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Dietary Calcium and Overweight in Preschoolers: Is There an Association?

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Abstract

Background: Several observational and experimental studies in humans and animals have noted an inverse relationship between calcium intake, particularly dairy products, and body weight and adiposity. However, these effects have not been consistently observed. **Objective:** To evaluate the relationship between calcium intake and anthropometric measures and adiposity in preschoolers. **Methods**: Cross-sectional study nested in a cohort born of 232 preschoolers from Diamantina, Minas Gerais, Brazil. The preschoolers underwent anthropometric (body mass index and waist circumference), adiposity (triceps and subscapular skinfold) and dietary (three 24-hour dietary recalls) evaluations. The association between calcium intake, adiposity and anthropometric measurements was performed using a logistic regression analysis. **Results:** The prevalence of overweight (overweight and obesity) among preschoolers was 17.24%. The average calcium intake was 480.51 mg/day. Only 7.7% of children reached their daily recommended intake value (800 mg/day), and calcium intake was equally low for both groups studied ($p = 0.74$). This study did not find a relationship between calcium intake and overweight or adiposity. **Conclusions**: Calcium intake was far below the recommendations for the age group studied, and no was identified association between low calcium intake and overweight or adiposity.

Keywords

Calcium Intake, Overweight, Obesity, Preschoolers, Adiposity

1. Background

Overweight and obesity are defined, simply, as abnormal or excessive fat accumulation the may impair health [1]. The prevalence of these problems has increased markedly in recent years in Brazil [2] and worldwide [1]. According to the World Health Organization (WHO), in 2011, more than 40 million children under the age of five were overweight. Once considered a high-income country problem, overweight and obesity are now on the rise in low- and middle-income countries, particularly in urban settings. More than 30 million overweight children are living in developing countries and 10 million in developed countries [1].

In Brazil, research shows that the prevalence of overweight has increased among children in pre-school and school. According to the Household Budget Survey (HBS), conducted between 2008 and 2009, one in three children 5 - 9 years old present as overweight [2]. Onis *et al.* [3] indicate that 43 million children, 35 million in developing countries and 8 million in developed countries, were overweight or obese. The worldwide prevalence increased from 4.2% in 1990 to 6.7% in 2010 and is forecast to reach 9.1%, or 60 million children, in 2020.

Being overweight is considered a risk factor for a range of chronic diseases, including diabetes, cardiovascular disease and certain forms of cancer. In addition, childhood obesity is associated with a greater likelihood of adult obesity, premature death and disability in adulthood [2].

Whereas a diet can be a risk factor or protective factor for overweight, several researchers have studied the dietary components that affect these diseases. The calcium effect has been widely studied in children and adolescents [4]-[13]. Some studies have demonstrated that calcium intake can affect the weight and/or body fat deposition, thereby playing a role in the regulation of energy metabolism and on obesity risk [4] [5] [6].

One of the mechanisms involved in this process is that calcium appears to binds to fatty acids in the colon. Thus, increasing calcium intake may increase the fecal excretion of these acids by inhibiting the absorption of lipids, and thereby increasing energy loss through the stool, which contributes to the anti-obesity effect [14] [15] [16].

Another calcium mechanism in weight control is due to its effect on adipocytes. Low calcium intake leads to increased serum levels of parathyroid hormone and 1,25-dihydroxy vitamin D3, or calcitriol. This vitamin acts on adipocytes by increasing the inside calcium concentration, stimulating enzymatic activity related to lipogenesis and factors that inhibit lipolysis [14]. In this way, low calcium diets may promote greater weight gain and lipid deposition in adipocytes, whereas diets with high calcium levels inhibit lipogenesis, accelerate lipolysis, increase thermogenesis and suppress weight gain in animals maintained on identical energy intake.

According to Zemel [17], the source of ingested calcium influences this result. Dairy sources produce superior effects on preventing weight gain and adiposity compared with non-dairy sources. This difference is most likely due to other bioactive compounds present in these products, which act with calcium to attenuate adipogenesis [17].

Considering the aspects discussed above the present study aims to evaluate the correlation between calcium intake and overweight/obesity and elevated adiposity in preschoolers from the city of Minas Gerais, Brazil.

2. Methods

Study type and subjects

This is a cross-sectional study nested in a cohort of children who were born in and resided in Diamantina/Minas Gerais/Brazil [18]. The details of the formation of the cohort are described elsewhere [19]. In this study the children were 5 years old (±5 months). For this research, preschoolers were recruited from the addresses used in the cohort cited above. The exclusion criteria were previously defined in the cohort study (prematurity, congenital malformations, twin birth, living outside the municipality Diamantina); to be included in this study, preschoolers had to be eligible for the cohort study and have the permission of the parents.

