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Longitudinal calcium intake is negatively related to children's body fat indexes

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ABSTRACT

Objective To determine if dietary calcium was negatively related to children's body fat (BF), if BF indexes and calcium intakes changed over time, and to identify variables related to BF and calcium intake.
Design Percent BF and kg BF were assessed by dual energy x-ray absorptiometry (DEXA) in 8-year-old children. In a prospective design, height, weight, dietary intakes, and related variables were monitored longitudinally from ages 2 months to 8 years during in-home interviews.
Subjects Fifty-two white children, (n=25 boys, 27 girls) participated in a longitudinal study with their mothers. At 8 years of age, mean BMI was 17.3±2.1 (standard deviation) for boys and 17.1±2.5 for girls.
Analyses Regression analysis of all variables, followed by further regression analysis on selected models.
Results At 8 years, percent BF was 22.7±6.7 for boys and 26.2±7.9 for girls, as assessed by DEXA. Dietary calcium (mg) and polyunsaturated fat intake (g) were negatively related to percent BF (P=.02 to .04) in 3 statistical models, which predicted 28% to34% of the variability in BF among children. Variables positively associated with percent BF were total dietary fat (g) or saturated fat (g), female gender, sedentary activity (hours/day), father's BMI, and mothers' percent BF. Calcium intakes were significantly correlated over time. Dietary variety was positively related to calcium intake, and intakes of carbonated beverages and other sweetened beverages were negatively related.
Applications/conclusions Children should be strongly encouraged to regularly include calcium-rich foods and beverages in their diets. *J Am Diet Assoc. 2003;103:1626-1631.*

Excess body fat among American children is of increasing concern to health professionals (1-7). Although overweight prevalence is greatest among African American and Hispanic children, the percentage of overweight non-Hispanic white children increased by 50% between 1986 and 1998 (2). The best predictors of childhood adiposity were overweight at an earlier age (3), limited physical activity (4,7), and parental obesity (3,5). In contrast, Whitaker et al showed the relationship between children's body fat percentage and parental body mass index (BMI) was significant only for mothers and daughters (6). Dietary factors, specifically total energy intake and percentages of energy from fat, protein, and carbohydrate,

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were not related to children's body fat in several studies (3-5), but in another study, fat intake was positively related and carbohydrate was negatively related (7). Other dietary constituents that have been investigated in studies of children include sugars, which were not related to body fat (8), and calcium/dairy products, which were negatively related (9,10).

Several recent human and animal studies have suggested a specific role for calcium in modulating body fat (11-17). Zemel and coworkers demonstrated that increased dietary calcium inhibited adipocyte intracellular Ca^{2+} resulting in simultaneous stimulation of lipolysis and inhibition of lipogenesis in energy-restricted aP_2-agouti transgenic mice (11-14). They also observed an inverse relationship between calcium and BMI in the Third National Health and Nutrition Examination Survey data for both women and men (11). In a 2-year exercise intervention study, Lin et al reported that calcium intake predicted changes in body weight and body fat in young women with low energy intakes (15). Davies et al reanalyzed data from 5 clinical studies and reported consistent associations between higher calcium intake and lower body weight (16). They estimated that calcium intake accounted for about 3% of the weight variability among women in these studies (16). Most recently, results from the 10-year Coronary Artery Risk Development in Young Adults (CARDIA) study showed that dairy intake was inversely related to the incidence of insulin resistance syndrome (IRS), which includes obesity, among individuals who were initially overweight (BMI≥25) (17). Thus, the majority of reported human studies included adults (11,13-17), and several involved weight loss and energy restriction (15,16).

Because energy restriction is rarely advocated for growing children, the studies that included healthy, normally growing children suggest that calcium may play a role in preventing childhood obesity (9,10). Thus, this study was planned as a follow-up to the earlier study from this laboratory (9) to answer the following questions:

1. How did children's body fat indexes change between ages 6 and 8 years?
2. How did children's dietary calcium intakes change over time (ages 2 to 8 years)?
3. What variables were related to children's dietary calcium intake?
4. Did the previously reported inverse dietary calcium/body fat relationship shown at 6 years still exist at 8 years of age? What other variables predicted body fat?

