Examination of the Relationship of Dairy Product Consumption and Dietary Calcium with Body Mass Index Percentile in Children

Carolyn W. Gunther[1,*], Paul Branscum[2], Julie Kennel[1], Elizabeth G. Klein[3], Laura E. Monnat[1] and Gail Kaye[3]

[1]*Department of Human Nutrition, The Ohio State University, 1787 Neil Avenue, Columbus, Ohio, 43210, USA*

[2]*Department of Health and Exercise Science, The University of Oklahoma, 1401 Asp Avenue, Norman, Oklahoma, 73019, USA*

[3]*College of Public Health, The Ohio State University, 1841 Neil Avenue, Columbus, Ohio, 43210, USA*

Abstract: *Aim*: The purpose of this study was to assess the relationships of dairy product and calcium intake with BMI percentile in children.

Methods: In this cross-sectional analysis, the relationships of dairy product (cup equivalents/day) and dietary calcium (mg/day) (measured by 24 hour recall) consumption with BMI percentile [derived from Centers for Disease Control and Prevention (CDC) sex-specific BMI-for-age growth charts] were assessed in 101 healthy U.S. children (ages 8-13).

Results: Subject characteristics included (mean $\pm$ SD): dairy product consumption (2.8 $\pm$ 1.4 cup equivalents/day), dietary calcium (1039.4 $\pm$ 431.4 mg/day), and BMI percentile (70.1 $\pm$ 29.7). Dairy product intake and dietary calcium were inversely related to BMI percentile (*p*= 0.005). In subjects <85th BMI percentile (n= 50 normal weight and n= 3 underweight), there was an inverse association of dairy product intake with BMI percentile (*p*= 0.001) and calcium intake with BMI percentile (*p*< 0.001). However, no association of dairy product consumption or calcium intake with BMI percentile was observed in overweight (85th percentile ≤ BMI < 95th percentile, n= 19) or obese subjects (BMI $\geq$ 95th percentile, n= 29). Removal of underweight subjects from the analysis only minimally impacted the results. Differences in dietary intake (MyPyramid food groups, calories, macronutrients, micronutrients) among normal, overweight, and obese subgroups were examined. No significant differences were detected between groups, and removing underweight subjects did not change the findings.

Conclusions: These results provide the basis for further investigation into a potential role of dairy and calcium in achieving a healthy body weight in children.

Keywords: Calcium, dairy, weight, BMI, children.

INTRODUCTION

The prevalence of overweight and obese children and adolescents in the United States has increased dramatically over the past three decades [1]. Of concern, overweight and obese children are at an increased risk for developing serious illnesses (e.g., type 2 diabetes, metabolic syndrome, and hypertension) and suffering negative psychological consequences (e.g., low self-esteem and depression) [2, 3]. The economic consequences are also vastly detrimental; in the past three decades obesity related health care costs have tripled among overweight children [4].

Understanding the role of dietary factors in weight management is critical and has attracted much interest. Studies indicate that dairy and/or calcium intake may play a beneficial role in healthy body weight management in adults and children [5-7]. Results from some studies suggest that high calcium and/or dairy intake may reduce body fat accumulation or enhance fat mass loss during energy restriction [8-12]. For example, in a two year intervention in 54 young, healthy women (ages 18 to 31 years) calcium intake adjusted for calories was negatively associated with changes in body weight and fat mass, specifically in those women whose energy intake was at or below the overall group mean of 1876 kcal/day [9]. However, conflicting results have been produced from other studies [13-26]. In a review by Barr, intervention trials that were designed to study bone status, without including individual calorie intake in the analysis of the trials, showed no weight or body fat relationship to calcium or dairy product intake [13]. Thus, the evidence in this area of inquiry is conflicting and the magnitude of the effect is uncertain. Determining the impact of dairy product and/or calcium consumption on body weight regulation is critical in the design of dietary recommendations for achieving and maintaining optimal body weight.

The purpose of this study was to assess the relationships of dairy product intake (cup equivalents/day) and calcium consumption (mg/day)

*Address correspondence to this author at the Ohio State University, 1787 Neil Ave, 313 Campbell Hall, Columbus, OH 43210, USA; Tel: 614-292-5125; Fax: 614-292-1330; E-mail: gunther.22@osu.edu

E-ISSN: 1929-4247/13

with BMI percentile in children prior to enrollment in an after-school nutrition education program. The central hypothesis of this study was that dairy products and/or calcium intake play a role in modulating a healthy body weight in children.

