SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2017; **17(3):** 12427-12440 **DOI: 10.18697/ajfand.79.16510**

DIETARY CALCIUM INTAKE AND SUNLIGHT EXPOSURE AMONG CHILDREN AGED 6-23 MONTHS IN DALE WOREDA, SOUTHERN ETHIOPIA

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July 2017
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ABSTRACT

Nutritional rickets can be caused by either or both calcium and vitamin D deficiencies, and can frequently occur in Africa. In Ethiopia, limited evidence exists regarding the calcium intake of children and their sunlight exposure practices. The purpose of this study was to assess information regarding dietary calcium intake and sunlight exposure practice, which are factors related to nutritional rickets. The study was conducted in Dale Woreda, Southern Ethiopia using a community based cross-sectional survey design with both descriptive and analytic components. A total of 170 children were selected using multi-stage sampling technique. A structured questionnaire and an interactive 24-hour dietary assessment method were used to collect data on socio-demographic and economic information and to assess dietary calcium intake of participant children. The Ethiopian food composition table supplemented by world food data were used to convert dietary intake into nutrient content. The mean (SD) age of the study children was 14.4 (±4.7) months. The male to female ratio was 1.24. The mean (± SD) calcium intake of participant children was 407 ± 235 mg/day; 26.5% had low dietary calcium intake compared with their age specific recommended nutrient intake (RNI) value. Regarding sunlight exposure, 41.1% participant mothers exposed their child to sunlight within 1 (one) month of birth and 56.5% of study children were exposed to sunlight for 20 to 30 minutes per day. In conclusion, the risk of dietary calcium inadequacy was prevalent because of low intakes by some children. Even if only 26.5% of participating children had low dietary calcium intake, the children in the study area have some risk of dietary calcium inadequacy due to the high content of phytate in the prevailing complementary foods such as fruits and maize based complementary food, which can inhibit bioavailability of calcium. The participant children were not at risk of inadequate exposure to sunlight because they had good exposure practices and there was no sunlight avoidance practices among the majority of participant children.

Key words: Calcium, Children, Ethiopia, Rickets, Sunlight exposure, Vitamin D, Phytate, Complementary foods ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Nutritional rickets can be caused by both calcium and vitamin D deficiencies. A review by Pettifor [1] reported that while there is relatively little population data on the prevalence of nutritional rickets in developing countries, studies do suggest that vitamin D deficiency is common in countries and regions such as the Middle East, North India, China, Ethiopia, Yemen and Turkey. For Ethiopia, Prentice [2], in a review of rickets, stated that the prevalence of rickets was as high as 40%, making it one of the highest in the world. A recent report showed vitamin D insufficiency in adolescents living in Ethiopia of 42% [3], which was worse for those children living in urban centers or those wearing clothing that concealed most of the skin from sun exposure. In developing countries where calcium intakes are characteristically low and the population relies heavily on cereal-based staples, with few or no dairy products, dietary calcium deficiency appears to be the major cause of nutritional rickets among children [4, 5].

Some studies suggest that rickets is an important child health problem in Ethiopia but the etiology is not known [1, 2, 6, 7, 8]. A review of pediatric admissions in Jimma hospital, South Western Ethiopia indicated that about 10 % of children were diagnosed to have rickets [6]. A second study in Jimma showed rickets prevalence of 4% in randomly selected children between 6-59 months of age [7]. This study indicated calcium as the cause of rickets in Ethiopia. However, in a study of 300 consecutive outpatients seen at the Ethio-Swedish Hospital, Addis Ababa, 122 (41%) had clinical signs of rickets [8] but neither calcium nor vitamin D deficiencies could be distinguished. Anecdotally, there has been indication of sun avoidance practices of lactating mothers and their children, but no published information exists. There is little information, therefore, about the major causes of nutritional rickets, namely vitamin D deficiency and calcium deficiency, among Ethiopian infants. To the best of the research team's knowledge, there is no study in the country looking at these major risk factors of nutritional rickets at the community level. Therefore, this study assessed the magnitude of the major causes of nutritional rickets in a woreda in Southern Ethiopia.