The data collection for the present research occurred in the households of each preschooler. Before the start of the study, the researchers were trained in data collection to avoid measurement errors. Each preschooler was visited at home during the period from July 2009 to July 2010. The interviews and data collection started only after the parents signed the informed consent that allowed their child to participate in the study.

As the present study is a cross-sectional study of a birth cohort, the sample power was calculated post-hoc. Were calculated as parameter risk difference for being overweight/obesity in relation to maternal obesity obtained by chi-square test. The power obtained was 96%, by using statistical software "G*Power" [20].

Anthropometry and adiposity

The anthropometric variables assessed were weight and height, which were used to calculate the Body Mass Index (BMI) and waist circumference (WC). Adiposity was assessed by triceps (TSF) and subscapular (SSF) skinfold measurements.

The subjects were weighed on a portable digital scale with a maximum capacity of 150 kg and with divisions of 50 g. Height was measured with a portable stadiometer, with accuracy to 0.1 cm. The procedures were carried out according to the protocols recommended by Jelliffe [21]. The WC was measured at the midpoint between the last rib and the iliac crest [22] using a flexible and inelastic tape that measures to the millimeter. The skinfolds were measured using a skinfold caliper (Lange Skinfold Caliper®) scaled up to 60 mm with an accuracy of ±1 mm on the right side of the body, according to the standardization of Lohman *et al.* [22]. Three measurements on each anatomical point were performed, and their average was used in analyses.

A z-score of < +1 identified children as underweight/eutrophic, and a z-score of ≥ +1 identified preschoolers with overweight/obesity according to BMI/age [23]. A value of a z-score of ≥ +1 for TSF and SSF classified children as having altered adiposity [23]. A value of waist circumference greater than the 75th percentile identified preschoolers with elevated circumference [24]. The z-scores were calculated using the WHO Antro® and WHO AnthroPlus® software, versions 3.0.1 and 1.0.3, respectively (WHO, Geneva).

Dietary intake

The assessment of food intake was performed using three 24-hour food recalls (24-hour recall), in which one weekend and two weekdays were recorded [25] and the mean values obtained from three RA 24 hours were used for analysis. Mothers or guardians of children answered these food recalls in their homes though face to face interview. According to Burrouws *et al.* [26], 24-hour recall is the most accurate method for estimating the total energy consumption in children in aged 4 - 11 years when compared to measurements taken using the doubly labeled water method.

The calculation of the estimated energy need of each child was conducted with reference to the formulas suggested by the Institute of Medicine (IOM) [27], which consider age, physical activity patterns, child height and weight and adds 20 kcal for energy deposition. The physical activity factor used was 1.16 for the girls and 1.13 for the boys. The decision to use a low activity factor was due to fact that children spent an average of 3 hours/day playing, and only nine participated in scheduled physical activities (e.g., swimming, soccer, and ballet). The evaluation of energy intake was performed using the estimated energy requirement (EER) [28]. Calcium intake adequacy was evaluated by Estimated Average Requirement (EAR), which is 800 mg/day for children aged 4 - 8 years, [29]. The software Diet PRO (version 5i) analyzed the nutrient composition.

We also assessed the possibility of under-/over-reporting of dietary intake in our sample. We used the methodology proposed by Burrows *et al.* [26], in which the energy intake (EI) was divided by EER (EI/EER). An EI/EER less than 0.84 indicates under-reporting, an EI/EER greater than 1.16 indicates over-reporting and an EI/EER between 0.85 and 1.16 indicates accurate reporting.

We performed an adjustment of calcium intake by dietary energy to control the effect of total caloric intake on the relation between calcium and obesity this relationship. Therefore, we used the residual nutrient, proposed by Willet *et al.* [30], in which the residual nutrient is the nutrient intake adjusted by energy and is calculated by adding the residual of a simple linear regression model. The total ingested energy was considered the independent variable and the absolute values of calcium intake the dependent variable.

Ethics approval (ref. No. ETIC 545/08) was obtained from the Federal University of Minas Gerais.

Statistical Analysis

The Kolmogorov-Smirnov test was used to test the normality of the distribution of the variables. For variables with normal distribution, comparison between means was performed by t-test or ANOVA, and for those with a non-parametric distribution, we used the Mann-Whitney U and Kruskal-Wallis tests.

An ANOVA was used to compare the anthropometric and adiposity means, by energy-adjusted calcium intake quartiles. The association between calcium intake, adiposity and anthropometric measurements was performed using a logistic regression analysis. Only variables with a p-value < 0.2 in the crude analysis were used in the adjusted analysis. Statistical analysis was performed using the Statistical Package for Social Sciences—PASW—version 19.0 for Windows system (SPSS Inc., Chicago, IL, USA).

