



Nutritional status of children from Cochabamba, Bolivia: a cross-sectional study

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ABSTRACT

Objective. To assess the adequacy of energy and nutritional intakes compared to recommended daily intakes (RDIs) in schoolchildren from the Cochabamba region (Bolivia) and to determine micronutrient intake distributions across different ages and genders.

Methods. This nutritional study ($n = 315$) was part of a larger population-based cross-sectional study (the "Bolkid" survey) that collected data on schoolchildren 5–16 years old in 2010 in the Cochabamba region. Information about food intake was gathered with a semiquantitative, food-frequency, parent-administered questionnaire about 12 months before the study. Descriptive and bivariate analyses of energy and nutrient intakes were assessed.

Results. For all ages studied and both genders, the average energy and micronutrient intakes were acceptable but below the requirements. The diet included high amounts of fiber, some minerals (iron, magnesium, phosphorus, potassium, sodium), and vitamins (pantothenic acid, niacin, vitamins B2, B12, C, and E), but was low in calcium and vitamin D. However, more than half the children had insufficient energy intake, and low calcium, vitamin A, and vitamin D intakes, according to RDIs adjusted for age and gender; one-third of the children had insufficient folate and magnesium intakes; and adolescent girls had low iron intakes.

Conclusions. Regardless of recommendations or demographic characteristics, the vast majority of children in Cochabamba consumed insufficient energy and too little calcium, folate, magnesium, and vitamin A and D. In addition, adolescent girls consumed insufficient iron. Higher energy intake for schoolchildren through increased food availability, frequency, and size portions in daily meals should be a priority for Bolivian public health institutions.

Key words

Child nutrition; adolescent nutrition; nutritional requirements; nutrition surveys; Bolivia.

The Plurinational State of Bolivia is currently undergoing a nutritional transition. Cochabamba has experienced

economic improvements and high levels of emigration to Europe over the past decade (1) and is thus most likely one of the most affected regions. The children and adolescents in Cochabamba have shown a dramatic increase in excess body weight and obesity.

Since the late 1990s, public health agencies in Latin America and the Caribbean have attempted to conduct nutritional

surveillance by collecting household data on the availability of food and beverages within the framework of the Program for the Improvement of Surveys and the Measurement of Living Conditions (MECOVI program) (2). In Bolivia, four annual countrywide household surveys were conducted from 1999 to 2002. The results showed disparities in food availability among distinct geographic

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regions, between rural and urban residency areas, and among populations with different socioeconomic statuses (2).

In addition, the latest national Demographic and Health Survey (DHS or MEASURE DHS) (3), which was carried out in 2008, showed that in Cochabamba children under 5 years old had relatively high rates of chronic malnutrition (30.5%), anemia (51.4%), and vitamin A deficiency (19%), even with vitamin A and iron supplementation (3).

These findings suggested that the MECOVI and DHS programs in Bolivia could be useful for nutritional policy-making (2); however, to date, regional and pediatric population-representative dietary data have not been described with pragmatic studies. Diet in adults differs little from that of children, so it is important to determine the diet in childhood to predict the diet composition in adulthood. Currently, only small studies on isolated populations (4) from Amazonian departments have focused on dietary patterns or trends in surveys of household food and nutrient availability (2).

As Cochabamba has become one of the main breadbaskets of Bolivia (4), household food scarcity is expected to be low (5). Because there is little need to import daily food products, food is affordable for households of any socioeconomic level.

This study aimed to 1) assess the adequacy of energy and nutritional intakes compared to recommended daily intakes (RDIs) in schoolchildren from the Cochabamba region and 2) determine micronutrient intake distributions across different ages and genders.

MATERIALS AND METHODS

Study design

This nutritional study was part of a larger population-based cross-sectional study (the “Bolkid” survey) that collected data on schoolchildren 5–16 years old in 2010 in the Cochabamba region (6). The sample population for the Bolkid survey was derived from public and private school registers obtained in the Bolivian Education Ministry official census. The sampling technique for the nutritional sub-study included 1) stratification, by population size of municipality and type of school (public or private), and 2) probabilistic sampling, according

to the size of the child population in each city in the Cochabamba region (i.e., randomly selecting participants from the Bolkid survey primary sampling units (schools) and the final sample units (schoolchildren)). Therefore, the data obtained were representative of school-aged children and adolescents randomly selected from 14 schools in five municipalities of the Cochabamba region, according to population proportion.