METHODS

The study was conducted in Dale woreda (a woreda being a third-level administrative division of Ethiopia, composed of a number of kebeles) in the Southern Nations, Nationalities and Peoples Region (SNNPR) of Ethiopia, located in the Sidama Zone of the Great Rift Valley. Based on the 2007 Census conducted by the CSA [9], the woreda has a total population of 242,658, of whom 122,918 (50.7%) are men and 119,740 (49.3%) women. A community based cross-sectional survey with both descriptive and inferential components was the design. All children who were the permanent residents in the study kebeles (villages) with the eligible age group of 6 to 23 months were included in the study population (n = 504), from which a total of 170 children were selected using a multi-stage sampling technique [10]. An interactive 24-hour dietary recall method was used to collect data on the intake of children using information from the caregivers. To enhance recall of consumed foods, picture charts were provided to the participants before the recall day. In addition, solid and semi-solid dough models and sample foods were used in the recall day to help quantify portion size estimation [11]. Standard cylinders and containers of water were used to measure the liquid food items.

For determining the history of sunlight exposure and socio demographic and economic data, a pretested structured questionnaire was adopted from previous studies of young children in SNNPR [12, 13] and from the Ethiopian demographic and health survey [9]. The recorded food items from the 24-hour dietary assessment were converted into nutrient content amounts using Ethiopian food composition table [14], which is designed for cooked and raw foodstuffs and commercial foods [15]. Four foods which were locally purchased or collected from participants' households were used for food laboratory analysis to determine their calcium and phytate contents, and phytate-to-calcium ratio. These foods were dried overnight at 105^{o}C in Hawassa University Human Nutrition Laboratory, then powdered, packed and sent to a certified laboratory at the University of Saskatchewan, Canada for analysis. To determine phytate, the modified Wade's reagent method was used [16]. Flame Atomic Absorption Spectrophotometry (FAAS) (NOVAA300, Germany) was used for determination of calcium after acid digestion. Prior to analysis, lanthanum chloride (1%) was added to suppress interference from phosphorus. The phytate-to-calcium molar ratio of the selected food samples was calculated by dividing mmol of phytate by mmol calcium. A phytate-to-calcium molar ratio greater than 0.2 was applied as the cut-off point for undesirable for calcium absorption [17]. All of these analyses were done in triplicate.

Dietary diversity score (DDS) was calculated for each of the children. The minimum dietary diversity score (MDDS) was defined as the proportion of children who receive foods from at least four food groups using a standardized list of seven food groups [18]. In order to evaluate adequacy of dietary calcium intake of participant children, the WHO 1998 document was used [19]. Data from the structured questionnaire and 24-hour dietary assessment was entered to the SPSS (statistical package for social sciences) software version 16 and checked for the completeness of the data.

Protein–energy malnutrition in children was determined as underweight, defined as -2 standard deviations (SD) under the normal weight- for- age (WAZ); stunting, -2 SD below height-for-age (HAZ); and, wasting, -2 SD below body mass index for age (BAZ). Anthropometric measurements (weight, length or height) of the young children were taken by trained health workers using standardized techniques and calibrated equipment. Weight was measured using an electronic scale (Seca 770), adjusted to zero for each measurement. Children were too young to stand; therefore, height was measured using recumbent length board to the nearest 1 mm.

Prior to the study, ethical clearance was secured from the institutional board of Hawassa University. Before the data collection started, informed written consent was obtained from the mothers. The purpose of the study was explained clearly to the mothers with the assurance that the information obtained from the respondents was to be kept confidential.

DOI: 10.18697/ajfand.79.16510

RESULTS

Socio demographic and economic characteristics of study participants

A total of 170 children aged 6-23 months were included in the study. The mean (±SD) age of the children was 14.4 (±4.7) months. The male to female ratio of the children was 1.2. Farming was the main source of livelihood for majority of the participant families. Regarding ownership of livestock, 102 (60%) of participant families had their own cow. About 41 (24.1%) of participant families had consumed the entire milk from their livestock; however, about 61(35.9%) of the families had partially consumed and partially sold the milk (Table 1).