METHODS

One hundred and one healthy U.S. children, ages 8 to 13 years, were assessed prior to enrollment in an after-school nutrition program. One extreme height outlier (2007 cm; assumed to be a data entry error) was removed from the analysis. The Ohio State University Institutional Review Board approved the study; parents of all subjects provided informed consent.

A validated method for obtaining 24 hour recalls with assisted food records was administered to assess subjects' total diet and food group consumption [27]. Children were educated on how to keep a simple food diary, and instructed to write small descriptions of the foods they ate for the following 24 hours in a distributed food journal. On the following day a trained dietetic intern administered a 24 hour recall, using the United States Department of Agriculture (USDA) Five-Step Multiple Pass Method. During each interview, interns used the food records to help children recall the foods eaten. Children were first prompted to make a short list all the foods eaten during the previous day, while the intern transcribed these foods onto a standardized form. Children were asked to be as specific as possible about the foods and beverages they reported. Food records were then entered into the dietary analysis software Nutricalc 2.1 (version 2.1, The McGraw-Hill Companies, Higher Education, New York, New York) by a trained dietitian.

Height was measured to the nearest 0.1 cm with a portable stadiometer (Seca 214) and body weight was measured to the nearest 0.1 kg with an electronic digital scale (Tanita HD 317) with subjects in light clothing and no shoes. BMI percentile was derived from the sex-specific for-age growth chart for children and adolescents available from Centers for Disease Control and Prevention (CDC) [28].

This study was a cross-sectional secondary analysis of baseline data by design. Descriptive statistics are reported as mean $\pm$ SD. Distributions of several baseline characteristics were compared across weight status subgroups (underweight, normal, overweight, and obese) using Mann-Whitney tests. The relationships of amounts of dairy product consumed (cup equivalent/day) and dietary calcium (mg/day) with BMI percentile were assessed using linear regression models. Caloric intake (kcal/day) and age were considered as potential covariates. Gender and weight status subgroups were incorporated into the analysis as potential moderators. Multivariate analysis of variance (MANOVA) was employed to assess differences in dietary intake including (1) daily servings of MyPyramid food groups [grains (ounce equivalent), vegetables (cup equivalent), fruits (cup equivalent), dairy (cup equivalent), meat and beans (ounce equivalent)]; (2) calories and macronutrients [calories (kcal/day), protein (g/day), carbohydrates (g/day), fiber (g/day), sugar (g/day), total fat (g/day), saturated fat (g/day)]; and (3) micronutrients [vitamin A (IU/day), vitamin C (mg/day), calcium (mg/day), and iron (mg/day)] among weight status subgroups. All models were fitted twice, once using all subjects and once excluding underweight subjects (n=3) with BMIs below the 5th percentile. Data were analyzed using Statistical Package for the Social Sciences (SPSS), version 19.0, Chicago, IL. Statistical significance was determined at an alpha level of 0.05.

RESULTS

Participating subjects were 101 U.S. children, ages 8 to 13 years old, both boys (n= 58) and girls (n= 43), and largely classified as either Caucasian (n= 51) or African American (n= 42). Baseline characteristics of the subjects are presented in Table **1** both in aggregate and divided by weight status subgroup. Subjects' mean $\pm$ SD weight and BMI percentile were 39.6 $\pm$ 13.5 kg and 70.1 $\pm$ 29.7, respectively. The mean $\pm$ SD dairy and calcium intakes of the subjects were 2.8 $\pm$ 1.4 cup equivalent/day and 1039.4 $\pm$ 431.4 mg/day, respectively. Mann-Whitney tests for baseline differences among weight status subgroups found significant differences between underweight subjects and each other subgroup in dairy consumption (p= 0.044 against normal, p= 0.014 against overweight, and p= 0.027 against obese), dietary calcium (p= 0.020, p= 0.001, and p= 0.017), and daily calorie intake (p= 0.017, p= 0.021, and p= 0.006). For each of these differences, underweight subjects had higher mean values than subjects in other groups. The only other significant differences were in weight, where each group differed from each other group ($p \leq$ 0.001) except for underweight vs. normal (p= 0.115), and in height, where normal subjects had a lower average value than obese subjects (p= 0.001).