METHODS

Sample

Initially, infants were recruited through birth announcements in local newspapers and referrals from enrolled participants. The 8-year-old children in this study were a subset of the larger study (n=70), (9,18-25) and included only those children whose mothers chose to have dual-energy x-ray absorptiometry (DEXA) scans for themselves and their children. The child/mother pairs (n=53) were continuous participants in a longitudinal study of factors related to children's growth, dietary patterns, and food preferences (18-25). Children were followed from ages 2 months to 8 years with in-home interviews at 20 data collection points. All children were healthy at birth, white, and most were from middle and upper socioeconomic status (SES) families. A single racial group was selected to eliminate growth differences among children due to race, and the SES criterion was included to assure that children had access to adequate food and health care for normal growth and development. To reduce participants' burden of frequent interviews during the early months of the longitudinal study, a randomized incomplete block design was used to schedule 7 or 8 interviews from the 13 data points between ages 2 months and 3 years (2, 3, 4, 6, 8, 10, 12, 16, 20, 24, 28, 32, 36 months); each child/mother pair participated in all 7 interviews from ages 3.5 to 8.0 years (3.5, 4.0, 4.5, 5.0, 6.0, 7.0, 8.0 years). Of the 98 children who participated in the first two years, 75 were continued in year 3; 23 of the 98 were dropped from the study due to the travel time required for interviews, and a lower income cohort (n=50) was added. Beginning at age 3.5 years, the lower-income cohort was dropped, and only children with data since infancy were included (n=75); this sample included a few lower-income children who had participated in another study from this laboratory (26). From 3.5 to 8 years, 4 children were lost to the study because the family moved from the area or chose to discontinue participation; one child was dropped from the study because data provided by the mother was consistently incomplete.

Growth and Body Composition Measures

At each interview, the interviewer measured the child's height and weight. Standard and age-appropriate protocols were used for all measurements (eg, recumbent height for infants, standing height at ages 2 years and older) (9,20,24,25). Birth weights were obtained from medical records. Children's body compositions were assessed with DEXA in the fan beam mode (Hologic QDR 2000, Waltham, MA) at ages 6 (9) and 8 years. Each mother's height and weight was measured, and her body composition was assessed by DEXA when her child was age 8 years. Both parents' heights and weights were reported by mothers when children were 3, 5, and 8 years of age. All interviews except the DEXA assessments were conducted in the child's home by one of two registered dietitians (RDs). Trained personnel in a clinical laboratory assessed the DEXA scans (9). The DEXA assessments at 6 years were done at the university medical center; the university's nutrition department subsequently acquired the DEXA instrument from the medical center. Thus, all of the 8-year DEXA assessments were done by one researcher (WB) in the nutrition department.

Dietary Methodology

At each interview before age 2 years, each child's mother provided 24-hour dietary recall of the child's food and beverage intake (19-21). At each subsequent interview, mothers provided a 24-hour recall and 2 days of food records for the child (22,24,25). Recording days were assigned, and each set of 3-day data included 1 weekend day. The RD initially taught mothers how to keep accurate and complete food records, using food models and typical sizes of glasses, bowls, etc. At each interview the RD reviewed the food records with the mother and clarified any ambiguities. Mothers also provided dietary data (a 24-hour recall and 2 food records) for themselves at the interviews when children were 7 and 8 years. Mothers were assigned days for keeping food records that did not overlap with the days assigned for children's food records; days for the 24-hour recalls were the same days for each mother/child pair.

Sedentary Activity Measure

Mothers estimated the daily time that their child spent in sedentary activities, including viewing television or videos, playing computer games, listening to audiotapes, and participating in other nonactive games/activities. These time estimates were collected separately for weekdays and weekend days when children were age 7 years.

