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Dietary calcium intake by a group of 13 18-year-old Costa Rican teenagers

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SUMMARY. Calcium intake is one of the most important predictors of the amount of bone mass gained during growth. Therefore, this study was designed to estimate the dietary calcium intake of Costa Rican urban and rural adolescents ages 13-18 years old. Calcium dietary intake was determined using prospective 3-d diet records. Two-thirds (or 66.7%) or less of the Adequate Intake (AI) was used as the criterion for inadequate calcium intake as suggested by several authors. Reported mean daily calcium intake was 573 mg ± 290. On average 82% of the adolescents did not meet two-thirds of the AI for calcium. A higher percentage of rural than urban youngsters reported inadequate calcium intake (92% and 75% respectively, p=0.000). Likewise a higher percentage of girls (91%) than boys (77%) reported marginal calcium intake. This study shows evidence that nutritional interventions and educational strategies are urgent for increasing calcium consumption among adolescents in order to reduce the future burden of osteoporosis in old age.
Key Words: Calcium, dietary intake, adolescents, Costa Rica.

RESUMEN. Consumo de calcio dietético en un grupo de adolescentes costarricenses de 13-18 años. El consumo de calcio es uno de los predictores más importantes de la cantidad de masa ósea ganada durante la adolescencia. Por tal razón, este estudio se diseñó para estimar el consumo dietético de calcio entre adolescentes urbanos y rurales de 13-18 años. El consumo de calcio fue determinado usando el registro de alimentos de tres días. El consumo de 2/3 (66.7%) o menos de la recomendación actual de calcio fue utilizado como criterio para determinar un consumo inadecuado del mineral tal y como recomiendan diversos autores. El consumo promedio de calcio fue 573 mg ± 290. En general, 82% de los adolescentes no alcanzó los dos tercios de la recomendación de calcio. Un mayor porcentaje de jóvenes urbanos que rurales mostraron un inadecuado consumo de calcio (92% y 75% respectivamente, p= 0.000). Así mismo, en una proporción significativamente mayor de mujeres (91%) que de hombres (77%) se evidenció un consumo marginal de calcio. Este estudio evidencia la necesidad de implementar urgentemente intervenciones nutricionales y estrategias educativas para incrementar el consumo de calcio entre adolescentes, a fin de reducir el riesgo de osteoporosis en la edad adulta.
Palabras clave: Calcio, consumo dietético, adolescentes, Costa Rica.

INTRODUCTION

Adequate calcium intake during adolescence is important for optimal mineralization of the skeleton (1). Because maximum bone mass is acquired during puberty (1), the calcium deposited during these years may determine the risk of osteoporosis and fractures in adulthood (1-3). Epidemiological studies suggest that variations in calcium intake early in life may account for a 5-10% difference in peak adult bone mass (4). This difference may subsequently account for a 50% greater risk of hip fracture later in life (1).

Studies investigating current calcium intake and bone mineral density (BMD) among adult pre-menopausal women have inconsistent results (5,6), whereas calcium intake among children, adolescents and young women more clearly predicts their BMD (7-9). These findings indicate that calcium intake during the crucial years of peak bone mass development is essential.

It is therefore conceivable that one approach to a reduction in the risk of later osteoporosis may be the provision of adequate calcium intake during the formative years. Matkovick and Heaney have suggested that a certain threshold level of dietary calcium is necessary to allow growing adolescents to achieve their genetically pre-determined peak bone mass (1-3). The current Adequate Intake (AI) for calcium for 9- to 18-year-olds is 1,300mg/d (10). This intake corresponds reasonably well to the threshold identified for this age group by Matkovick and Heaney (3).

The purpose of this research was to estimate dietary calcium intake by Costa Rican urban and rural adolescents aged 13-18 years.

METHODS

Dietary calcium intake of 275 adolescents aged 13-18 years, from urban and rural areas around San José, Costa Rica, was evaluated. Adolescents were recruited from five urban and five rural public high schools. Written parental and adolescent consent was required to participate in the study, based on the rules provided by the Bioethics Committee of the Costa Rican Institute for Research and Education on Nutrition and Health (Inciensa).

Calcium dietary intake was determined using prospective 3-d diet records including two weekdays and one weekend day (11). A series of three to six photographs of foods commonly consumed in Costa Rica were used to estimate the portion size while maintaining the food record.

