according to the element to be assayed, and then subjected to the spectrophotometer (URIT 810, China) for determining the content serum assayed elements. As regards the C-reactive protein, the mixture between the latex reagent and the serum CRP was performed and indicated the positive or negative agglutination which reflecting the presence or absence of C-reactive protein in the serum. The results were expressed in mg/dl for phosphorus, calcium and magnesium concentrations, in g/l for albumin and in µg/dl for zinc. The reference values were from 38 to 44 g/l, 63.8 to 110 µg/dl, 1.9 to 2.5 mg/dl, 10 to 12 mg/dl and 4 to 7 mg/dl respectively for albumin, zinc, magnesium, calcium and phosphorus.

Statistical analyses

Data from anthropometric measurement and biochemical were analyzed using SPSS Version 16 software. Student's test, Chi 2 test and Pearson correlation were used to compare the values of different parameters. The results were given as mean ± standard deviation and differences were considered significant from $P < 0.05$.

RESULTS

The children's ages ranged from 2 weeks to 5 years in both boys and girls and the average age of these children was 24 ± 17.28 months. This study showed that 26.96 and 44.03% of women were respectively farmer and

Table 1. Foods consumed by children.

Food		Frequency of consumption (%)
Carbohydrate foods		
	Rice	18
Cereals	Corn	17
	Wheat flour	4
	Potatos, bananas, taro	21
Tubers	Cassava and derivatives	13
	Plantain	7
Fat foods		
Red palm oil		34
Refined oil		25
Protein foods		
Meats (beef, chicken)		6
Fishes (fresh or dry)		12
Legume (peanut, bean)		35
Vegetables (leafy)		12
Fruits		2

Table 2. Distribution of anthropometric indices by sex.

Indices	Male	Female	Significance (P value)
Height/age (z-score)	-1.95 ± 2.19	-1.43 ± 2.42	0.01*
Weight/age (z-score)	-0.45 ± 1.34	-0.24 ± 1.41	0.87
Weight/height (z-score)	0.88 ± 1.76	0.95 ± 0.14	0.72

Values expressed are mean ± standard deviation, * Significant difference from P < 0.05.

housewife. Approximately 45.78, 48.38 and 0.32% of the parents had respectively the level of primary, secondary and higher education, while 5.52% were not in school. After of survey forms, food investigation showed that the foods most consumed by children were tubers and cereals, fat rich food and green legumes. The consumption of meat, fresh fish, vegetables and fruits was very low (Table 1).

The measurement of anthropometric parameters showed that the average weight for boys was 11.1 ± 3.6 kg and their average size was 78.5 ± 15.27 cm. While among girls, the average weight was 10.11 ± 0.22 kg and their average size was 76.5 ± 16.17 cm.

The average z-score index height for age, weight for age and weight for height of children who participated in this study (Table 2) were respectively -1.95 ± 2.19, -0.45 ± 1.34 and 0.88 ± 1.76 in boys. In girls, the values of these indices were respectively -1.43 ± 2.42, -0.24 ± 1.41 and 0.95 ± 0.14.

The prevalence of nutritional status (Table 3) showed that 41.26% of children suffering from stunting (chronic malnutrition), more than 20.84% as severe. Nearly 3.58% of children were wasted (acute malnutrition) with approximately 1.26% as severe and 10.52% of children was underweight with 1.89% in its severe form. The prevalence of children who had a normal nutritional status was 42.63%. Stunting was higher among male children (21.6%) than female (20%), but the difference between growth retardation in both sexes was not significant (χ^2 = 1.29, P = 0.25). Underweight was higher among male children (6.31%) than females (4.21 %), but there is no significant difference between underweight boys and girls (χ^2 = 3, P = 0.08). Wasting was highest among male children (1.89%) than females (1.69%) and there is a significant difference between wasting among girls and boys (χ^2 = 4.96, P = 0.025).

Table 4 shows that 49.52% of children had hypoalbuminemia (serum albumin <38 g/L), 23.56% of boys and 25.96% of girls. Approximately 25% of these children had a hyperalbuminemia (serum albumin > 44 g/L), 9.62 % of boys and 15.38% of girls. While 25.48% had a normal serum albumin levels (38 to 44 g/L), 13.94% of boys and 11.54% of girls. The average of serum albumin in children was 36.22 ± 16.87 g/L, 38.7 ± 15.62

Table 3. Distribution of children according to nutritional status and sex.