Approvals

The University of Tennessee's institutional review committee for protection of human subjects approved data collected during the in-home interviews. The institutional review board at the university's medical center approved the DEXA assessments. Mothers signed informed consent forms for each set of interviews (eg, the first year, ages 3.5 to 5.0 years, age 8) and for each DEXA assessment. Beginning at age 5 years, the children also gave their assent to participate in each interview and the DEXA assessments.

Table 1
Physical characteristics of 8-year-old children and their mothers

Characteristics	Boys (n=25)	Girls (n=27)	Mothers (n=52)
	← mean ± standard deviation →		
Height (cm)*	132.4±4.3	127.6±5.3	164.8±5.4
Weight (kg)*	30.5±4.5	27.9±4.7	69.0±12.5
BMI (kg/m^2)	17.3±2.1	17.1±2.5	25.5±4.8
Body fat (%)[a]	22.7±6.7	26.2±7.9	37.0±8.1
Body fat mass (kg)[a]	7.1±3.1	7.6±3.5	25.9±9.9

[a]Assessed by dual energy absorptiometry (DEXA).
*Significantly different between boys and girls, $P \leq .05$.

Analyses

SAS System for UNIX (version 8.1, 2000, Cary, NC) was used for all analyses. Body mass indexes (BMIs), defined as weight (kg)/height (m^2), were calculated from measured data for children at each interview and for their parents from the measured and reported data. Body fat, as assessed by DEXA, was obtained as percent of body weight (%BF) and body fat mass (kg BF) for mothers and children. Correlation statistics (Pearson r) were calculated among the variables BMI, %BF, and kg BF at 8 years, between the DEXA measures at 6 and 8 years, and between mother/daughter pairs and mother/son pairs for %BF and kg BF.

Dietary data were coded for energy/nutrient analyses using Nutritionist IV (version 3.5, 1994, Nutritionist, Salem, OR), for the early interviews (ages 2 months to 36 months), and Nutritionist IV (version 4.1, 1995, First Data Bank, San Bruno, CA) for the remaining interviews. Additional foods (eg, baby foods, new food products) were added to the database using manufacturers' information. For foods with missing nutrient data, individual generic components were used (eg, hamburger bun, ground beef, lettuce, tomato, ketchup, pickle). Each 3-day set of records/recalls was averaged to provide a representative daily intake for each child at each interview. These 9 representative daily intakes, ages 2 through 8 years, were summed and averaged to provide a longitudinal daily intake for each child. Thus, the longitudinal daily intake was derived from 27 days of dietary data per child. Mother's dietary data were averaged to provide representative daily intakes from each of the two data collection points (child's ages 7 and 8 years). Group means ± standard deviations (SD) were calculated for energy and selected nutrients for children by gender and for their mothers. Because of the previously reported relationship between dietary calcium and body fat (9-17), tracking individuals' calcium intakes over time was of particular interest. The methodology of Boulton et al (27), who defined tracking as the correlation coefficient between age points, was selected. The age points selected to determine tracking for this study were 2, 3.5, 5.0, 7.0, and 8.0 years.

Factors related to children's dietary calcium intake at 8 years were explored using the following independent variables from the longitudinal data set: breast feeding duration; age of introduction of cereal; child's mean dietary variety score from ages 3.5 to 7 years; sedentary activity time of the child; number of foods the child liked from a list of 196 commonly eaten foods, as reported by mothers (18); the number of foods liked by mothers, assessed from the same food list (18); whether the mother perceived the child as a "picky eater" (23); child's carbonated beverage intake at 8 years; child's intake of "other" beverages (beverages other than milk, 100% juices, carbonated drinks, and water) at 8 years; mothers' calcium intake; and child's previous milk intake (ie, at 2 to 7 years). The statistical procedures to predict children's calcium intake included PROC RSQUARE and stepwise regression.

A weighted mean (5 weekdays plus 2 weekend days) was calculated from the weekend and weekday sedentary activity hours to provide a single value for each child. Group means±SD were calculated.