Sample size estimation for the nutritional sub-study could not be performed because, to the best of the authors’ knowledge, the study was the first to determine the status and adequacy of nutritional intake in Cochabamba in children 5–16 years old. Therefore, the study population was selected using a convenience sample from the Bolkid survey, which derived its sample estimations based on different objectives (6, 7).

The age groups that were studied included were children (5.1–10.0 years old), preadolescents (10.1–13.0 years old), and adolescents (13.1–16.0 years old).

Participation was voluntary, with no financial incentive. Ethical issues and sampling procedures are described in previous studies (6, 7).

Questionnaire

The Bolkid survey consisted of serologies (6, 7), a physical examination based on anthropometric measures (8), and a questionnaire. The questionnaire collected dietary information through an expanded semiquantitative food-frequency questionnaire (SFFQ; see [Supplementary Material](#)) that had been adapted to local available food and nomenclature and validated by the authors in previous studies (9). The SFFQ was chosen because 1) it provides valid information for children in the studied age group (10, 11); 2) it is suitable for large-scale cross-sectional studies (10) intended to capture habitual dietary intake over long periods of time; and 3) its data collection can be completed in a relatively short time frame (11). In addition, SFFQs have a relatively low respondent and analytic burden (12) and can be completed by different types of respondents, including the study participant (“self”), his/her proxy, or an interview administrator. Household measures were used to quantify portion sizes (e.g., one glass, one teaspoon) and food items (one piece of bread) to facilitate reporting of the quantity of food consumed. The

authors did not include photographs (13, 14), which would have increased the overall cost of the study. A final group of probing questions was carried out to capture any forgotten items, particularly drinks and snacks.

For seasonal foods, the questionnaire collected information on 1) the period of consumption (e.g., during one season only or across different seasons) and 2) when the foods were available in the market over a one-year period. As each study participant was only surveyed once, individual variability in reporting nutrient intake could not be calculated (15).

Most questionnaires were completed in the home, by study participants’ mothers, regardless of the study participants’ age (16, 17), as mothers were most often responsible for food provision within the family environment (18). Interview questions covered the frequency and quantity of consumption of 141 food items over the past year. In some cases, other adults (father or grandparents) acted as proxy (17) and responded instead of, or in consensus with, the mother. All proxy respondents (parents or guardians) were trained in data collection prior to the survey. When the parents or guardians were unable to read or understand the survey (< 5% of the sample), the questionnaires were completed at a school, where those responding received guidance, in their own language, from technical assistants.

For each food item, nutrients were calculated by multiplying the daily frequency of consumption by the portion size and the amount of nutrients contained in 100 g. Caloric and nutrient content of the food items, and the RDIs, were derived from various health experts (19–21). RDIs were defined as the daily intake level considered sufficient to meet the requirements of 97%–98% of healthy individuals in a given country (21). The estimated rates of insufficient nutritional and energy intakes were expressed in two parameters: the percentage of population with intakes below the RDIs, and the percentage of population with intakes below two-thirds of the RDIs (22).

Statistics

A descriptive analysis was performed to evaluate the socio-demographic data (age and gender) and the dietary intake data. Quantitative variables with a normal distribution (Kolmogorov–Smirnov test;

$P > 0.05$) were expressed as means and standard deviations (SDs), central and dispersion measures, and percentages.

Dietary analysis results were expressed as the absolute intake (g, mg, etc.) or as the percentage of the population with intakes below the RDIs or below two-thirds of the RDIs.

Qualitative comparisons were performed with the chi-square test, Fisher's test, or a trend test, when required. For continuous variables, means were compared by gender or age distribution using the Kruskal-Wallis or Mann-Whitney U-test.

In all cases, a P value < 0.05 was considered statistically significant. Statistical analysis was performed with the statistical package SPSS 17.0 for Windows (2011) (SPSS Inc., Chicago, Illinois, United States).