Nutritional status		Male N (%)	Female N (%)	Total N (%)
Stunting	Moderate	49 (10.32)	48 (10.11)	97 (20.42)
	Severe	52 (10.94)	47 (9.89)	99 (20.84)
	Total	101 (21.26)	95 (20)	196 (41.26)
Underweight	Moderate	26 (5.47)	15 (3.16)	41 (8.63)
	Severe	4 (0.84)	5 (1.05)	9 (1.89)
	Total	30 (6.31)	20 (4.21)	50 (10.52)
Wasting	Moderate	9 (1.89)	2 (0.42)	11 (2.32)
	Severe	0 (0)	6 (1.27)	6 (1.26)
	Total	9 (1.89)	8 (1.69)	17 (3.58)
Healthy development	Total	90 (18.95)	122 (25.68)	212 (44.63)

N = number of children, % = percentage

Table 4. Distribution of albumin in gender and number of children.

Parameter	Boys (n = 98)	Girls (n = 110)	Total (n=208)
Albuminemia (g/L)	38.7 ± 15.62	33.47 ± 17.62	36.22 ± 16.87*
Significance	0.02		
Hypoalbuminemia	49 (50 %)	54 (4.09 %)	103 (49.52 %)
Hyperalbuminemia	20 (20.41 %)	32 (29.09 %)	52 (25 %)
Reference values	29 (29.59 %)	24 (21.82 %)	53 (25.48 %)

n = number, % = percentage, mean ± standard deviation, * Significant difference from P < 0.05

Table 5. Distribution of children based on serum micronutrient.

Parameter	Magnesemia Range (mg/dl) N (%)	Calcemia Range (mg/dl) N (%)	Zincemia Range (µg/dl) N (%)	Phosphoremia Range (mg/dl) N (%)
Hypo	<1.9 91 (45.96)	<10 153 (73.56)	<63.8 131 (62.98)	<4 120 (61.23)
Reference values	1.9 – 2.5 61 (30.8)	10 - 12 23 (11.06)	63.8 - 110 71 (34.14)	4-7 59 (30.1)
Hyper	>2.5 46 (23.24)	>12 32 (15.38)	>110 6 (2.88)	>7 17 (8.67)
Total	198 (100)	208 (100)	208 (100)	196 (100)

N = number of children; % = percentage

g/L for females and 33.47 ± 17.62 g/L in males. There was a significant difference P< 0.05) between serum albumin boys and girls.

The mean serum albumin in malnourished children (poor nutritional status) and healthy children (good nutritional status) was respectively 35.3 ± 14.36 and 38 ± 19.31 g/L. There was a significant difference (P = 0.04) between serum albumin levels in boys and girls.

Table 5 shows the percentage of children varies according to the level and type of micronutrients assayed in serum. This table shows that, 45.96, 30.8 and 23.24% of the children had respectively hypomagnesemia, reference values of magnesemia and hypermagnesemia. Approximately 73.56, 11.06 and 15.38% of the children

Table 6. Distribution of children according to the serum micronutrient deficiency.

Micronutriments	Boys			Girls		
	Mean ± SD	N	Deficiency N (%)	Mean ± SD	N	Deficiency N (%)
Magnesium (mg/dl)	1.95 ± 0.93	95	43 (45.26)	1.95 ± 0.66	103	47 (45.6)
Calcium (mg/dl)	6.67 ± 4.1	98	78 (79.59)	8.67 ± 4.64	110	75 (68.18)
Zinc (µg/dl)	62.01 ± 26.96	98	59 (60.2)	62.3 ± 24.68	110	71 (64.55)
Phosphore (mg/dl)	4.28 ± 2.5	95	52 (54.73)	3.91 ± 0.2	101	68 (67.33)

N = number of children; % = percentage of children; Mean ± SD = mean ± standard deviation.

Table 7. Distribution of children according to nutritional parameters and age groups.