Dietary variety was calculated at each interview by comparing the number of servings eaten from each food group with the number recommended in the Food Guide Pyramid with portion sizes adjusted, as appropriate, for the child's age. This procedure created a value ranging from 0 to 1.0 for each food group. These food group scores were then averaged to provide an overall variety score. Several additional procedures were followed to ensure that the score represented dietary variety. To ensure variety within food groups, no single food (except milk) could provide more than one third of the recommended servings in each 3-day period. To ensure variety among food groups, the number of servings consumed was truncated at the minimum number recommended for that food group. Thus, the maximum score of 1.00 indicated that the child had dietary variety both within and among food groups and met at least the minimum number of recommended servings from each food group (22).

A multistep process was used to identify variables that were significantly associated with children's body fat. Potential variables were identified from our earlier study (9) and literature sources. First, PROC RSQUARE in SAS was conducted using the following potential independent variables: mother's %BF or g BF; mother's BMI; father's BMI; the child's gender; the child's weighted sedentary activity hours/day; and the child's daily longitudinal dietary intakes for calcium, energy, protein, carbohydrate, fat, saturated fat, polyunsaturated fat, and monounsaturated fat. Separate PROC RSQUARE analyses were conducted with each dependent variable, %BF, and g BF. Consistent with a major objective of the study, all possible models that included calcium were examined to identify models for further analyses. Regression (PROC REG) was used to test selected models for significance, and the forward selection process was used to obtain the relative contribution of each variable in the model. Final models were evaluated to maximize R^2 and include only statistically significant (P <.10) independent variables.

Table 2
Children's mean longitudinal daily dietary intakes for energy and selected nutrients, ages 2 to 8 years

Energy/Nutrient	Boys (n=25)	Girls (n=27)
	←— *mean ± SD*[a] —→	
Energy (kcal)*	1,690±283	1,515±257
(kJ)*	7,065±1,184	6,331±1,073
Calcium (mg)	912±235	805±245
Total fat (g)	59±11	54±11
Saturated fat (g)	22±4	20±4
Polyunsaturated fat (g)	9±2	9±2
Monounsaturated fat (g)	21±4	19±4
Protein (g)	58±12	53±12
Carbohydrate (g)*	238±45	210±41

[a]Mean ± standard deviation per day, derived from 27 days of dietary data collected from age 2 to 8 years.
*Significantly different between genders, $P \leq .05$.

Table 3
Tracking children's calcium intakes, ages 2 to 8 years, over time

Age (y)	Calcium intake: Boys (n=25)	Calcium intake: Girls (n=27)
	←— *mean ± SD*[a] *(in mg)* —→	
2.3[b]	820±362	770±322
2.8[c]	827±264	767±330
3.5	820±279	777±320
4.0	854±368	729±261
4.5	930±254	867±300
5.0*	1,007±355	787±359
6.0	982±380	828±290
7.0	1,028±292	844±370
8.0	942±366	876±283

[a]SD=standard deviation. From 9 sets of 3 days of dietary data (two food records and one 24-hour recall provided by mothers), averaged at each age.
[b]The mean age of randomly assigned interviews at 24, 28, or 32 months of age.
[c]The mean age of randomly assigned interviews at 28, 32, or 36 months of age.
*Significant difference between genders.

Table 4
Tracking boys' and girls'[a] calcium intakes,[b] ages 2 to 8 years, correlations over time

Age (y)	2	3.5	5	7	8
	←— Correlations (*P* values)[a] —→				
2		0.78 (<.0001)	.57 (.002)	0.59 (.001)	0.57 (.002)
3.5	0.63 (.001)		.63 (.001)	0.64 (.001)	0.39 (.042)
5	0.28 (.178)	.25 (.22)		0.54 (.004)	0.34 (.082)
7	0.53 (.007)	0.46 (.02)	0.32 (.122)		0.51 (.007)
8	0.29 (.160)	0.40 (.046)	0.31 (.128)	0.17 (.42)	

[a]Girls' correlations are to the right of the diagonal line in the matrix and boys' values are to the left.
[b]From 9 sets of 3 days of dietary data (two food records and one 24-hour recall provided by mothers), averaged at each age.