Food records were verified by trained nutritionists who reviewed them in detail with each youngster. Foods and three-dimensional food models were used to verify the size of some portions reported by the adolescents. The Food Processor® for Windows version 6.0 (Esha Research, Salem-Oregon) was used to perform nutrient calculations from dietary data. The nutrient information in the ESHA database is a compilation of the latest USDA data and of over a thousand additional scientific sources (12). The nutritive value of approximately 60 food preparations commonly consumed in Costa Rica was incorporated into this database. The School of Nutrition at the University of Costa Rica provided the information.

A comparison with the current Adequate Intake (AI) for calcium (10) was made to evaluate calcium intake. Two-thirds (or 66.7%) or less of the AI was used as the criterion for inadequate calcium intake as suggested by several authors (13). Because the consumption of nutrients is at least partially dependent on total energy intake and because the nutrient density of the diet in this instance is more relevant than actual gross intake, an adjustment for energy intake was made by computing nutrient intakes per 1,000 kcal.

Food groups were created to identify the dietary sources of calcium. The contribution of total dietary calcium for each food group was determined using the following formula: (total grams of dietary calcium from all foods in a group)÷(total grams of dietary calcium from all foods).

Data were examined with SPSS for Windows using a variance analysis to determine significant differences in calcium intake and energy-adjusted calcium intakes between urban and rural adolescents. A level of $p < 0.05$ was considered significant.

RESULTS

The sample consisted of 131 urban and 144 rural adolescents; 52% of whom were males and 48% of whom were females for each area. All adolescents were from the same ethnic background (mestizo-mixed indigenous and Caucasian races). The adolescents' mean age was 15 ± 1.6 years old with no difference between urban and rural areas.

Reported mean daily calcium intake was 571 mg ± 299. Mean daily calcium intake was higher in boys than in girls (619 mg ± 312 and 523 mg ± 287 respectively, p= 0.000). This difference was maintained after adjusting for total energy intake (263 mg ± 117 and 258 ± 109 per 1,000 Kcal respectively, p= 0.000) (Table 1).

TABLE 1
Characteristics of the study population

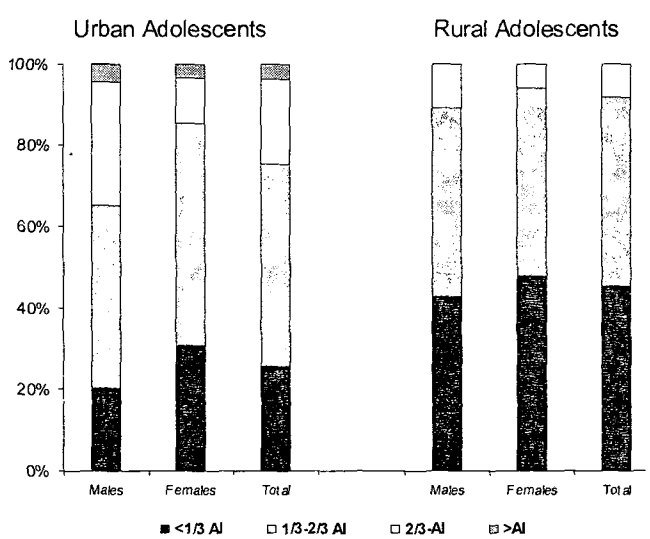
Variable	Urban Boys (n=68)	Urban Girls (n=62)	P value	Rural Boys (n=68)	Rural Girls (n=62)	P value	Total Boys (n=136)	Total Girls (n=124)	P value
Weight (kg)	58.7 ± 12	53.5±7	0.001	55.6±11	53.4±8	0.197	57.2 ± 11	53.2 ± 8	0.001
Height (cm)	165.4 ± 9	157,7± 6	0.000	163.6±8.9	156±5	0.000	164.9 ± 9	157 ± 6	0.000
Energy intake (kcal)	2439±227	2078±216	0.002	2318±278	1939±248	0.002	2378 ± 203	2008 ± 287	0.000
Protein intake (g)	78 ±15	63 ±12	0.000	66±11	57±13	0.009	72 ± 14	59 ± 13	0.000
Calcium intake (mg)	723 ± 336	578±302	0.011	516±347	467±361	0.285	619 ± 312	523 ± 287	0.000
Calcium intake/1000 kcal	303 ± 131	274 ±109	0.180	222±84	242±106	0.256	263 ± 117	258 ± 109	0.010
Calcium intake/ kg	13 ±8	11±6	0.093	9.4±5	8.7±5	0.449	11± 7	10 ± 5	0.081
Ratio calcium/Protein	9.3±3.5	9.3 ±3.7	0.955	7.9±3.0	8.5±3.2	0.280	8.6± 3	8.9 ± 3	0.510