Table 1: Baseline Characteristics of Subjects (Mean ± SD)

	All subjects n=101	Underweight n=3	Normal n=50	Overweight n=19	Obese n=29
Age (yr)	9.3 ± 1.0	9.3 ± 0.6	9.2 ± 1.2	9.2 ± 1.1	9.3 ± 0.9
Height (cm)	138.5 ± 8.5	138.5 ± 7.4	136.1 ± 8.9	138.9 ± 7.5	142.4 ± 7.3
Weight (kg)	39.6 ± 13.5	26.4 ± 3.5	31.3 ± 5.9	39.8 ± 6.5	55.2 ± 12.9
BMI Percentile	70.1 ± 29.7	3.0 ± 1.7	50.8 ± 23.3	89.3 ± 3.8	97.6 ± 1.3
Dairy Intake (cups/day)	2.8 ± 1.4	5.1 ± 1.9	2.9 ± 1.4	2.3 ± 1.1	2.7 ± 1.4
Dietary Calcium (mg/day)	1039.4 ± 431.4	1665.1 ± 341.7	1076.7 ± 415.0	885.0 ± 318.8	1101.3 ± 477.7
Calorie Intake (kcal/day)	1952.6 ± 641.4	3072.7 ± 853.5	1938.9 ± 618.6	2085.4 ± 725.3	1773.4 ± 479.1

Regression models were fitted to the data to assess the relationships of amounts of dairy product consumed (cup equivalent/day) and dietary calcium (mg/day) with BMI percentile (Table **2**). Higher levels of dairy product intake and dietary calcium were significantly associated with lower BMI percentile (β= -5.71%/cup per day, *p*= 0.005; β= -0.019%/mg per day, *p*= 0.005, respectively). The strength of these associations was lessened slightly when underweight subjects (n= 3) were removed (dairy intake: β= -3.81%/cup per day, *p*= 0.061; dietary calcium: β= -0.013%/mg per day, *p*= 0.048). Dairy product intake and dietary calcium were highly correlated (r= 0.935), so using them simultaneously as independent variables resulted in inflation of standard errors, rendering both effects non-significant. Consequently, models with both variables included simultaneously were not considered further.

Age and caloric intake were assessed as potential covariates in the regression models of BMI percentile on dairy product intake and dietary calcium. Neither age nor caloric intake was significant in either model (*p*= 0.914 and *p*= 0.838 respectively for dairy intake, and *p*= 0.852 and *p*= 0.939 respectively for dietary calcium), but the effects of dairy intake and dietary calcium on BMI percentile remained significant and consistent with the previous models (β= -5.51%/cup per day, *p*= 0.018; β= -0.020%/mg per day, *p*= 0.017, respectively). Removing underweight subjects, both age and caloric intake were still non-significant in both models, and results were similar to the original regression models with underweight subjects removed (dairy intake: β= -4.34%/cup per day, *p*= 0.055; dietary calcium: β= -0.017%/mg per day, *p*= 0.033).

Gender and weight status subgroup were entered into the regression models both as main effects and interacted with the dairy/calcium variable to assess moderating effects (Table **2**). Neither the main effect of gender nor the interaction of gender with the dairy/calcium variable was found to be significant in either of the models (*p*= 0.793 and *p*= 0.783 for the main effects in the dairy intake and dietary calcium models, respectively; *p*= 0.547 and *p*= 0.605 for the interaction effects in those models). These findings did not change substantially when underweight subjects were removed. Weight status subgroup had significant main effects in both models, and the interaction term was significant in the model with dietary calcium as an independent variable (p= 0.049). For the model including dairy intake, weight status subgroup, and their interaction as independent variables, the interaction approached significance (*p*= 0.077). In the underweight/normal group higher levels of dairy product intake were significantly associated with lower BMI percentile (β= -5.74%/cup per day, *p*= 0.001), but no such association was found in the overweight or obese groups (p= 0.984 and p= 0.952, respectively). Similar patterns were observed in the model with dietary calcium. In the normal group, higher levels of dietary calcium were significantly associated with lower BMI percentile (β= -0.021%/mg per day, *p*< 0.001), but no such association was found in the overweight or obese groups (*p*= 0.933 and *p*= 0.917, respectively). Removal of underweight subjects from the analysis had only minor impacts on the results. The interaction of weight status subgroup with dairy intake became non-significant (p= 0.281), although tests of effects in each group still found a significant association between dairy intake and BMI percentile in the normal weight group (p= 0.021) and no significant association in the overweight or obese groups. Similarly, the interaction of weight status subgroup with dietary calcium became non-significant (p= 0.221), although tests of effects in each group still found a significant association between dietary calcium and BMI percentile in the normal weight group (p= 0.017) and no significant association in the