RESULTS

Sample Characteristics

Fifty-three child/mother pairs agreed to participate in the DEXA assessment when children were 8 years old. However, one mother was pregnant; therefore her DEXA was not administered. Thus, the final sample was 52 child/mother pairs; 46 of these children participated in the earlier DEXA assessment when children were 5.9±1.1 years (9). Mean age of the children was 8.1±0.1 years; mean age of their mothers was 38.0±3.6 years.

Body Composition

Anthropometric characteristics of mothers and 8-year-old children by gender are shown in Table 1. Between the two DEXA assessments the children had gained approximately 12 to 14 cm in height and 7 kg in weight. Thus, boys were approximately 4 cm taller and 5 kg heavier than the median for US children, and girls were approximately 2 kg heavier than the median (28). To answer the research question related to changes in body fat over time, we found that the %BF had increased by 4.8% in boys and 5.4% in girls. The correlations between the two DEXA assessments were 0.74 ($P<.0001$) for %BF and 0.75 ($P<.0001$) for kg BF. For the 8-year-old children, correlations with BMI were 0.84 for %BF and 0.91 for g BF. Girls' %BF was 3.5% higher than that of boys ($P=.10$). The range of %BF was wide for girls, 14.5% to 44.1%, and boys, 15.3% to 41.3 %. Mothers' range of %BF was 17.4% to 51.7%. Body fat indexes were significantly correlated between mothers and daughters: $r=0.58$, $P=.002$ (%BF); $r=0.59$, $P=.001$, (g BF). Specific sites (arms, legs, trunk) also were significantly correlated between mother/daughter pairs. However, there were no significant correlations between body fat (%, g) at any site or for the total body fat between mother/son pairs.

Dietary Intakes

Children's longitudinal dietary intakes for energy and selected nutrients are shown in Table 2. Percentages of energy were about 14%, 32%, and 56% from protein, fat, and carbohydrate, respectively, and did not differ significantly by gender. However, the boys' diets averaged approximately 175 kcal more per day and approximately 100 mg more calcium compared with the girls' intakes.

Table 5
Predictive models showing variables related to children's[a] body fat indexes[b]

Dependent variable, R^2/F/P value	Independent variables	Parameter estimate	Partial R^2	*P* value
I. % BF	Calcium (mg)	−0.001	0.07	.04
R^2=0.336	Total fat (g)	0.08	0.06	.001
F=4.66	Polyunsaturated fat (g)	−0.35	0.05	.01
P=.002	Gender (M=1, F=2)	4.13	0.06	.03
	Sedentary activity (hr/d)	1.43	0.10	.02
II. % BF	Calcium (mg)	−0.002	0.09	.02
R^2=0.322	Total fat (g)	0.09	0.02	.001
F=4.37	Polyunsaturated fat (g)	−0.44	0.09	.002
P=.002	Dads' BMI	0.61	0.06	.03
	Gender (M=1, F=2)	5.67	0.05	.01
III. % BF	Calcium (mg)	−0.001	0.07	.03
R^2=0.276	Saturated fat (g)	0.14	0.02	.003
F=4.49	Polyunsaturated fat (g)	−0.22	0.06	.02
P=.004	Mother's BF (%)	0.26	0.12	.03
IV. kg BF	Calcium (mg)	−0.0005	0.05	.10
R^2=0.26	Total fat (g)	0.034	0.06	.01
F=4.19	Polyunsaturated fat (g)	−0.145	0.05	.03
P=.006	Sedentary activity (hr/d)	0.655	0.11	.02

[a]n=52 children, 25 boys and 27 girls; mean ± standard deviation age of children was 8.1±0.1 years.
[b]Assessed by dual energy x-ray absorptiometry.