Mean daily calcium intake was significantly higher in urban adolescents compared to rural youngsters (654 mg ± 327 and 492 mg ± 254 respectively, p= 0.000). This pattern was similar even when calcium intake was adjusted per 1,000 Kcal (289 mg ± 122 and 231 ± 96 respectively, p= 0.001) (Table 1).

The calcium/protein ratio was lower in rural youngsters than in urban adolescents (8.2 ± 3.1 and 9.3 ± 3.5 respectively, p= 0.005). A similar situation was found among rural males compared to urban boys (7.9 ± 3.0 and 9.3 ± 3.5 respectively, p=0.011). No significant differences were found between girls (on average the Ca/protein ratio was 8.9 ± 3.4) (Table 1).

Almost the entire adolescent sample fell below 1,300 mg of calcium per day (Figure 1). On average 82% of the adolescents did not meet two-thirds of the AI for calcium, which is equivalent to 867 mg per day. A higher percentage of rural than urban youngsters reported a calcium intake lower than 66.6% of the AI for this mineral (92% and 75% respectively, p=0.000). In addition, 25% of urban adolescents and 46% of rural youngsters did not even meet one-third of the AI (433 mg/d) of this mineral.

FIGURE 1
Percentage of urban and rural Costa Rican adolescents meeting the adequate intake (AI) for calcium

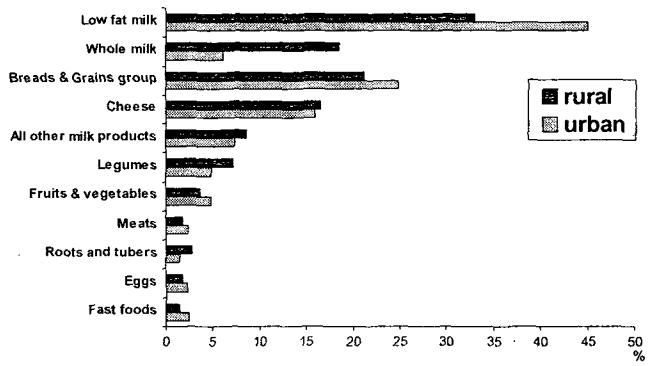


The prevalence of inadequate dietary calcium intake (<2/3 AI) among girls (91%) was significantly higher (p=0.000) than among boys (77%). Likewise, inadequate calcium intake among rural boys (89%) was significantly greater (p=0.000) than among urban boys (65%). There were no significant differences in girls.

Food sources of dietary calcium in the adolescents' diet are presented in Figure 2. Fluid milk was the main contributor of dietary calcium (39,5%). It contributed 45% of the calcium in the urban adolescents' diet and only 33% of the rural adolescents' diet. Low fat milk was the main contributor of calcium in urban areas whereas whole milk was the main contributor in rural areas. The bread and grains group was the second contributor of dietary calcium (23%). White bread was the major contributor for this group, contributing about 13% of this micronutrient. Tortillas contributed 4% of the calcium intake. Cheese was the third contributor (16%) of calcium. Other dairy products contributed 8% and together fruits and vegetables contributed 4.5% of the calcium intake. Legumes contributed 6% of dietary calcium intake. It contributed more in rural areas (6% and 3% respectively). Roots and tubers, meats, eggs and fast food together contributed 9.5% of the calcium intake.

On average the urban adolescents' intake was 2.1 servings per day of dairy products, while rural youngsters' intake was less than 1.5 servings per day.

FIGURE 2
Estimated main food sources of dietary calcium for urban and rural adolescents



DISCUSSION

In Costa Rica there are no data available about the prevalence of osteoporosis. However, data based on hospital patient releases suggests a high incidence of pathology associated with that disease. During 1998, 1,698 femur head fractures were reported, of which 50% occurred in women and 20% occurred in men older than 60 years of age (14). Although this cannot be ascribed solely to the presence of osteoporosis, it does suggest that prompt attention must be paid to the problem.