Nutritional status of children

Mean (±SD) weight and height of the children were 9.2 ±1.7g and 74.3 ±6.2cm, respectively. Mean (±SD) weight-for-age z-score (WAZ), height-for-age z-score (HAZ) and body mass index-to-age z-score (BAZ) of the children was -0.6 (±1.2), -1.1 (±1.5) and 0.2 (±1.4), respectively. From the 170 children, 23 (13.5%) had less than negative 2 WAZ score indicating underweight. About 38 (22.3%) and 8 (4.7%) of the children had less than negative two HAZ and BAZ scores, indicating high prevalence of stunting and relatively lower prevalence of wasting, respectively.

Dietary diversity

The commonly eaten foods are shown in Table 2. The most common foods were fruit, especially avocado and banana. Milk and maize were eaten by approximately half of all the children. Corn bread, enset and potato were less commonly consumed. Overall, the mean DDS of the children was 3.1± 0.8. Slightly more than one quarter (27%) of all the children had DDS of four or more.

Calcium intake of the children

Overall, the mean (± SD) intake of calcium was 407 ± 235 mg/day. Table 3 provides dietary calcium intakes as (mean ± SD) by age and sex. Of the 170 children, 45 (26.5%) had low dietary calcium intake from their complementary food. "Low" intake of calcium is defined as being below the age-appropriate Recommended Nutrient Intake (RNI) [19]: 336 mg (age 6-8 mo), 353 mg (age 9-11 mo) and 496 mg (age 12-23 mo). Mean daily dietary calcium intake of the male and female children was 403 ± 240 mg and 412 ± 230 mg, respectively; no significant sex difference was observed. Of the 94 male and 76 female children, 28.7% and 23.7%, respectively, had low dietary calcium intake from their complementary food compared with their age specific recommended nutrient intake (RNI) value (Table 3). Younger children (ages 6-8 months and 9 – 11 months) were less likely (44% and 46%) to have met the RNI value than older children (20%).

Nutrient content of foods

In Table 2, the calcium content of commonly consumed foods is provided using Ethiopian Food Composition tables [14]. The main sources of calcium were milk and enset (also known as false banana, *Enseteventricosum*), although it should be noted that neither was the most commonly consumed. The other foods provided little calcium per serving.

Four selected sample foods, which were purchased or obtained from the woreda were examined (Table 4). These included mixes of prepared enset, wheat porridge, maize porridge and *meten* (packed mixed grain contains maize, wheat, barley, oats). Analyzed calcium and phytate values (per 100 g dry weight) are shown in Table 4. The phytate-to-calcium molar ratio of three of the sample foods was less than 0.2, indicating no effect on calcium absorption [17]. One food, the maize porridge mix, had the ratio above cut-off point suggesting a lower bioavailability of calcium in this food.

Knowledge and practice of mothers regarding sunlight exposure and rickets
Practices about sun exposure and about knowledge of rickets were asked of the mothers (Table 5). About 70 (41.1%) of the 170 mothers that participated in this study exposed their child to sunlight within 1(one) month of birth. Most of the children were exposed to sunlight for 20 to 30 minutes per day. From the total participant children, 84 (49.4%) were exposed to sunlight for 7 days in a week. About 153 (90.0%) children were exposed to sunlight without clothing. Sun exposure ranged from 0 to 8 hours per day. Most children (92.9%) played outside the house; the median duration of the children being outside was 1.5 (IQR = 1-2) hour.

One-fifth of participant mothers reported that there was sunlight avoidance practice in their areas at the early age of the child. The reported underlying reasons were: fear of cold, fear of "evil eye" of the sun, and fear of sunburn '*mich*'. Regarding sunlight exposure during pregnancy, all respondent mothers reported they had spent most of their daytime outside the house and there was no sunlight exposure restriction during pregnancy in their locality. From the total respondent mothers, more than half (52.4%) did not know about rickets, and few of them were aware of how it would be prevented and/or treated using calcium and/or vitamin D. A small number (10%) of respondent mothers reported fenugreek (*Trigonellafoenum-graecum*) also called '*amesa*', as treatment for rickets in their locality.