Table 2: Regression Models for Relationships of Dairy Product Consumed and Dietary Calcium with BMI Percentile (n=101)

Main effects models for BMI percentile by dairy intake and dietary calcium[a]						
	Moderator	Effect	Estimate	Std. Error	t	p value
Dairy intake	-	Intercept	86.121	6.286	13.700	< 0.001
	-	Dairy Intake	-5.709	1.993	-2.865	0.005
Dietary Calcium	-	Intercept	89.970	7.460	12.061	<0.001
	-	Dietary Calcium	-0.019	0.007	-2.886	0.005
Regression model for BMI percentile by dairy intake, dietary calcium, gender/weight status subgroups[b]						
	Moderator	**Effect**	**Estimate**	**Std. Error**	**t**	**p value**
Dairy intake	Gender	Intercept	86.707	8.748	9.912	<0.001
		Dairy Intake	-6.364	2.560	-2.486	0.015
		Female	-3.403	12.929	-0.263	0.793
		Male	0	-	-	-
		Female × Dairy Intake	2.594	4.294	0.604	0.547
		Male × Dairy Intake	0	-	-	-
	Weight status subgroup	Intercept	97.172	7.134	13.620	<0.001
		Dairy Intake	0.139	2.321	0.060	0.952
		Normal/Underweight	-31.636	8.968	-3.528	0.001
		Overweight	-8.032	12.101	-0.664	0.508
		Obese	0	-	-	-
		Normal/Underweight × Dairy Intake	-5.882	2.822	-2.084	0.040
		Overweight × Dairy Intake	-0.064	4.478	-0.014	0.989
		Obese × Dairy Intake	0	-	-	-
Dietary Calcium	Gender	Intercept	90.707	10.383	8.736	<0.001
		Dietary Calcium	-0.021	0.009	-2.441	0.016
		Female	-4.271	15.503	-0.276	0.783
		Male	0	-	-	-
		Female × Dietary Calcium	0.007	0.014	0.518	0.605
		Male × Dietary Calcium	0	-	-	-
	Weight status subgroup	Intercept	96.814	7.759	12.478	<0.001
		Dietary Calcium	0.001	0.007	0.105	0.917
		Normal/Underweight	-25.909	10.273	-2.522	0.013
		Overweight	-6.525	14.456	-0.451	0.653
		Obese	0	-	-	-
		Normal/Underweight × Dietary Calcium	-0.021	0.009	-2.368	0.020
		Overweight × Dietary Calcium	-0.002	0.015	-0.124	0.902
		Obese × Dietary Calcium	0	-	-	-

[a]The inverse relationship of dairy intake and dietary calcium with BMI percentile remained when they were controlled for potential covariates, age and caloric intake.
[b]The inverse relationship of dairy intake and dietary calcium with BMI percentile in the normal/underweight subgroup remained when they were controlled for potential covariates, age and caloric intake.

overweight or obese groups. All of the models incorporating moderating effects of gender and weight status subgroup were run with age and caloric intake as covariates. Inclusion of these terms in the model changed p-values slightly, but all findings of significance were unchanged.