Ethics approval

Ethics approval was provided by 1) the institutional review boards from the Universitat de Barcelona and the Universidad Mayor de San Simón; 2) the Bolivian Education and Health and Sport ministries; and 3) the school directors of the schools participating in the survey. Informed consent from

participants, which was mandatory, was obtained from study participants' parents due to the age of the sample group. To guarantee the anonymity of the data, each participant was assigned a random identification number, and no personal identification data were collected.

RESULTS

Of the 441 children and adolescents participating in the Bolkid survey, 315 participated in the nutritional sub-study (71.4%). Reasons for nonparticipation in the sub-study included absence from school ($n = 10$) and incomplete dietary questionnaire ($n = 101$). Fifteen questionnaires had outlier data (any data point more than 1.5 interquartile ranges (IQRs) below the first quartile or above the third quartile) and discarded from the analyses. The ages and sex of children with completed questionnaires had distributions similar to those found in the overall Cochabamba population (1). Table 1 shows the energy, macronutrient, and micronutrient intakes of children in the study, by sex.

The average energy intake (Table 1) was 2 377.9Kcal (SD 1 124.3), and the energy contributions of carbohydrates,

proteins, and lipids were 54%, 18%, and 28.0% respectively. According to the RDIs for Bolivian children, the average micronutrient intake was high in iron, fiber, magnesium, phosphorus, niacin, potassium, vitamin B2, sodium, pantothenic acid, vitamin B12, vitamin C, and vitamin E, but low in calcium and vitamin D. As there were no statistical differences by sex in energy and nutrient intake, adequacy of energy and nutritional intakes is reported by sex as well as age.

Table 2 shows the energy, macronutrient, and micronutrient intakes of children in the study, by age. Results were very similar to those shown in Table 1, as there were no statistical differences between age groups in energy or nutrient intake. However, more than half of both males and females had energy intakes below the energy RDIs, and approximately one-fifth had energy intakes below two-thirds of the RDIs. This deficiency increased with age ($P < 0.05$).

At least 80% of all male children had calcium, vitamin A, and vitamin D intakes below the RDIs, and at least 65% had intakes below two-thirds of the RDIs (Table 3). About 30%–40% of male children had magnesium and folate intakes below the RDIs, and 10% had vitamin B1

TABLE 1. Energy, macronutrient, and major micronutrient intakes in schoolchildren ($n = 315$), Cochabamba, Bolivia, 2010

Intake	Male ($n = 135$)		Female ($n = 180$)		Total ($n = 315$)		P^a
	Mean	SD	Mean	SD	Mean	SD	
Energy (Kcal)	2 401.8	1 110.7	2 360.0	1 137.1	2 377.9	1 124.3	0.744
Macronutrient							
Carbohydrate (g)	324.5	163.2	317.2	165.0	320.3	164.0	0.696
Protein (g)	110.8	50.9	107.0	50.1	108.6	50.4	0.506
Lipid (g)	73.4	36.7	73.7	37.9	73.6	37.3	0.943
Micronutrient							
Calcium (mg)	706.6	412.7	733.5	435.7	721.9	425.5	0.579
Cholesterol (mg)	306.4	186.0	310.8	196.9	308.9	192.0	0.838
Iron (mg)	22.9	12.8	22.7	13.2	22.8	13.0	0.889
Fiber (g)	30.4	16.1	30.3	17.4	30.3	16.8	0.955
Folate (mg)	405.6	208.6	405.2	230.1	405.3	220.8	0.987
Phosphorus (mg)	1 616.1	773.3	1 583.2	773.6	1 597.3	772.4	0.709
Magnesium (mg)	399.4	196.9	390.6	206.2	394.4	202.0	0.701
Niacin (mg)	31.6	15.4	31.3	16.4	31.4	16.0	0.903
Pantothenic acid (mg)	7.1	4.6	7.5	4.7	7.4	4.6	0.457
Potassium (mg)	4 223.7	2 354.8	4 124.2	2 260.3	4 167.2	2 298.5	0.770
Retinol (μ g)	500.9	773.2	450.6	717.8	472.3	741.4	0.738
Sodium (mg)	2 282.7	1 444.2	2 277.2	1 475.2	2 279.6	1 459.7	0.880
Vitamin B1 (mg)	2.1	1.4	2.1	1.4	2.1	1.4	0.845
Vitamin B2 (mg)	2.3	1.5	2.3	1.5	2.3	1.5	0.980
Vitamin B12 (μ g)	9.2	13.5	8.6	11.7	8.9	12.5	0.731
Vitamin B6 (mg)	2.9	1.7	2.8	1.7	2.8	1.7	0.700
Vitamin C (mg)	168.9	118.5	175.9	121.2	172.9	119.9	0.507
Vitamin D (mg)	1.7	1.7	1.6	1.5	1.7	1.6	0.681
Vitamin E (mg)	36.3	51.2	34.7	45.2	35.4	47.8	0.724