DISCUSSION

The study aimed to assess whether dietary calcium intake or sunlight exposure practices, which are factors related to nutritional rickets, were prominent in Ethiopia by studying one woreda. It was found that in this woreda that mothers reported having had heard of rickets. However, while the reported prevalence of rickets in Ethiopia was about 40 % as found by Muhe *et al.* [8] and reported by Prentice [2], no evidence of rickets was seen when conducting this study in Dale woreda. In the present study, evidence of low dietary calcium intake and potential for poor absorption of calcium, due to phytate content in the foods, was found. No evidence for sun avoiding behaviors of mothers towards children were reported or observed during this study.

The results of this study show that dietary calcium intake of 75% of all the children was adequate, with 25% having calcium intake below the RNI. The very young children (aged 6-11 months) were more at risk of inadequate intake of dietary calcium. Studies comparing dietary calcium intake between children with and without rickets in developing countries have shown that in Nigeria, South Africa, India, Bangladesh and

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ISSN 1684 5374

even Ethiopia, calcium intake by children can be very low as the predominant diets in these countries are mostly cereal-based diets that are often deficient in milk and milk products [1, 4, 5, 6, 7]. The better intake that was observed in this study was due to having more than half of the participant children (52.9%) drinking at least one small cup of skimmed milk in a day. Further, enset was a good source of calcium. The Ethiopian National Food Consumption Survey conducted in 2011 reported that "children and women have intakes below the recommended amounts of vitamins and minerals such as vitamin A, zinc, and calcium" [20] yet calcium data on intakes of these groups has not yet been published.

It should be noted that some of the most predominant foods in the study area are made with corn and include maize porridge and unleavened corn bread. These foods contain significant amounts of phytate which, when present at a molar ratio of phytate-to-calcium above 0.2, can inhibit calcium absorption [17]. Abebe *et al.* [21] reported that whole dried kernels of white maize and unrefined maize flour used in Southern Ethiopia contained phytate and had the lowest calcium content. Roba [22] reported that home processing in Ethiopia such as pounding and soaking can reduce phytate levels of maize. Until these processing methods become widely known and correctly practiced, dietary calcium bioavailability in these communities will be low.

Overall, the diet diversity of young children in the woreda was poor, with an average of 3.1 foods which was under the cut-off of four foods [18]. Only one-quarter of the children achieved this cut-off. In another study done in Southern Ethiopia, in areas where maize and enset were not predominate but the complementary food was primarily grains and roots, the DDS was also only 3.1, with two-thirds not achieving the minimum of four foods per day [12]. Thus, low DDS is a common problem in Southern Ethiopia. The poor DDS of the study children is reflected in underweight (WAZ score) seen in 13.5 % and stunting (HAZ score) in 22.3 %. In Ethiopia, survey data show that 44 % of children are stunted, and that 29 % are underweight, with little difference by sex, but those in the rural areas are more at risk; and survey data show 10 % of Ethiopian children are wasted [9]. The study children had a prevalence of wasting that was only half that of the country as a whole. This low prevalence may be reflective of their adequate energy intake; however, energy was consumed as high carbohydrate maize and enset, with little protein content. Further, while maize provides energy, its calcium content is low and phytate high; this had the potential to contribute to poor calcium status. Dairy products would be an ideal food to emphasize for improving calcium intake and diet diversity.

From the questionnaire, it appeared that the participant children had good sunlight exposure. Based on this, it can be concluded that as majority of the children were exposed to sunlight, they may not be at risk of vitamin D deficiency in terms of sunlight exposure. A study of older children in Southern Ethiopia showed that rural children had better vitamin D status than urban children, the latter being indoors more of the time [3]. Thus, vitamin D deficiency is possible but for rural children it is less likely. Mothers in this study had positive attitudes and practices towards sun exposure for their children as well as for themselves.

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ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Limitations of the present study include use of a 24- hour recall dietary assessment method, which may not reflect usual intake and has social desirability and season of the year biases. The study was conducted at only one time point. Further, investigation of calcium intakes and sources for children in Ethiopia is needed.