Calcium Tracking

Children's mean calcium intakes were similar over the 9 interviews from age 2 to 8 years (Table 3). Differences in intake between genders were significant only at 5 years of age. Although boys' mean intakes met the adequate intake (AI) amount at each time, girls' mean intakes were slightly less than 800 mg/day at 2 of 6 of the interview times from ages 4 to 8 years (29). As shown in Table 4, correlations tracking boys' calcium intakes over time were significant for 4 of the 10 comparisons between interview times whereas girls' calcium intakes were significantly correlated for 9 of the 10 comparisons. Milk and other dairy products were the major contributors to children's calcium intakes over time. Milk alone provided approximately 50% of the total calcium intake.

Predictors of Calcium Intake

The best model predicting children's calcium intake (R^2=0.39, F=10.28, P<.0001) included 3 variables. Children's mean dietary variety score (ages 3.5 to 7 years) was positively related, F=20.2, P=.0001, β=1,092, and predicted 29% of the variability. The other significant variables were negatively related to children's calcium intake: carbonated beverage intake (ounces/day) at 8 years, F=4.2, P=0.05, $\beta=-10.3$, 5% of the variability; and childrens' intake of "other" beverages, F=5.6, P=.02, $\beta=-14.3$, 5% of the variability in calcium intake.

Children's Sedentary Activity

The children averaged 2.9±1.7 hours per day in sedentary activities such as watching television or playing computer games, although the range was 0.8 to 8.8 hours per day. Sedentary activity time did not differ between the boys and girls.

Body Fat Models

The 4 models showing statistically significant relationships between dietary calcium and body fat indexes are presented in Table 5. R^2 values for these statistically significant models ranged from 0.26 to 0.34. Dietary calcium and polyunsaturated fat were negatively related to children's body fat in all 4 models. Positive predictors of body fat were total fat (models I, II, IV) or saturated fat (model III), sedentary activity (models I, IV), female gender (models I, II), mothers' %BF (model III), and fathers' BMI (model II). Longitudinal dietary calcium explained 4.5% to 9.0% of the variability in body fat among these children.

DISCUSSION

The similarities of the children's mean calcium intakes over time and the significant correlations among age periods highlight the importance of establishing food habits early in a child's life. This notion is further supported by the reported consistency in children's food preferences over time (18). Boulton et al (27) reported similar correlations in tracking calcium intake in Australian children from 2 to 15 years of age, but correlations for boys were stronger than for girls, which contrasts the results in the current study. Although Fisher et al (30) found similarities between mothers' and daughters' milk consumption, mothers' calcium intake was not predictive of children's calcium intake in the current study. However, the negative relationship between children's carbonated beverage consumption and calcium intake was consistent with findings from the Fisher et al study, which reported that mothers and daughters who consumed fewer soft drinks drank more milk (30).

The current study confirms the negative relationship of calcium to body fat, which has been shown in previous human (9-11,15-17) and animal studies (11-14). Unlike these previous studies, which involved weight restriction or statistical consideration of energy intake, the current study and our previous report (9) included normally growing, healthy children with a range of energy intakes and a wide range in adiposity. Whereas our previous study included children's BMI as a controlling factor in the statistical analyses, the current study showed a statistically significant negative relationship between dietary calcium and body fat without children's BMI in the model, possibly indicating a wider effect of the role of dietary calcium in 8-year-old children than in these children at age 6 years. The negative relationship between dietary calcium and body fat (4.5% to 9.0% of the variance) indicates that children could reduce their body fat by 0.4% if they increased their calcium intake with one 8-oz glass of skim milk or 8 oz of yogurt per day.

