Does Dairy Calcium Intake Enhance Weight Loss Among Overweight Diabetic Patients?

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OBJECTIVE — To examine the effect of dairy calcium consumption on weight loss and improvement in cardiovascular disease (CVD) and diabetes indicators among overweight diabetic patients.

RESEARCH DESIGN AND METHODS — This was an ancillary study of a 6-month randomized clinical trial assessing the effect of three isocaloric diets in type 2 diabetic patients: *1*) mixed glycemic index carbohydrate diet, *2*) low–glycemic index diet, and *3*) modified Mediterranean diet. Low-fat dairy product consumption varied within and across the groups by personal choice. Dietary intake, weight, CVD risk factors, and diabetes indexes were measured at baseline and at 6 months.

RESULTS — A total of 259 diabetic patients were recruited with an average BMI $>$31 kg/m^2 and mean age of 55 years. No difference was found at baseline between the intervention groups in CVD risk factors, diabetes indicators, macronutrient intake, and nutrient intake from dairy products. Dairy calcium intake was associated with percentage of weight loss. Among the high tertile of dairy calcium intake, the odds ratio for weight loss of $>$8% was 2.4, $P = 0.04$, compared with the first tertile, after controlling for nondairy calcium intake, diet type, and the change in energy intake from baseline. No association was noted between dairy calcium and other health indexes except for triglyceride levels.

CONCLUSIONS — A diet rich in dairy calcium intake enhances weight reduction in type 2 diabetic patients. Such a diet could be tried in diabetic patients, especially those with difficulty adhering to other weight reduction diets.

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Recent studies suggest that calcium metabolism and perhaps other components of dairy products may contribute to weight reduction in animal and human models (1,2). In addition, an accumulating body of evidence suggests that calcium-rich diets play a direct role in the prevention of obesity (2–5). Zemel et al. (4) analyzed data from National Health and Nutrition Examination Study III and demonstrated that the odds of being in the highest quartile of adiposity are negatively associated with calcium and dairy product intake. These findings have been confirmed in other settings as well (6,7). Other studies (8–10), however, did not find significant effects of dairy consumption on body weight and body composition.

Dairy consumption is an emerging factor that might affect insulin resistance syndrome (IRS). Prevalence of obesity and type 2 diabetes have increased concomitantly with the decrease in milk intake over the past three decades (11–13). In a cross-sectional study conducted by Mennen et al. (14), an inverse association between dairy intake and IRS was observed in men. More recently, analysis of the Coronary Artery Risk Development in Young Adults study by Pereira et al. (15) showed that increased dairy consumption has a strong inverse association with IRS among overweight adults and may reduce the risk of type 2 diabetes. In another longitudinal study (16), low-fat dairy intake was associated with lower incidence of type 2 diabetes among men during 12 years of follow-up. However, in a 1-year randomized intervention trial (17) for dairy calcium among normal-weight, young, healthy women, increased consumption of dairy products did not alter body weight or fat mass of the participants.

Ancillary analyses of data from a randomized clinical trial allowed us to examine the impact of low-fat dairy consumption, particularly dairy calcium, on weight loss and type 2 diabetes indicators among overweight type 2 diabetic patients.

RESEARCH DESIGN AND METHODS

— We recruited type 2 diabetic participants from a health maintenance organization (Clalit HMO) who met the following inclusion criteria: *1*) type 2 diabetes duration of 1–10 years according to the primary care physician's diagnosis, *2*) aged between 30 and 65 years, *3*) BMI 27–34 kg/m^2, *4*) A1C levels 7–10%, *5*) plasma triglyceride levels 160–400 mg/dl, *6*) creatinine $<$1.4 mg/dl, and *7*) $\geq$3 months on the same medications before entering the study.

The study protocol was approved by the ethics committee of Soroka University Medical Center, Beer-Sheva, Israel. All participants provided written informed consent and were assigned to one of three isocaloric diets: mixed glycemic index carbohydrate diet (MGI), low–glycemic index diet (LGI), and modified Mediterranean diet (MMD). Dairy consumption was not predetermined by the diet plan and varied within and across the groups by personal choice. All three diet plans were based on food groups, and participants could design their own plan based on their choices. Low-fat dairy products (0–5% fat) were included in the protein group and thus could be consumed in lieu

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Abbreviations: CVD, cardiovascular disease; IRS, insulin resistance syndrome; LGI, low–glycemic index diet; MMD, modified Mediterranean diet; MGI, mixed glycemic index carbohydrate diet.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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of other sources of protein such as meat and legumes.

Outcome measurements

For the purpose of this study, we compared the values of the outcome variables at baseline and at the 6-month visit.

Clinical measurements. Weight, height, and waist and hip circumferences (mean of two measurements) were obtained at both visits. Body weight was measured using a single calibrated scale (Detecto, Webb City, MO) with the patient wearing light clothing and no shoes. Height was measured with a wall-mounted stadiometer. To control for differences in baseline measurements, we calculated changes in the measurements as the percentage of difference from baseline values. Waist circumference was measured in a standing position, with measurements obtained midway between lateral lower-rib margin and the iliac crest. The measurements were taken mid-exhalation using a spring-calibrated tape measure, and the average of two readings was recorded. Blood pressure was measured by the primary care physician using an automated instrument with digital readout (Dinamap; Criticon, Tampa, FL) with the patient sitting, after 5 minutes rest. Values represent a mean of two readings.