3. Results

Of the 281 children in the original cohort, 232 (82.6%) were included in this study. The 17.3% loss was due to families moving away from the city (n = 37; 75.5%), incorrect addresses (n = 8; 16.3%) or family refusal to participate (n = 4; 8.2%).

The loss of 0.9% during follow-up was due family refusal to participate (n = 2). They have 5-year-old (±5 months).

The prevalence of eutrophic (underweight + eutrophic) and overweight (overweight + obesity) occurred in 82.8% (n = 192) and 17.3% (n = 40) of children, respectively. Among boys, overweight occurred in 16.2% (n = 23) and among girls in 18.9% (n = 17).

The socioeconomic, maternal, early life and current characteristics of preschoolers according to nutritional status are shown in **Table 1**. Most of the overweight children are daughters of obese mothers and had higher than average weight gain during the first four months of life.

The average calcium intake was 480.51 mg/day, a value been far below the recommended intake for children in the age group studied (800 mg/day). We did not find a statistically significant difference when comparing the average energy intake and energy-adjusted calcium intake by BMI classification (**Table 2**). We also found no differences in macronutrient intake according to nutritional status (date not show). The percentage of calories from carbohydrates, proteins and lipids for both groups was adequate (**Table 2**).

The mean values of anthropometric and adiposity variables of eutrophic and overweight preschoolers did not differ significantly by quartiles of energy-adjusted calcium intake (**Table 3**).

We found that under-reporting occurred in 21.3% (n = 41), over-reporting occurred in 21.8% (n = 42) and accurate reporting occurred in 56.8% (n = 109) of eutrophic children. However, among the overweight group, under-, over- and accurate reporting were 27.5% (n = 11), 17.5% (n = 7) and 55.0% (n = 22), respectively.

4. Discussion

In the present study, the mean of calcium intake, adjusted for energy, was far

Table 1. Socioeconomic, maternal, early life and current characteristics of preschoolers in Diamantina, Minas Gerais, Brazil by nutritional status.

Variables	Eutrophic		Overweight		value-*p*
	n	%	n	%	
Gender					
Girls	73	28.0	16	40.0	0.597
Boys	119	61.9	24	60.0	
Time spent playing (hours/day)					
<3	57	29.7	16	40.0	0.201
≥3	135	70.3	24	60.0	
Breastfeeding duration (months)					
<6	48	25.0	13	32.5	0.327
≥6	144	75.0	27	67.5	
Energy intake[2] (Kcal/day)					
<1479.87	91	47.4	22	55.0	0.381
≥1479.87	101	52.6	18	45.0	
Adjusted[4] carbohydrates intake[1] (g/day)					
<218.88	95	49.5	21	52.5	0.728
≥218.88	97	50.5	19	47.5	
Adjusted[4] proteins intake[2] (g/day)					
<54.05	99	51.6	16	40.0	0.183
≥54.05	93	48.4	24	60.0	
Adjusted[4] lipids intake[2] (g/day)					
<45.76	100	52.1	17	42.5	0.270
≥45.76	92	47.9	23	57.5	
Adjusted[4] calcium intake[3] (mg/day)					
<463.64	105	54.7	17	42.5	0.160
≥463.64	87	45.3	23	57.5	
Mother's obesity[4]					
Yes	27	14.4	14	13.9	**0.000**
No	160	85.6	26	86.1	

[1]Value refers to the daily intake adjusted for dietary energy. [2]Value refers to the mean. [3]Value refers to the median. [4]Variable with loss of five data for eutrophic.

Table 2. Dietary variables by nutritional status of preschoolers from diamantina, minas gerais, brazil.

Dietary Variables	Eutrophic (n = 192)	Overweight (n = 40)	value-*p**
	Mean/Median ± sd[2]	Mean/Median ± sd[2]	
Energy intake (Kcal/day)	1467.5 ± (325.4)	1539.1 ± (312.9)	0.196*
Adjusted calcium[1] (mg/day)	464.4 ± (212.5)	462.9 ± (238.4)	0.741**
Carbohydrates intake[1] (%)	62.7 ± (0.16)	58.7 ± (0.12)	0.215
Proteins intake[1] (%)	15.6 ± (0.05)	14.2 ± (0.04)	0.09
Lipids intake[1] (%)	30.9 ± (0.08)	29.1 ± (0.16)	0.244

*T Test. **Mann-Whitney U Test. [1]Adjusted for energy. [2]Standard deviation.

Table 3. Anthropometric and adiposity variables of overweight and eutrophic preschoolers from diamantina, minas gerais, brazil by quartiles of calcium intake adjusted for energy.