Whereas this percentage decrease over time may not seem substantial, even a slight decrease in body fat in childhood may reduce the risk of obesity in later childhood/adolescence/adulthood; it is well accepted that obesity in childhood/adolescence increases the risk of adult obesity and the related health problems (1). This notion is confirmed by the strong consistency in %BF reported over 2 years in the current study and the report by Magarey et al (3), who purported that the best predictor of fatness in children ages 2 to 15 years was previous adiposity. In other words, it could be argued that anything that interrupts the pattern of developing adiposity may reduce future risks for obesity. Most importantly, calcium intake is a modifiable factor, unlike genetic factors, which also play a significant role in the development of obesity (31). The separation of environment and genetics is always problematic, but this study and others (3,5-7) show parental BMI/adiposity to be related to children's %BF.

This study also supports the role of physical activity in controlling childhood obesity. Children averaged more than 20 hours per week in sedentary activities, which is especially significant considering that most of the interviews over 7 years were conducted in June, July, and August, when school was not in session. Other researchers have also reported the role of limited physical activity and childhood obesity (4,7,31).

The models including calcium as a negative predictor of body fat also included polyunsaturated fat as negatively related to body fat. Because calcium and polyunsaturated fat rarely occur in the same foods, these similarities probably reflect general dietary patterns and the recent emphasis on replacing animal fats with plant-based fats and oils. However, all models also included either total fat or saturated fat as a positive predictor of body fat. Thus, it is very important that attempts to increase dietary calcium focus on low-fat, calcium-rich foods. Previous studies have shown mixed results regarding the relationship of dietary fats and various measures of obesity (3-5,7).

APPLICATIONS

Parents should be encouraged to help children develop health-promoting habits that include:

- Regular intake of calcium-rich foods, such as skim, 1% or 2% fat milk and other low-fat dairy products.
- Limited time spent in sedentary activities and increased time in physically active pursuits.
- Restricted intake of carbonated beverages and other low-nutrient beverages, such as fruit drinks, fruit "ades", and tea.

References

1. Deckelbaum RJ, Williams CL. Childhood obesity: The health issue. *Obes Res*. 2001;9(Suppl 4):239S-243S.

2. Strauss RS, Pollack HA. Epidemic increase in childhood overweight, 1986-1998. *JAMA*. 2001;286:2845-2848.

3. Magarey AM, Daniels LA, Boulton TJC, Cockington RA. Does fat intake predict adiposity in healthy children and adolescents aged 2-15 y? A longitudinal analysis. *Eur J Clin Nutr*. 2001;55:471-481.

4. Atkin LM, Davies PSW. Diet composition and body composition in preschool children. *Am J Clin Nutr*. 2000;72:15-21.

5. Francis CC, Bope AA, MaWhinney S, Czajka-Narins D, Alford BB. Body composition, dietary intake, and energy expenditure in nonobese, prepubertal children of obese and nonobese biological mothers. *J Am Diet Assoc*. 1999; 99:58-65.

6. Whitaker RC, Deeks CM, Baughcum AE, Specker BL. The relationship of childhood adiposity to parent body mass index and eating behavior. *Obes Res*. 2000;8:234-240.

7. Tucker LA, Seljaas GT, Hager RL. Body fat percentage of children varies according to their diet composition. *J Am Diet Assoc*. 1997;97:981-986.

8. Naismith DJ, Nelson M, Burley V, Gatenby S. Does a high-sugar diet promote overweight in children and lead to nutrient deficiencies? *J Hum Nutr Diet*. 1995;8:249-254.

9. Carruth BR, Skinner JD. The role of dietary calcium and other nutrients in moderating body fat in preschool children. *Int J Obes*. 2001;25:559-566.

10. Tanasescu M, Ferris AM, Himmelgreen DA, Rodriguez N, Pérez-Escamilla R. Biobehavioral factors are associated with obesity in Puerto Rican children. *J Nutr*. 2000;130:1734-1742.

11. Zemel MB, Shi H, Greer B, Dirienzo D, Zemel PC. Regulation of adiposity by dietary calcium. *FASEB J*. 2000;14:1132-1138.

12. Shi H, Dirienzo D, Zemel MB. Effects of dietary calcium on adipocyte lipid metabolism and body weight regulation in energy-restricted aP_2-agouti transgenic mice. *FASEB J*. 2001;15:291-293.