Source: prepared by the authors based on the study results.

^a P value obtained using the Mann-Whitney U test.

TABLE 2. Energy, macronutrient, and major micronutrient intakes in schoolchildren in various age groups (n = 315), Cochabamba, Bolivia, 2010

Intake	Age 5.1–10.0 years (n = 66)		Age 10.1–13.0 years (n = 148)		Age 13.1–16.0 years (n = 101)		P ^a
	Mean	SD	Mean	SD	Mean	SD	
Energy (Kcal)	2 325.4	1 159.5	2 454.8	1 175.0	2 280.2	1 007.2	0.458
Macronutrient							
Carbohydrate (g)	314	168.6	331.9	170.3	304.3	149.5	0.420
Protein (g)	104.3	50.9	111.5	52.4	106.3	46.7	0.558
Lipid (g)	72.3	37.6	75.7	38.6	70.9	35.1	0.590
Micronutrient							
Calcium (mg)	721.5	491.6	735.1	419.8	701.1	392.0	0.832
Cholesterol (mg)	292.0	217.7	306.6	182.0	326.1	192.6	0.547
Iron (mg)	22.6	13.7	23.6	13.6	21.6	11.4	0.495
Fiber (g)	30.4	18.9	31.3	17.1	28.5	14.9	0.437
Folate (mg)	403.1	233.8	412.3	224.3	393.2	207.9	0.803
Phosphorus (mg)	1 553.1	791.7	1 651.5	810.1	1 531.8	689.9	0.441
Magnesium (mg)	386.8	214.6	407.0	208.7	376.4	181.5	0.489
Niacin (mg)	30.2	15.7	32.0	16.5	31.2	15.4	0.754
Pantothenic acid (mg)	7.1	5.0	7.5	4.5	7.2	4.7	0.798
Potassium (mg)	4 121.8	2 317.8	4 302.5	2 160.1	4 006.9	1 850.1	0.549
Retinol (µg)	457.7	711.9	468.6	718.0	429.4	658.6	0.913
Sodium (mg)	2 171.6	1 385.7	2 321.9	1 298.7	2 231.2	1 320.1	0.717
Vitamin B1 (mg)	2.1	1.2	2.2	1.2	2.1	1.1	0.830
Vitamin B2 (mg)	2.2	1.3	2.3	1.3	2.2	1.2	0.864
Vitamin B12 (µg)	8.4	9.7	9.7	13.0	7.5	8.7	0.339
Vitamin B6 (mg)	2.7	1.5	2.9	1.5	2.7	1.4	0.770
Vitamin C (mg)	176.2	130.3	178.1	110.4	162.1	99.5	0.534
Vitamin D (mg)	1.6	1.6	1.6	1.4	1.7	1.3	0.985
Vitamin E (mg)	31.0	39.3	36.2	50.7	35.6	43.1	0.749

Source: prepared by the authors based on the study results.

^a P value obtained by Kruskal-Wallis test.

intakes below two-thirds of the RDIs. Again, these deficiencies increased with age.

Similarly, at least 80% of female children had calcium, vitamin A, and vitamin D intakes below the RDIs and at least 65% had intakes below two-thirds of the RDIs in all age groups (Table 4). Only the vitamin A deficiency appeared to increase with age. About 40% of all female children had magnesium, folate, and iron intakes below the RDIs; 20%–30% of all females had vitamin B2, B6, and E intakes below the RDIs. The iron insufficiency showed some tendency to increase with age, but this was not statistically significant ($P = 0.090$).