Table 3: Summary of MyPyramid Food Groups, Calories, Macronutrients, and Micronutrients (Mean ± SD)

	All subjects n=101	Normal/Underweight n=53	Overweight BMI n=19	Obese BMI n=29
Grains (ounce equivalent)	6.69 ± 3.45	7.2 ± 3.9	5.91 ± 2.96	6.28 ± 2.76
Vegetables (cup equivalent)	0.75 ± 0.74	0.67 ± 0.7	0.98 ± 0.76	0.75 ± 0.79
Fruits (cup equivalent)	1.31 ± 0.98	1.26 ± 0.98	1.61 ± 1.15	1.2 ± 0.86
Dairy (cup equivalent)	2.81 ± 1.44	3.03 ± 1.52	2.32 ± 1.08	2.73 ± 1.43
Meat and Beans (ounce equivalent)	3.59 ± 2.64	3.79 ± 2.92	3.83 ± 2.29	3.08 ± 2.31
Calories (kcal/day)	1952.62 ± 641.42	2003.08 ± 677.17	2085.41 ± 725.33	1773.41 ± 479.05
Protein (g/day)	68.39 ± 23.45	71.06 ± 23.72	66.61 ± 19.93	64.66 ± 25.19
Carbohydrates (g/day)	270.21 ± 94.47	271.36 ± 103.77	293.36 ± 90.77	252.93 ± 76.83
Fiber (g/day)	13.22 ± 5.52	13.39 ± 5.23	14.31 ± 5.73	12.2 ± 5.93
Sugar (g/day)	127.61 ± 63.65	124.71 ± 63.55	150.79 ± 59.3	117.72 ± 65
Total Fat (g/day)	69.47 ± 34.78	73.62 ± 36.85	75.42 ± 42.14	58 ± 21.53
Saturated Fat (g/day)	26 ± 16.97	27.87 ± 20.84	25.38 ± 13.06	22.99 ± 9.77
Vitamin A (IU/day)	4084.74 ± 4567.84	4361.9 ± 5248.36	4290.3 ± 4287.37	3443.55 ± 3308.51
Vitamin C (mg/day)	85.34 ± 80.84	82.27 ± 71.89	114.77 ± 126.25	71.69 ± 51.93
Calcium (mg/day)	1039.35 ± 431.41	1110.03 ± 430.85	885.04 ± 318.79	1011.28 ± 477.69
Iron (mg/day)	12.03 ± 5.59	13.07 ± 5.21	10.75 ± 3.62	10.99 ± 6.97

A MANOVA model examined differences between the weight status subgroups in dietary intake measured as daily servings of MyPyramid food groups as well as calories, macronutrients, and micronutrients (Table **3**). No significant differences (Pillai's Trace F= 1.379, df= 32 and 168, p= 0.100) were detected in these dietary variables between groups. None of the individual tests of differences between groups were found to be significant. Removing underweight subjects from the analysis had no impact on the MANOVA findings.

DISCUSSION

In addition to the well-established role of calcium in bone and mineral metabolism, recent studies suggest that high calcium intake may lead to reduced body fat accumulation or enhance fat mass loss during energy restriction [8-12]. Some [5-12, 29-37], but not all [13-26], evidence support an inverse relationship between calcium and/or dairy product intake and body fat mass. The majority of the work conducted in this area of inquiry has focused on the adult population; while only a relatively limited number of studies have investigated the relationship in children and adolescents [14]. Due to the conflicting published data, limited longitudinal, human clinical trials, and the alarming increase in rates of childhood obesity *and* the strong role of dietary factors, there is a critical need to better understand the impact of a high calcium and/or dairy diet on body weight regulation, particularly in children.

In the current study, we demonstrated that dairy intake and dietary calcium were inversely related to BMI percentile using a sample of healthy U.S. children, aged 8 to 13 years old. When relationships were assessed in weight status subgroups (normal, overweight, and obese), the inverse association between dairy and calcium with BMI percentile was observed only in normal subjects. Results from the MANOVA test indicated no significant differences in dietary intake among the subgroups.

Results from the current study bear some similarity to other evidence published in the peer-reviewed literature. For example, in a cross-sectional baseline analysis of children aged, 9 to 14 years old, conducted by Rockett *et al*., it was shown that overweight subjects consumed fewer dairy products than non-overweight children [38]. In a study published by Novotny *et al*., similar results were produced [6]. In that analysis, which included Asian and Caucasian early adolescents aged 9 to 14 years old, calcium intake, age, and physical activity inversely correlated with iliac skinfold thickness. Dairy calcium was shown to have a stronger association than total dietary calcium. On the other hand, results from this study demonstrate inconsistency with other published data. In a prospective, secondary analysis, Phillips *et al*. demonstrated no associations of calcium and/or dairy intake with BMI or percent body fat in non-obese preadolescent girls [21]. In another study of young girls, Lorenzen *et al*. demonstrated that there was no impact of calcium supplementation on height, body weight, body fatness, or lean mass over a year period [20]. And in a recently published review, it was demonstrated that milk and milk products do not negatively affect body weight and composition in children and adolescents [41].