13. Zemel MB. Calcium modulation of hypertension and obesity: Mechanisms and implications. *J Am Coll Nutr*. 2001;20(5 Suppl):428S-435S.

14. Zemel MB. Regulation of adiposity and obesity risk by dietary calcium: Mechanisms and implications. *J Am Coll Nutr*. 2002;21:146S-151S.

15. Lin YC, Lyle RM, McCabe LD, McCabe GP, Weaver CM, Teegarden D. Dairy calcium is related to changes in body composition during a two-year exercise intervention in young women. *J Am Coll Nutr*. 2000;19:754-760.

16. Davies KM, Heaney RP, Recker RR, Lappe JM, Barger-Lux MJ, Rafferty K, Hinders S. Calcium intake and body weight. *J Clin Endocrinol Metab*. 2000;85:4635-4638.

17. Pereira MA, Jacobs DR Jr, Van Horn L, Slattery ML, Kartashov AI, Ludwig DS. Dairy consumption, obesity, and the insulin resistance syndrome in young adults. The CARDIA study. *JAMA*. 2002;287:2081-2089.

18. Skinner JD, Carruth BR, Bounds W, Ziegler PJ. Children's food preferences: A longitudinal analysis. *J Am Diet Assoc*. 2002;102:1638-1647.

19. Skinner JD, Carruth BR, Houck K, Moran J III, Coletta F, Cotter R, Ott D, McLeod M. Transitions in infant feeding during the first year of life. *J Am Coll Nutr*. 1997;16:209-215.

20. Carruth BR, Skinner JD, Houck KS, Moran JD III. Addition of supplementary foods and infant growth (2 to 24 months). *J Am Coll Nutr*. 2000;19:405-412.

21. Skinner JD, Carruth BR, Houck KS, Coletta F, Cotter R, Ott D, McLeod M. Longitudinal study of nutrient and food intakes of infants aged 2 to 24 months. *J Am Diet Assoc*. 1997;97:496-504.

22. Skinner JD, Carruth BR, Houck KS, Bounds W, Morris M, Cox DR, Moran J III, Coletta F. Longitudinal study of nutrient and food intakes of white preschool children aged 24 to 60 months. *J Am Diet Assoc*. 1999;99:1514-1521.

23. Carruth BR, Skinner JD. Revisiting the picky eater phenomenon: Neophobic behaviors of young children. *J Am Coll Nutr*. 2000;19:771-780.

24. Skinner JD, Carruth BR, Moran J III, Houck K, Coletta F. Fruit juice intake is not related to children's growth. *Pediatrics*. 1999;103:58-64.

25. Skinner JD, Carruth BR. A longitudinal study of children's juice intake and growth: The juice controversy revisited. *J Am Diet Assoc*. 2001;101:432-437.

26. Carruth BR, Nevling W, Skinner JD. Developmental and food profiles of infants born to adolescent and adult mothers. *J Adolesc Health*. 1997;20:434-441.

27. Boulton TJC, Magarey AM, Cockington RA. Tracking of serum lipids and dietary energy, fat and calcium intake from 1 to 15 years. *Acta Paediatr*. 1995;84:1050-1055.

28. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Mei Z, Curtin LR, Roche AF, Johnson CL. CDC Growth Charts: United States. Hyattsville, MD: National Center for Health Statistics; 2000. Advance Data from Vital and Health Statistics. No. 314.

29. Food and Nutrition Board, Institute of Medicine. *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride.* Washington, DC: National Academy Press; 1997.

30. Fisher J, Mitchell D, Smiciklas-Wright H, Birch L. Maternal milk consumption predicts the tradeoff between milk and soft drinks in young girls' diets. *J Nutr*. 2001;131:246-250.

31. Dietz WH, Gortmaker SL. Do we fatten our children at the TV set? Obesity and television viewing in children and adolescents. *Pediatrics*. 1985;75:807-812.

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