DISCUSSION

To the best of the authors' knowledge, this was the first nutritional survey conducted in Andean children to assess nutritional adequacy compared to energy and micronutrient RDIs by age and gender.

An adequate intake of iron, vitamin C, B1, B2, B3, B6, and B12 were detected independent of age and gender. These results were consistent with a recently

published systematic review of the nutritional adequacy of the diet in the Central Andes across Bolivia, Ecuador, Colombia, and Peru (23). Taken together the data suggest the risk of developing glossitis, anorexia, sprue, bone fragility, gastrointestinal problems, or various nervous system or skin disorders could significantly decrease in a short period of time (17, 21). These appropriate levels of nutritional intake should be encouraged to improve the quality of life of subsequent Bolivian generations. On the other hand, nutritional intakes that are inadequate, according to the RDIs, do not necessarily indicate the need for a vitamin supplement. While vitamin supplementation can mitigate the problem in the short term, it is not an efficient solution in the long term; the inadequate nutritional levels will eventually reemerge because the source of the problem—lower frequency of food intake or low portion size—has not been addressed. The most effective public health interventions to improve nutrition in the long term are those that focus on changing food frequency, eating habits, and the size of daily portions. Increasing schoolchildren's food frequency through

nutrition education programs would improve their quality of life in the long term and possibly throughout their lives.

SFFQs have been criticized for generating overestimations of intake (24) and using limited food lists and inaccurate portion sizes, and because they do not account for dietary recall bias (24). SFFQs are often designed to rank intakes and identify food patterns associated with inadequate intakes of specific nutrients in large-scale prospective studies, but they do not produce reliable estimates of absolute or mean intakes (25). However, SFFQs are the most common health survey tools for screening for possible diet-disease associations, and can be used as a short-term quantitative measure of consumption, even with a limited sample size (25). The reliable and validated Bolivian SFFQ developed in 2004 for adolescents in La Paz (26) was not chosen because the age range of the target population for this study (5–16 years old) was wider than that of the original study, and the climate was more variable (mean temperatures, 7–24°C). The difference in climate suggested that the types of food available in the Cochabamba region were likely to be different from those

TABLE 3. Percentages of male children (n = 135) with nutrient intakes below recommended daily intakes (RDIs), Cochabamba, Bolivia, 2010

Intake	Lack of adequacy group	Age	Age	Age	Total (n = 135)	P ^a
		5.1–10.0 years (n = 34)	10.1–13.0 years (n = 63)	13.1–16.0 years (n = 38)		
Energy (Kcal)	< 2/3 RDI	17.6	20.6	42.1	25.9	0.016
	< RDI	44.1	58.7	76.3	60.0	0.005
Macronutrient Protein	< 2/3 RDI	2.9	1.6	5.3	3.0	0.541
	< RDI	14.7	3.2	13.2	8.9	0.883
Micronutrient Calcium	< 2/3 RDI	50.0	69.8	81.6	68.1	0.004
	< RDI	61.8	87.3	94.7	83.0	0.001
Iron	< 2/3 RDI	8.8	6.3	.0	5.6	0.149
	< RDI	20.6	14.3	28.9	20.0	0.347
Magnesium	< 2/3 RDI	17.6	19.0	26.3	20.7	0.358
	< RDI	35.3	36.5	60.5	43.0	0.028
Folate	< 2/3 RDI	2.9	14.3	34.2	17.0	< 0.001
	< RDI	5.9	28.6	63.2	32.6	< 0.001
Niacin	< 2/3 RDI	8.8	1.6	13.2	6.7	0.414
	< RDI	17.6	12.7	15.8	14.8	0.845
Vitamin A	< 2/3 RDI	58.8	81.0	86.8	77.0	0.006
	< RDI	64.7	90.5	86.8	83.0	0.016
Vitamin B1	< 2/3 RDI	5.9	6.3	18.4	9.6	0.066
	< RDI	11.8	12.7	18.4	14.1	0.410
Vitamin B12	< 2/3 RDI	14.7	1.6	5.3	5.9	0.107
	< RDI	20.6	9.5	7.9	11.9	0.104
Vitamin B2	< 2/3 RDI	11.8	7.9	10.5	9.6	0.878
	< RDI	26.5	27.0	34.2	28.9	0.461
Vitamin B6	< 2/3 RDI	11.8	4.8	13.2	8.9	0.790
	< RDI	20.6	15.9	34.2	22.2	0.149
Vitamin C	< 2/3 RDI	5.9	6.3	7.9	6.7	0.730
	< RDI	14.7	11.1	10.5	11.9	0.592
Vitamin D	< 2/3 RDI	88.2	90.5	94.7	91.1	0.331
	< RDI	91.2	96.8	100.0	96.3	0.050
Vitamin E	< 2/3 RDI	5.9	6.3	10.5	7.4	0.445
	< RDI	14.7	23.8	28.9	23.0	0.156