In conclusion, the study investigated some of the major causes of nutritional rickets, for example calcium intake and potential for vitamin D deficiency caused by exposure to sunlight, in a group of very young children (6-24 months). Measurements included determining calcium intakes, investigation of factors affecting calcium availability, and questions to mothers regarding sun exposure practices. It was found that young children in Dale Woreda, Southern Ethiopia have risk of dietary calcium inadequacy because of low intakes, and the detrimental effect of phytate on prevailing foods in the locality such as fruit and maize based complementary food. However, regarding sunlight exposure, it was not possible to determine if the participant children were likely at risk of vitamin D inadequacy. There appeared to be good exposure practices and there was no sunlight avoidance practice for majority of participant children.

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Table 1: Sociodemographic and economic characteristics of study participants in Dale Woreda Ethiopia

Variables (n=170)		Frequency	Percent (%)
	Protestant	150	88.2
	Others	20	11.8
Ethnicity	Sidama	168	98.8
	Others	2	1.2
Maternal education	Illiterate	90	52.9
	Primary	67	39.4
	Secondary	11	6.5
	Read and/or write	2	1.2
Agro-ecology	Midland	121	71.2
	Highland	26	15.3
	Lowland	23	13.5
Farm ownership	Yes	149	87.6
	No	21	12.4
Livestock	Cow	102	60.0
	Goat	14	8.2
	Sheep	9	5.3
Milk sell/consume	Consume and sell	61	35.9
	Consume	41	24.1
	Don't have mature livestock or don't have livestock	68	40.0

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Table 2: Commonly used food types by participant children based on dietary assessment information Dale Woreda Ethiopia

Food type (n=170)	% of Children who consume	Calcium content of foods# mg/ 100 g edible portion
Avocado	87.6	13
Banana	82.3	8
Skimmed milk	52.9	123
Maize porridge	52.9	5
Enset	34.2	70.8
Corn unleavened bread	24.1	8.1
Potato boiled	13.5	9

#Source: Ethiopian food composition table [14]

Table 3: Daily calcium intake of participant children in Dale Woreda Ethiopia categorized by their age or sex group

Age group (months)	Calcium intake (mg) Mean ± SD	RNI	% low Ca intake
All (n = 170)	407 ± 235		
6-8 (n=13)	305 ± 223	336	46.2
9-11(n=32)	376 ± 221	353	43.8
12-23(n=125)	426 ± 238	196	20.0
Male (n=94)	403 ± 240	196-353	28.7
Female (n=76)	412 ± 230	196-353	23.7

RNI: Recommended Nutrient Intake [19]

Table 4: Analyzed calcium and phytate content of collected dry (powdered) samples food from Dale Woreda Ethiopia

Food types	Calcium mg/100gDW	Phytate mg/100gDW	Phytate: calcium mol:mol
Wheat porridge dry mix	52	117	0.14
Enset food dry mix	310	212	0.04
Mixed grain for porridge	100	74	0.05
Maize for porridge	24	189	0.47

DW: Dry Weight

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ISSN 1684 5374

Table 5: Sun light exposure practice by mothers of participant children in Dale Woreda Ethiopia

Variable (n=170)		Frequency	Percent
	Within 1 month	70	41
	In the 2nd month	51	30
	After the 2nd month	48	28.2
Frequency of sunlight exposure per week	1-3 days	46	27.1
	4-6 days	40	23.5
	7 days	84	49.4
Duration of exposure at each sitting	<20 minutes	67	39.4
	20-30 minutes	96	56.5
	>30 minutes	7	4.1
Exposure style	No cloth	153	90
	Fully clothed	10	5.9
	Diaper only	7	4.1
Child usually plays outside	Yes	158	92.9
	No	12	7.1
Duration child play outside (hours)	1-3 hours	150	88.2
	4-6 hours	15	8.8
	>6 hours	5	2.9
Local rickets treatment	Fenugreek	20	11.8
	Amesa*	12	7.1
	Do not know	138	81.2

*Amesa is a local name of a leaf that the local people boiled and used to treat rickets

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ISSN 1684 5374

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