Parameters		Age groups (months)					
		[0-6]	[6-12]	[12-24] N (%)	[24-36]	[36-48]	[48-60]
Nutritional status N = 475	Stunting	19 (4)	32 (6.74)	88 (18.6)	94 (19.7)	69 (14.5)	77 (16.2)
	Underweight	4 (0.83)	5 (1.05)	5 (1.05)	12 (2.53)	12 (2.53)	12 (2.53)
	Wasting	3 (0.63)	3 (0.63)	2 (0.42)	3 (0.63)	4 (0.85)	2 (0.42)
Proportion deficient children	Albumin (N = 208)	23 (11.06)	11 (5.29)	19 (9.13)	20 (9.62)	16 (7.69)	14 (6.73)
	Magnesium (N = 198)	20 (10.1)	9 (4.55)	11 (5.56)	23 (11.6)	17 (8.59)	11 (5.56)
	Calcium (N = 208)	31 (14.9)	16 (7.69)	34 (16.35)	28 (13.5)	19 (9.1)	25 (12.02)
	Zinc (N = 208)	17 (8.17)	17 (8.17)	38 (18.27)	22 (10.58)	12 (5.77)	25 (12.02)
	Phosphorus (N = 196)	28 (14.29)	10 (5.1)	20 (10.2)	29 (14.8)	12 (6.12)	21 (10.72)

N = number of children; % = percentage

had respectively hypocalcemia, reference values of calcemia and hypercalcemia. Nearly 62.98, 34.14 and 2.88% of the children had respectively hypozincemia, reference values of zincemia and hyperzincemie. Regarding the phosphorus, 61.23, 30.1 and 8.67% of the children had respectively hypophosphotemia, reference values of phosphotemia and hyperphosphotemia.

Table 6 shows that 45.26% of boys and 45.6% girls, or 20.67% of boys and 22.59% girls in all children had hypomagnesemia. For boys, the mean serum magnesemia was 1.95 ± 0.93 mg/dl, while in girls it was 1.95 ± 0.66 mg/dl. There is no significant difference (P = 0.94) between serum magnesemia and both sex. The prevalence of hypocalcemia was 79.59% boys and 68.18% girls, 37.7% boys and 36.06% girls in all children. Boys, mean serum calcium was 6.67 ± 4.1 mg/dl, while in girls it was 8.67 ± 4.64 mg/dl. There is a very significant difference (P = 0.001) between the serum calcium in boys and girls. The prevalence of hypozincemia was 60.2% for boys and 64.55% girls, or 28.37% of boys and 34.13% girls in all children. For boys, the average zincemia was 62.01 ± 26.96 mg/dl, while in girls it was 62.3 ± 24.68 mg/dl. There is no significant difference (P = 0.93) between serum zinc in boys and girls. In the end, the prevalence of hypophosphotemia was 54.73% for boys and 67.33% for girls, or 26.53% of boys and 34.69% girls in all children. For boys, the mean serum phosphorus was 4.28 ± 2.5 mg/dl, while in girls it was 3.91 ± 0.2 mg/dl. There is no significant difference (P = 0.27) between serum phosphorus in boys and girls.

The prevalence of acute infection or inflammation was determined by analysis of a biological marker, the C-reactive protein (CRP). For serum CRP concentration below 6 mg/L, the result is positive and negative if the concentration is greater than or equal to 6 mg/L.

The presence of acute infection or inflammation was observed in 11.83% of children, or 7.53% of boys and 4.3% girls. While 88.17% of children, or 38.17% of boys and 50% of girls showed no acute infection or inflammation.

Table 7 indicated that stunting, underweight and wasting have varied by age groups. The results in this table have indicated that children of age groups [12 to 24] and [24 to 36] have the high levels stunting (18.6 and 19.7%) and the age group [0 to 6] has the low levels stunting (4%). Table 7 also reported that deficiencies of albumin, magnesium, calcium, zinc and phosphorus in serums varied by age groups. The lowest levels of these elements in serum were found in children of age group [6 to 12].

Table 8 shows that there is a significant positive correlation between serum albumin and weight/age index (r = 0.25, P = 0.03) and between serum albumin and weight/height index (r = 0.25, P = 0.03). There is a

Table 8. Correlation between biochemical parameters and anthropometric indices.