Source: prepared by the authors based on the study results.

^a P value obtained using the linear trend test.

available in La Paz. Data from the Acha-cachi province, approximately 100 km from La Paz, showed that 70% of the surveyed households had moderate or severe food insecurity (5). Nothing is known about household food insecurity in Cochabamba, but it was assumed to be much lower than in other areas due to the regional geography and food production characteristics. The low level of food insecurity might explain why the relative contributions of carbohydrates, proteins, and lipids to energy intake (Potosí: 80%, 12%, and 7% respectively (27); La Paz 65%, 14.4%, and 20.6% respectively) were consistent with recommendations but not with previous data published in children from other Bolivian areas (28).

RDIs express the overall nutritional requirements of a healthy population. This study population did not present any

chronic disease or comorbidity, and the majority presented normal body weight (75.9%; 95% confidence interval (CI): 71.9–79.9) (8). Nevertheless, it should be a cause for concern that more than 80% of the children studied had insufficient intakes of energy and of some micronutrients. These data are consistent with data published in 2008 that indicated the degree of chronic malnutrition detected in the Cochabamba region in children under 5 years old (30.5%) (29). No previous data on nutritional insufficiency have been described in Bolivian youth for comparison.

Nutritional intake below the RDI indicates a deficiency; therefore, this population is at risk of developing clinical and functional outcomes that may be irreversible and permanent. In the study, a high to moderate prevalence of deficiencies in vitamin D, A, E, calcium, and

folate was found. Vitamin A, E, and folate inadequacies in 80% of the studied population could be partly due to a poor-quality diet (30). These results might be generalized to all children 5–16 years old from Andean countries, and more studies should be performed.

The most probable consequence of these insufficiencies could be the development of adult anemia. Mild to moderate anemia is estimated to be present in 25.9% and 23.2% of adults, respectively, in Cochabamba (3). On the other hand, the study results indicated some paradoxes, such as insufficient intake for age and growth while 24.1% of the overall studied population presented overweight or obesity. A problem with nutrition in the region is observed, and its origins must be studied in depth.

There is a strong interrelationship and reliance between calcium and vitamin D.

TABLE 4. Percentages of female children (n = 180) with nutrient intakes below recommended daily intakes (RDIs), Cochabamba, Bolivia, 2010