One complicating factor that makes the interpretation of studies difficult in the critical analysis of calcium consumption and body composition is that the primary source of calcium is dairy products. Independent from its calcium content, dairy protein (a macronutrient having high satiety properties) [39] and other dairy components (e.g., caseinomacropeptide or CMP) [40] have been implicated themselves in regulating body composition and food intake or affecting mediators of food intake. In the current study, we demonstrated that both calcium and dairy (separately) were inversely correlated with BMI percentile.

There are several strengths and limitations to this study that need to be addressed. One such strength is the use of free-living subjects. While a study conducted in a controlled environment might yield more accurate results (i.e., capturing and controlling for daily variations in influential lifestyle factors), one might argue that the results of this study better reflect what might occur in response to a public health recommendation to increase dairy calcium aimed at children. The method employed for dietary data collection (24-hour recall, using the USDA Five-Step Multiple Pass Method) is another strength of the current study since it has enhanced recall with reduced respondent burden. In addition to these strengths, there are limitations worth noting. First, a cause and effect relationship can't be established due to the observational nature of this study. The cross-sectional (observation made at single time point) versus longitudinal (multiple observations made over time) design of this study presents an additional limitation. The lack of physical activity data is another study weakness, which introduces a potential unmeasured confounding variable to the current study. Unfortunately, this limitation could not be overcome, since this study was a secondary analysis of an existing dataset.

In summary, we demonstrated an inverse relationship between calcium/dairy intake and BMI percentile in preadolescent children. Interestingly, when weight status subgroups were explored, the relationship was lost in overweight and obese children, but maintained in normal weight children. Results from this study provide evidence for a potential beneficial role of dairy and calcium consumption in achieving a healthy body weight in preadolescent children and the basis for further examination of the relationship between dietary calcium/dairy and body weight and fat mass. Additional longitudinal and/or experimental research (i.e., a randomized controlled trial) is needed to further explore the relationship of calcium/dairy product intake with changes in body weight and fat mass in children and adolescents.

ACKNOWLEDGEMENT

We thank Dr. Christopher Holloman and Ms. Jennifer Squiric for their assistance with data analysis. This study was supported in part by American Dairy Association Mideast and The Columbus Foundation.

This research was presented at Experimental Biology, New Orleans, LA, April 2009. Study approved by The Ohio State University Institutional Review Board.

DISCLOSURE

There are no financial disclosures or conflicts of interests related to this study.

REFERENCES

[1] Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. JAMA 2012; 307: 483-90. http://dx.doi.org/10.1001/jama.2012.40

[2] Daniels SR, Arnett DK, Eckel RH, Gidding SS, Hayman LL, Kumanyika S, *et al.* Overweight in children and adolescents: pathophysiology, consequences, prevention, and treatment. Circulation 2005; 111: 1999-12. http://dx.doi.org/10.1161/01.CIR.0000161369.71722.10

[3] Goodman E, Whitaker RC. A prospective study of the role of depression in the development and persistence of adolescent obesity. Pediatrics 2002; 110: 497-504. http://dx.doi.org/10.1542/peds.110.3.497

[4] Wang G, Dietz WH. Economic burden of obesity in youths aged 6 to 17 years: 1979-1999. Pediatrics 2002; 109: E81. http://dx.doi.org/10.1542/peds.109.5.e81

[5] Davies KM, Heaney RP, Recker RR, Lappe JM, Barger-Lux MJ, Rafferty K, *et al.* Calcium intake and body weight. J Clin Endocrinol Metab 2000; 85: 4635-38. http://dx.doi.org/10.1210/jc.85.12.4635

[6] Novotny R, Daida YG, Acharya S, Grove JS, Vogt TM. Dairy intake is associated with lower body fat and soda intake with greater weight in adolescent girls. J Nutr 2004; 134: 1905-909.