Parameters	Weight/age		Height/age		Weight/height	
	r	P	r	P	r	P
Albuminemia	0.25*	0.03	-0.09	0. 91	0.25*	0.03
Calcemia	-0.03	0.67	-0.26*	0.02	0.14	0.051
Magnesemia	0.05	0.45	-0.07	0.33	0.26*	0.03
Phosphoremia	-0.003	0.97	0.005	0.94	-0.06	0.40
Zincemia	-0.02	0.77	-0.29*	0.03	0.001	0.99
Serum CRP	-0.31	0.16	-0.15	0.52	-0.25	0.26

r = correlation coefficient, P = Significance, * Correlation is significant at the 0.05 threshold.

significant negative correlation between serum calcium and height/age (r = -0.26, P = 0.02). There is significant relationship between serum magnesium and weight/height index (r = 0.26, P = 0.03). There is a significant negative correlation between serum zinc and height/age (r = -0.29, P = 0.03).

DISCUSSION

The present results confirmed the high prevalence of malnutrition in Cameroon, mainly in the stunting form. It showed the low consumption of fruits and vegetables. In addition, it showed that malnutrition was a reality among children aged 0 to 5 years considered healthy in Bangang rural community, village located in the region of western Cameroon. The prevalence of stunting in our study was higher than that found among children of the same age in sub-Saharan Africa (39%) (Souganidis, 2012). It was also high compared to the national prevalence of stunting in Cameroon, which was 33% (EDS-MICS, 2011) and lower than the prevalence of stunting in northwest Ethiopia which was 24% (Worku et al., 2009). In this study, the prevalence of underweight (acute malnutrition) was higher than the prevalence of underweight children in sub-Saharan Africa and Cameroon (15%) (EDS-MICS, 2011; Souganidis, 2012). Regarding the prevalence of wasting, it was lower than that observed in sub-Saharan Africa and Cameroon (6%) (EDS-MICS, 2011; Souganidis, 2012). As in many studies like Sbaibi and Abdoussaleh (2011), stunting was the form of malnutrition most encountered. The fact that the prevalence of stunting was significantly higher than underweight and wasting confirms that the major problem is chronic malnutrition. Protein-energy malnutrition was influenced by various factors. The education of women was an important factor in malnutrition, but also their socio-economic situation (Ake-Tano et al., 2011; Mishra, 2013). This study showed that the population was poor and the mothers were housewives and cultivators. In addition, the majority of parents have done a primary and secondary school, a few were illiterate. Socio-economic status and educational level of the parents could then influence the nutritional status of children who participated in this study. Different forms of malnutrition among children in this study could also be related to inadequate nutrition of the child, poor knowledge of infant feeding by the mother, poor access to food and nutrients with limited health care of the child and an unhealthy environment. The determination of serum albumin in this study showed that the children had hypoalbuminemia. This decrease of serum albumin has also been reported by Diouf et al. (2000) and Simpore et al. (2009) among children suffering from severe malnutrition, and Yapi et al. (2010) in children under 5 years suffering from malnutrition minor and moderate. In general, the nutritional point of view, the hypoalbuminemia resulted from protein-calorie insufficiency (Bach-Ngohou et al., 2004). Pretreatment (cooking more often) that the food undergo could affect the nutritional value, digestibility and bioavailability of proteins (Jacotot et al., 2003), which could also justify the low concentration of albumin in the blood. Other units, the low serum albumin would be caused by an inflammatory process initiated by interleukine1 secretion, which results in an increase in C-reactive protein (Yapi et al., 2010).

Magnesium is important in the maintenance of several cellular functions. It is a natural activator of most enzymes. Magnesium deficiency is often developed in a wide variety of clinical conditions. These clinical conditions may be protein-energy malnutrition, malabsorption, hypoalbuminemia, sepsis, conditions that are commonly seen in children in developing countries (Amare et al., 2012). In this study, serum magnesium deficiency has been observed in some children recruited. This prevalence was higher compared to 20.7% and low compared to 51.9% respectively found by Rodriguez et al. (2008) and Nguyen et al. (2008) among children in Mexico and Vietnam. Hypomagnesemia could be due to inadequate dietary intake of magnesium, to protein-energy malnutrition or to hypoalbuminemia (Amare et al., 2012).