Intake	Lack of adequacy group	Age	Age	Age	Total (n = 180)	P ^a
		5.1–10.0 years (n = 32)	10.1–13.0 years (n = 85)	13.1–16.0 years (n = 63)		
Energy (Kcal)	< 2/3 RDI	29.6	22.0	24.5	23.9	0.746
	< RDI	40.7	55.0	64.2	55.6	0.049
Macronutrient Protein	< 2/3 RDI	7.4	0.0	1.9	1.7	0.201
	< RDI	14.8	5.0	9.4	7.8	0.663
Micronutrient Calcium	< 2/3 RDI	48.1	68.0	69.8	65.6	0.095
	< RDI	70.4	90.0	88.7	86.7	0.066
Iron	< 2/3 RDI	11.1	16.0	0.0	12.1	0.173
	< RDI	18.5	46.0	43.4	41.1	0.090
Magnesium	< 2/3 RDI	29.6	18.0	20.8	20.6	0.508
	< RDI	29.6	40.0	43.4	39.4	0.268
Folate	< 2/3 RDI	3.7	19.0	26.4	18.9	0.018
	< RDI	7.4	39.0	54.7	38.9	< 0.001
Niacin	< 2/3 RDI	7.4	5.0	9.4	6.7	0.562
	< RDI	18.5	14.0	20.8	16.7	0.610
Vitamin A	< 2/3 RDI	59.3	75.0	81.1	74.4	0.045
	< RDI	74.1	83.0	86.8	82.8	0.176
Vitamin B1	< 2/3 RDI	3.7	2.0	5.7	3.3	0.471
	< RDI	22.2	11.0	22.6	16.1	0.574
Vitamin B12	< 2/3 RDI	11.1	10.0	3.8	8.3	0.191
	< RDI	18.5	20.0	13.2	17.8	0.433
Vitamin B2	< 2/3 RDI	14.8	10.0	15.1	12.2	0.774
	< RDI	25.9	32.0	26.4	29.4	0.870
Vitamin B6	< 2/3 RDI	7.4	9.0	13.2	10.0	0.361
	< RDI	25.9	23.0	37.7	27.8	0.141
Vitamin C	< 2/3 RDI	3.7	6.0	5.7	5.6	0.782
	< RDI	22.2	9.0	11.3	11.7	0.281
Vitamin D	< 2/3 RDI	88.9	91.0	86.8	89.4	0.641
	< RDI	96.3	97.0	94.3	96.1	0.559
Vitamin E	< 2/3 RDI	7.4	9.0	15.1	10.6	0.226
	< RDI	14.8	20.0	20.8	19.4	0.575

Source: prepared by the authors based on the study results.

^a P value obtained using the linear trend test.

Therefore, a deficiency in either calcium or vitamin D can lead to potential skeletal outcomes, providing a strong justification for studies measuring intakes versus the RDIs. However, there is currently no compelling evidence that either nutrient benefits or is causally related to extraskeletal health outcomes. For example, several studies have investigated effects of calcium or vitamin D in type 2 diabetes (31), immune-mediated diseases (32), bacterial and viral infections (33), cancer (34, 35), neuropsychological impairments (36), language difficulties (37), cardiovascular disease (38), infertility (39), and all-cause mortality (40).

It cannot be ascertained that a vitamin D insufficiency exists based only on inadequate dietary intake because vitamin status can also be affected by fortification, supplementation, and ultraviolet B exposure (UVB) (41). To the best of the

authors' knowledge, fortified foods and supplemental vitamin D intakes are not traditionally implemented in Bolivia. The level of UVB exposure depends on latitude, elevation, clouds, and pollution (41). However, there is no consensus on the effect of latitude on vitamin D synthesis (41). Therefore, before recommending an increase in sun exposure to Bolivian youth, it should be determined whether there is a vitamin D deficiency and how much sun exposure is required to obtain an effective dose of vitamin D (40, 42).

In addition, inadequacy of a specific nutrient may not be exclusively due to low nutrient intake but also depends on the nutrient composition of each food, which can hinder nutrient absorption or bioavailability; the size of the food portion; and the frequency of consumption. To improve the quality of life of children from the Cochabamba region, first steps

should include increasing energy intake and the frequency of some foods. These changes would most likely mitigate some of the inadequate nutrient intakes. Later steps should focus on increasing the frequency of other foods, according to their composition in nutrients, to improve nutrient bioavailability and impact.

Since 1984, when Bolivia had the highest national prevalence of goiter in the world (65%), the Bolivian government has implemented various nutritional policies to fortify staples and condiments (e.g., iodized salt, sugar with vitamin A, and flour with folate and iron). In addition, vitamin A and iron supplements were provided for Bolivian children 6–59 months old (3). In 2008, 22.3% of children in Cochabamba received vitamin A supplements and 43.3% received iron supplements (3); no data on children that received the

supplements were available for this study, however, and no participants in this study presented with goiter, consistent with regional data from 2008 that showed 92.8% utilization of iodized salt (3).