[7] Pereira MA, Jacobs DR, Van Horn L, Slattery ML, Katashov AI, Ludwig DS. Dairy consumption, obesity, and the insulin resistance syndrome in young adults: The CARDIA study. JAMA 2002; 287: 2081-89. http://dx.doi.org/10.1001/jama.287.16.2081

[8] Eagan MS, Lyle RM, Gunther CW, Peacock M, Teegarden D. Effect of 1-year dairy product intervention on fat mass in young women: 6-month follow-up. Obesity 2006; 14: 2242-48. http://dx.doi.org/10.1038/oby.2006.263

[9] 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: 754-60.

[10] Skinner JD, Bonds W, Carruth BR, Ziegler P. Longitudinal calcium intake is negatively related to children's body fat indexes. J Am Diet Assoc 2003; 103: 1626-31. http://dx.doi.org/10.1016/j.jada.2003.09.018

[11] Zemel MB, Richards J, Mathis S, Milstead A, Gebhardt L, Silva E. Dairy augmentation of total and central fat loss in obese subjects. Int J Obesity 2005; 29: 391-97. http://dx.doi.org/10.1038/sj.ijo.0802880

[12] Zemel MB, Thompson W, Milstead A, Morris K, Campbell P. Calcium and dairy acceleration of weight and fat loss during energy restriction in obese adults. Obes Res 2004; 12: 582-90. http://dx.doi.org/10.1038/oby.2004.67

[13] Barr SI. Increased dairy product or calcium intake: is body weight or composition affected in humans? J Nutr 2003; 133: 245S-48S.

[14] Barr SI. Calcium and body fat in peripubertal girls: cross-sectional and longitudinal studies. Obesity 2007; 15: 1302-10. http://dx.doi.org/10.1038/oby.2007.152

[15] Berkey CS, Rockett HRH, Willett WC, Colditz GA. Milk, dairy fat, dietary calcium, and weight gain. Arch Pediatr Adolesc Med 2005; 159: 543-50. http://dx.doi.org/10.1001/archpedi.159.6.543

[16] Bowen J, Noakes M, Clifton PM. Effect of calcium and dairy foods in high protein, energy-restricted diets on weight loss and metabolic parameters in overweight adults. Int J Obesity 2005; 29: 957-65. http://dx.doi.org/10.1038/sj.ijo.0802895

[17] DeJongh ED, Binkley TL, Specker BL. Fat mass gain is lower in calcium supplemented than in unsupplemented preschool children with low dietary calcium intakes. Am J Clin Nutr 2006; 84: 1123-27.

[18] Gunther CW, Legowski PA, Lyle RM, McCabe GP, Eagan MS, Peacock M, *et al.* Dairy products do not lead to alterations in body weight and fat mass in young women in a one year intervention. Am J Clin Nutr 2005; 81: 751-56.

[19] Harvey-Berino J, Gold BC, Lauber R, Starinski A. The impact of calcium and dairy product consumption on weight loss. Obes Res 2005; 13: 1720-26. http://dx.doi.org/10.1038/oby.2005.210

[20] Lorenzen JK, Molgaard C, Michaelsen KF, Astrup A. Calcium supplementation for one year does not reduce body weight or fat mass in young girls. Am J Clin Nutr 2006; 83: 18-23.

[21] Phillips SM, Bandini LG, Cyr H, Cloclough-Douglas S, Naumova E, Must A. Dairy food consumption and body weight and fatness studied longitudinally over the adolescent period. Int J Obes 2003; 27: 1106-13. http://dx.doi.org/10.1038/sj.ijo.0802370

[22] Shapses SA, Heshka S, Heymsfield SB. Effect of calcium supplementation on weight and fat loss in women. J Clin Endocrinol Metab 2004; 89: 632-37. http://dx.doi.org/10.1210/jc.2002-021136

[23] Thompson WG, Rostad Holdman N, Janzow DJ, Slezak JM, Morris KL, Zemel MB. Effect of energy-reduced diets high in dairy products and fiber on weight loss in obese adults. Obes Res 2005; 13: 1344-53. http://dx.doi.org/10.1038/oby.2005.163

[24] Wagner G, Kindrick S, Hertzler SM, DiSilvesto RA. Effects of various forms of calcium on body weight and bone turnover markers in women participating in a weight loss program. J Am Coll Nutr 2007; 26: 456-61.