The present study showed that some children had hypocalcemia and hypercalcemia. The prevalence of hypocalcemia found in our study population was less than that found (97%) by Laillou et al. (2013) among children under five in Vietnam. Hypocalcemia could be caused by vitamin D deficiency or insufficient parathyroid hormone levels or resistance of these hormones or by inadequate dietary intake. Indeed, insufficient levels of vitamin D (low 25-hydroxyvitamin D and 1.25-dihydroxyvitamin D) leads to a reduction of the gastrointestinal absorption of calcium by up to 50%, so that only 10 to 15% of intestinal calcium from food sources is absorbed (Fong and Khan, 2012). Insufficient parathyroid hormone levels resulting in excessive urinary calcium loss by reduced bone remodeling and low intestinal absorption of calcium and would lead to hypocalcemia (Cooper and Gittoes, 2008). High calcium intake, sun exposure and infection could explain the prevalence of hypercalcemia in children recruited in this study. When the exposure to sunlight (abundant radiation) is extended, the 25-hydroxyvitamin D3 is relatively high serum which could lead to hypercalcemia. Upon infection (CRP > 6 mg/L), macrophages and other immune cells could stimulated 1α-hydroxylase, the enzyme which converts the 25-hydroxyvitamin D3 to 1.25-dihydroxyvitamin D3. The 1.25-dihydroxyvitamin D3 is the active form of vitamin D and increasing the synthesis of this compound could further contribute to hypercalcemia (Amare et al., 2012).

The prevalence of zinc deficiency in children has far-reaching implications (growth retardation, skin alterations, immune disorders, learning disabilities), because zinc is an important element for many functions in the body. Zinc also is a cofactor in the synthesis of a number of enzymes, DNA and RNA (Sandstead et al., 2008; Hininger and Roussel 2009). The results of this study have shown that some children had zinc deficiency. This prevalence was lower than the national prevalence obtained in Cameroon. Zinc deficiency could result from inadequate intake of foods containing zinc or its poor absorption. Most foods high in zinc were of animal origin, such as meat, fish and dairy products, but the consumption of such foods by children recruited was low (Table 1) which could explain the hypozincemia of these children. In addition, the bioavailability of zinc content in cereals and legumes (most foods consumed by children) was very low because these foods contain a lot of dietary fibers and phytates. Dietary fiber and phytates bind to zinc, with which they form insoluble complexes and inhibit absorption (Sandstead et al., 2008; Roussel and Hininger, 2009). Excess zinc intake could be the cause of hyperzincemia observed in this study, which had the consequent decrease in the absorption of ingested copper resulting in a severe copper deficiency (Trocello et al., 2011).

The prevalence of phosphorus deficiency in children may result in several disorders (respiratory, cardiac, neurological), because the phosphorus involved in a good bone structure, nervous function, and to the cellular metabolism in an integral part of the ATP. The present study showed that some children had hypophosphoremia and hyperphosphoremia. Hypophosphoremia's children could be due to inadequate nutrition and poor absorption. In fact, most foods rich in phosphorus, particularly cereals and legumes contain phytates. Phosphorus which however is in the form of phytate will hardly absorb as phytates have the property to bind to divalent cations (particularly zinc and iron) and to minimize the absorption (Briend, 1998). This factor could be the cause of hypophosphoremia of children because their diet was grain and legumes. The hyperphosphoremia met in some children could be explained by high intakes of phosphorus in their diet. An excess of phosphorus could possibly, if calcium intake is insufficient (Ca/P < 1), causing secondary hyperparathyroidism and induced bone loss (Potter et al., 2003).

The main limitations of our study were the difficulty to understand local feeding practices of children. No model of breastfeeding and complementary was available and we have to develop local dietary guidelines. These inquiries could be important to compare the energy intakes by children with nutritional needs per age groups.

CONCLUSION

The main goal of this study was to assess nutritional status of preschool children in the Bangang rural community. At the end of this work, it appears that malnutrition is a real problem among the children of this community. This malnutrition is due to many problems such as inappropriate eating habits of children, food insecurity, poor sanitary conditions and lack of knowledge of mothers. The active participation of mothers in the promotion of preventive health activities (growth monitoring of children), nutrition education and the development of a nutrition program in this locality, are recommended to protect children and reduce malnutrition rate.

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