Variables	Calcium intake by overweight preschoolers				
	1st quartile	2nd quartile	3rd quartile	4th quartile	value-*p*
BMI[1]	17.4 ± 1.2	18.4 ± 1.6	17.7 ± 1.0	17.9 ±1.8	0.264*
WC[2]	53.9 ± 2.3	57.3 ± 4.5	55.4 ± 3.9	56.0 ±2.8	0.088**
TSF[3]	10.0 ± 2.8	12.5 ± 4.5	11.0 ± 3.3	12.3 ± 2.8	0.275*
SSF[4]	7.0 ± 2.7	8.3 ± 3.1	7.0 ± 3.0	8.0 ± 2.4	0.168*
	Calcium intake by eutrophic preschoolers				
	1st quartile	2nd quartile	3rd quartile	4th quartile	value-*p*
BMI[1]	15.1 ± 1.0	14.7 ± 1.0	15.0 ± 1.1	15.0 ±1.0	0.673*
WC[2]	50.3 ± 2.9	49.5 ± 3.2	49.6 ± 3.1	50.5 ±3.0	0.319**
TSF[3]	7.0 ± 2.1	7.0 ± 1.6	7.0 ± 2.2	8.0 ± 2.5	0.082*
SSF[4]	5.0 ± 1.2	4.7 ± 1.1	5.0 ± 1.8	5.0 ± 1.6	0.225*

[1]Body mass index in kg/m^2. [2]Waist circumference in cm. [3]Triceps skinfold thicknesses in mm. [4]Subscapular skinfold thicknesses in mm. *Kruskal-Wallis H. **ANOVA.

below the recommendations for the studied group age. This result is similar to that found in other studies [4] [10] [11], although the majority of research on this topic focuses on calcium intake from dairy products [6] [8] [9] [11].

We chose to study the intake of calcium independent of the source because, in this study, the consumption of milk was below the recommended servings per day [31], making our analyses more difficult. Low calcium intake, especially in the first life years, is concerning because of calcium's necessity for children's growth and development. A low intake of this nutrient at this life stage can promote deficient bone formation and increase osteoporosis risk in later life [32].

The lack of significant differences between quartiles of calcium intake on means of anthropometric variables and adiposity for both groups (eutrophic and overweight) indicate that these variables are not yet being affected by calcium intake. However, considering that calcium intake was well below recommendations, and equally distributed among children, it is possible that this is influencing the results obtained.

Another possible explanation for the lack of correlation between these variables and calcium intake among overweight children may be because, in our sample, of the forty overweight children, only two presented as obese, and it is possible that this effect is best identified in the presence of obesity.

The present study did not find an association between calcium intake, adiposity and anthropometric measures. This result corroborates previous research that also did not identify an association between these variables [8] [9] [11] [32]. The relationship between calcium intake and overweight remains with controversial results. Lanou and Barnard [32] performed a systematic review on the topic and found that among 49 randomized trials, 41 no showed effect of calcium intake on body weight gain and identified that two showed weight gain, that one showed a lower rate of weight gain, and five found weight loss.

Others researchers also found that volunteers with lower calcium intake presented with higher adiposity [5] and BMI in girls [10] or in the overall sample [6] [8] [11]. Others point to a direct relationship, such that the higher the consumption of dairy products the higher the BMI [4] [7].

However, despite a review [13] that concluded that milk and dairy products do not negatively affect body weight and composition in children and adolescents, it is worth noting that to evaluate the effect of calcium intake on the anthropometric and adiposity parameters, it is important to adjust it to total energy intake because the result may be masked by differences in total energy. Much research on this mineral's effect on adipogenesis has focused on dairy sources, and these foods are often rich in energy. This attribute may influence the studied effect, which may not be the result of the amount of calcium intake alone.

We observed that, among the eutrophic children, under-reported energy intake was equal to over-reported energy intake, indicating a good dietary assessment. However, among overweight children, under-reported energy intake was higher than the over-reported energy intake, indicating that results may be biased according to Black and Cole [33].

The present study has some limitations, the most important of which is its cross-sectional design, which might be considered inadequate for the investigation of food intake and anthropometric characteristics under some circumstances. In this type of study, reverse causality is also possible; in this case, overweight children's mothers could be offering healthier food to their children, this may have occurred in this study. This fact can be seen in **Table 2**, which shows that among euthopic individuals there was a higher proportion of consumption of carbohydrates and proteins than those with overweight.

5. Conclusion

Finally, we did not identify a relation between overweight and low calcium intake in this study. The low calcium intake identified among preschoolers signals a higher risk for a deficit in bone formation, which makes this group a good target for educational activities to stimulate consumption of sources of calcium.

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