Limitations

This study had several limitations. First, it was designed as a population-based nutritional study, with information reported by mothers, but there was a high nonparticipation rate (28.6%). Therefore, the results might not be representative of school-age children that attended school from Cochabamba region. However, nonparticipant children were not significantly different from participant children in age, gender, or municipality, reducing this potential risk of bias. A second important source of bias in this study was the level of error in obtaining accurate information due to recall bias, which may have led to a misclassification of subjects in each category (43) and thus produced a non-differential information bias. On the other hand, given the survey methodology, some under- or overestimations of nutrient intakes were assumed. The risk of under- or overestimations was minimized by the use of an anthropological approach in which 1) all regional foods were included, 2) household measurements were used as portion sizes, and 3) maternal reports of their children's diet were encouraged.

Typically, estimation of micronutrient intake with a semiquantitative questionnaire is high correlated with biochemical results (35). Nevertheless, to ascertain that some deficiencies were present in this population, a biochemical study that could confirm functional alterations should be performed. In addition, checking for the appearance of any irreversible or permanent consequences of insufficient childhood nutritional intake that might have affected cognition; physical development (stunting, wasting); or immunology could have been done.

Conclusions

There were substantial inadequacies in some nutritional intakes among Cochabamba schoolchildren, primarily in total energy, calcium, folate, magnesium, vitamin A, and vitamin D. In addition, iron intake was insufficient in adolescent girls, who tend to require higher iron compared to other children. The nutritional composition of adult diets differed little from that of children. Therefore, there is a potential for persistence of these nutritional inadequacies into adult life, which could contribute to a high prevalence of chronic disease in subsequent generations. The clinical implications of energy and micronutrient insufficiencies during childhood merit further study. The continuation of iron and vitamin A supplementation

beyond 5 years of age should be considered.

In summary, this study found persistent, systematic, low intake levels of total energy, calcium, and vitamin D, and adequate intake of iron, vitamin C, B1, B2, B3, B6, and B12 in children from Cochabamba, Bolivia, independent of age and gender. Boosting the energy intake in schoolchildren by increasing food availability, frequency, and the portion size in daily meals should be a priority for Bolivian public health institutions.

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Estado nutricional de los niños de Cochabamba, Bolivia: un estudio transversal

RESUMEN

Objetivo. Evaluar la idoneidad del consumo energético y de nutrientes en escolares de la región de Cochabamba, Bolivia, por comparación con las cantidades diarias recomendadas (CDR), y determinar la distribución de la ingesta de micronutrientes en distintas edades y ambos sexos.

Métodos. Este estudio nutricional (n = 315) formó parte de un estudio transversal poblacional más amplio (la llamada encuesta Bolkid) en que se obtuvieron datos de escolares de 5 a 16 años de edad en la región de Cochabamba en el 2010. Se usó un cuestionario semicuantitativo, administrado por los padres, para obtener información acerca de la frecuencia del consumo de alimentos alrededor de 12 meses antes del estudio. Se evaluaron los resultados de análisis descriptivos y bivariados de la ingesta energética y de nutrientes.

Resultados. En todas las edades estudiadas y ambos sexos, las ingestas energética y de micronutrientes fueron aceptables pero inferiores a las cantidades necesarias. La alimentación tenía un alto contenido de fibra, de algunos minerales (hierro, magnesio, fósforo, potasio, sodio) y de vitaminas (ácido pantoténico, niacina, vitaminas B2, B12, C y E), pero poco contenido de calcio y vitamina D. No obstante, más de la mitad de los niños tenían una ingesta energética insuficiente e ingestas demasiado bajas de calcio, vitamina A y vitamina D, según las CDR ajustadas por edad y sexo; una tercera parte consumían cantidades insuficientes de folato y magnesio; y las adolescentes tenían ingestas de hierro demasiado bajas.

Conclusiones. Independientemente de las cantidades recomendadas o de las características demográficas, la gran mayoría de los niños en Cochabamba tenían un consumo energético insuficiente e ingestas demasiado bajas de calcio, folato, magnesio y vitaminas A y D. Además, las adolescentes consumían cantidades insuficientes de hierro. Las instituciones de salud pública bolivianas deberían dar prioridad a aumentar el consumo energético de los escolares propiciando una mayor disponibilidad de alimentos, un consumo más frecuente y porciones más grandes en las comidas diarias.

Palabras clave

Nutrición del niño; nutrición del adolescente; necesidades nutricionales; encuestas nutricionales; Bolivia.