[25] Winzenberg T, Shaw L, Fryer J, Jones G. Calcium supplements in children do not affect weight gain, height, or body composition. Obesity (Silver Spring) 2007; 15: 1789-98. http://dx.doi.org/10.1038/oby.2007.213

[26] Yanovski JA, Parikh SJ, Yanoff LB, Denkinger BI, Calis KA, Reynolds JC, *et al.* Effects of calcium supplementation on body weight and adiposity in overweight and obese adults. Ann Intern Med 2009; 150: 821-29.

[27] Lytle LA, Nichaman MZ, Obarzanek E, Glovsky E, Montgomery D, Nicklas T, *et al.* Validation of 24-hour recalls assisted by food records in third-grade children. The CATCH Collaborative Group. J Am Diet Assoc 1993; 93: 1431-36. http://dx.doi.org/10.1016/0002-8223(93)92247-U

[28] National Center for Health Statistics. CDC Growth Charts. Version current 2000. Internet: http://www.cdc.gov/growthcharts (accessed on 1/15/10).

[29] Barba G, Troiano E, Russo P, Venezia A, Siani A. Inverse association between body mass and frequency of milk consumption in children. Br J Nutr 2005; 93: 15-19. http://dx.doi.org/10.1079/BJN20041300

[30] Carruth BR, Skinner JD. The role of dietary calcium and other nutrients in moderating body fat in preschool children. Int J Obes 2001; 25: 559-66. http://dx.doi.org/10.1038/sj.ijo.0801562

[31] dos Santos LC, de Pa´dua Cintra I, Fisberg M, Martini LA. Calcium intake and its relationship with adiposity and insulin resistance in post-pubertal adolescents. J Hum Nutr Diet 2008; 21: 109-16. http://dx.doi.org/10.1111/j.1365-277X.2008.00848.x

[32] Heaney RP. Normalizing calcium intake: Projected population effects for body weight. J Nutr 2003; 133: 268S-70S.

[33] Jacqmain M, Doucet E, Despres JP, Bouchard C, Tremblay A. Calcium intake, body composition, and lipoprotein-lipid concentrations in adults. Am J Clin Nutr 2003; 77: 1448-52.

[34] Major GC, Alarie F, Dore J, Phouttama S, Tremblay A. Supplementation with calcium + vitamin D enhances the beneficial effect of weight loss on plasma lipid and lipoprotein concentrations. Am J Clin Nutr 2007; 85: 54-59.

[35] Moore LL, Bradlee ML, Gao D, Singer MR. Low dairy intake in early childhood predicts excess body fat gain. Obesity 2006; 14: 1010-18. http://dx.doi.org/10.1038/oby.2006.116

[36] Ochner CN, Lowe MR. Self-reported changes in dietary calcium and energy intake predict weight regain following a weight loss diet in obese women. J Nutr 2007; 137: 2324-28.

[37] Zemel MB, Donnelly JE, Smith BK, Sullivan DK, Richards J, Morgan-Hanusa D, *et al.* Effects of dairy intake on weight maintenance. Nutr Metab (Lond) 2008; 5: 28. http://dx.doi.org/10.1186/1743-7075-5-28

[38] Rockett HR, Berkey CS, Field AE, Colditz GA. Cross-sectional measurement of nutrient intake among adolescents in 1996. Prev Med 2001; 33: 27-37. http://dx.doi.org/10.1006/pmed.2001.0850

[39] Halton TL, Hu FB. The effects of high protein diets on thermogenesis, satiety and weight loss: a critical review. J Am Coll Nutr 2004; 23: 373-85.

[40] Pedersen NL, Nagain-Domaine C, Mahé S, Chariot J, Rozé C, Tomé D. Caseinomacropeptide specifically stimulates exocrine pancreatic secretion in the anesthetized rat. Peptides 2000; 21: 1527-35. http://dx.doi.org/10.1016/S0196-9781(00)00307-7

[41] Spence LA, Cifelli CJ, Miller GD. The Role of Dairy Products in Healthy Weight and Body Composition in Children and Adolescents. Curr Nutr Food Sci 2011; 7: 40-49.

Received on 28-01-2013 Accepted on 21-02-2013 Published on 28-02-2013

http://dx.doi.org/10.6000/1929-4247.2013.02.01.1