Several studies suggest that elevating the calcium intake of adolescents and young adults will almost certainly assure higher peak bone mass (1-3,7-9). Peak bone mass is important because, together with loss later on, it is one of the two principal factors in determining bone mass late in life and hence one of the factors determining resistance or susceptibility to fracture (1). Therefore, achieving optimal values for bone mass during growth should decrease the risk of osteoporotic fractures in later life (1-3). Unfortunately, this study provides evidence that the current calcium intake by Costa Rican adolescents is restricting their peak bone mass, mainly in females and rural youngsters.

The higher calcium consumption found in boys is consistent with others studies (15,16) and may be attributed to a greater caloric intake by adolescents boys. However, this study shows that girls had a lower calcium-dense diet. This is of considerable importance because it has been suggested that calcium intake among teen-age girls begins to decline at puberty and continues thereafter (17). Moreover, the ratio between calcium intake and optimum skeletal calcium retention is lowest for adolescent females, again suggesting that this age group may be especially prone to skeletal calcium deficiency (17).

The dietary calcium intake for the adolescents studied was far less than the current Adequate Intake (AI) for this mineral. However, this discrepancy does not necessarily mean that dietary intakes are generally inadequate because the relationship between the AI and the distribution of requirements for the nutrient is not known (10).

Estimated dietary calcium intake of Costa Rican youngsters was approximately 200-400 mg lower than similar estimates from recent surveys (4,15,16,18). In this regard, it is worrisome that a high proportion (35%) of adolescents reported a dietary calcium intake lower than 433 mg/d. Matkovic et al. (17), had shown that at very low intake (< 500 mg/d) by adolescents does not support positive calcium balance. Likewise, Chan et al. (19), have clearly documented that adolescents with a calcium intake as low as 450mg/d, did not show an increase in bone mass compared with adolescents that received approximately the RDA for calcium.

On the other hand, Peacock (20) has indicate that in adolescents with average intake below ~ 1,000 mg/d in males and ~ 800 mg/d in females, it is unlikely that optimal bone mass will be achieved. This is worrisome, because over 80% of Costa Rican adolescents reported a dietary calcium intake lower than 1,000 mg/d. Therefore, it is probable that a high proportion of teenagers are suffering an inadequate calcium retention and a reduction in peak bone mass.

A negative association between age and calcium intake has been reported previously (21,22). However, our results do not concur with those observations; probably as a reflection of the low calcium intake among adolescents at all ages.

Several factors have been identified as influencing dietary calcium intake among adolescents including lifestyle, dairy product perceptions, limited dietary knowledge, lactose intolerance, cultural beliefs about dairy products, enjoyment of dietary product tastes, and consumption of soft drinks (18,23,24). However these variables left much of the variance in calcium intake unexplained (18).

Purchasing power and availability are also strongly related to the calcium intake pattern (25). In Costa Rica, as in other developing countries, economic crises may have modified the adolescents' eating patterns. Average family income has decreased, restricting access by the general population to expensive foods, such as dairy products, mainly in rural areas (26). Therefore, the nutritional ecosystem in rural areas is characterized by a predominance of vegetable protein (26). Unfortunately a minimum of three servings of low-fat dairy products each day is certainly necessary for adolescents to reach the 1,300 mg/day AI for calcium (4).

Whole milk was the main contributor to calcium intake in rural areas; however whole milk is an important source of lauric (C12:0), miristic (C14:0) and palmitic (C16:0) acids (27). These fatty acids constitute approximately 40% of the fatty acids in milk fat and they are known to be the main cholesterol-raising dietary fatty acids (28).

Efforts to increase calcium consumption among adolescents, mainly females and rural youngsters, appears critical. Elevating the calcium intake of adolescents will almost certainly assure higher peak bone mass and, as a result, will reduce to some extent the future burden of fractures in old age (2). According to Heaney and Matkovic (1), this is the safest stratagem currently available to help us gain some control over osteoporosis: a growing public health problem. However, the promotion of skimmed milk and low-fat dairy products is needed in order to reduce the atherogenic potential of diet

Education is a primary means to increase dietary calcium intake among teens (18,24,29), however other alternatives may be necessary to increase calcium intake. Environmental strategies such as pricing and availability should be considered. Availability appears to have inconsistent effects on food choices (30,31); nevertheless, lower prices are consistently associated with higher consumption of targeted items (32,33).

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