Dietary questionnaires. All participants completed a validated food frequency questionnaire (18,19). The dietary assessment questionnaires were analyzed in the S. Daniel Abraham International Center for Health and Nutrition at Ben-Gurion University (20) for total macronutrient and micronutrient intake. Intake of dairy products was calculated by summing the intake of all dairy products that are included in the food frequency questionnaire in grams and averaged per day. The percentage of contribution of these products to the total daily energy intake was also calculated.

Physical activity questionnaire. Physical activity was measured by a questionnaire that was based on synthesis and modification of previously validated international questionnaires (21,22). The questionnaire includes a table with a list of recreational activities with intensity, duration, and frequency of each activity in the past 6 months. It also includes questions regarding hours of sleep and activities at work, at home, and during the weekend. Energy expenditure was calculated using the Harris and Benedict equation (23). The resting energy expenditure for each participant was calculated using sex-specific equations. An activity factor according to the individual's total 24-h activities (23,24) was computed at baseline and at 6 months.

Laboratory measurements

All tests were performed in a central laboratory of Clalit Health Services. The following measurements were obtained: fasting blood glucose (glucose-oxidase technique, Hitachi 747), plasma insulin levels (immuno-enzymatic technique, Immulite 2000), homeostasis model assessment, A1C (Cobas-integra), total cholesterol, HDL cholesterol, and triglycerides (Hitachi 747). All the blood test samples were taken after an overnight fast by standard methods (25). We used the Fridewald formula (26) to calculate LDL cholesterol.

Statistical analyses

Statistical analyses were conducted using SPSS version 12. One-way ANOVA or paired Student's *t* tests were used to compare between the diet groups at baseline and between baseline and 6 months. Generalized linear models were used to compare between various parameters by dairy calcium tertiles. Weight loss percentage of change was computed and recoded as a dichotomous variable using the median values as cutoffs. Multivariable logistic regression model was used to determine the independent contribution of dairy calcium intake (defined by tertiles of intake) to weight change percentage after controlling for possible confounders. Goodness-of-fit measures were used to select the best fitting model.

RESULTS — The average BMI of the 259 diabetic patients recruited for the study was >31 kg/m^2, and the average age was ~55 years. No difference in any of the coronary heart disease risk factors or in any of the diabetes indicators was noted between the three diet groups at baseline. In addition, no significant difference in macronutrient intake was noted at baseline between the groups. The mean ± SD daily energy intake after 6 months of intervention was 1,908.0 ± 521.6 kcal for the MGI, 1,924.6 ± 534.8 kcal for the LGI, and 1,995.7 ± 513.5 kcal for the MMD. Mean protein intake at 6 months was ±90.523.4 g for the MGI, ±95.123.3 g for the LGI, and ±99.425.6 g for the MMD. The fiber intake at 6 months was 30.8 ± 9.1 g in the MGI, 31.4 ± 9.1 g in the LGI, and 33.3 ± 10.9 g in the MMD, with no significant difference among the groups. Calcium intake was also similar in all three diet groups, with an average daily intake of >800 mg.

No difference in nutrient intake from dairy products was detected between the groups (Table 1). After 6 months, mean protein intake was 20.1 g for the MGI, 17.8 g for the LGI, and 20.4 g for the MMD. Dairy products contributed 276.2 kcal in the MGI, 265.5 kcal in the LGI, and 276.6 kcal in the MMD. The lack of significant difference in dairy intake between the diet groups allows us to examine the relationship between dietary intake of dairy and weight in the group as a whole.

To examine dietary intake by level of dairy calcium, we compared dietary intake of selected nutrients by dairy calcium intake tertiles. The group with the highest calcium intake consumed significantly more energy (1,998.0 ± 412 vs. 1,897.2 ± 433.5 and 1,692.4 ± 450 kcal in the medium and lower tertiles, respectively, $P = 0.001$) and saturated fat (11.2 ± 2.2 vs. 10.3 ± 1.4 and 9.8 ± 1.6 g in the medium and lower tertiles, respectively, $P < 0.001$). This group also consumed significantly less polyunsaturated fat (10.8 ± 2.4 vs. 12.9 ± 3.2 and 12.4 ± 2.9 in the medium and lower tertiles, respectively, $P < 0.001$) and vitamin E (5.2 ± 3.9 vs. 6.1 ± 4.4 and 7.5 ± 6.4 mg in the medium and lower tertiles, respectively, $P = 0.04$), suggesting lower intake of vegetable oils. No difference between the groups was detected in other nutrients. The comparison of micronutrient intake between the groups was adjusted for energy intake.

To determine whether dairy calcium intake (in tertiles) is an independent and unconfounded factor associated with weight loss and other cardiovascular disease (CVD) and diabetes indexes, we used generalized linear models. In the models, we controlled for age and change in energy intake from baseline (Table 2). The models examined the percentage of change at 6 months from baseline in weight and waist circumference, selected CVD risk factors, and diabetic indicators. Percentages of weight and triglyceride changes from baseline were the only variables that differed significantly between the dairy calcium intake tertiles. Percentage of weight change was 8.5 ± 2.9% in the highest dairy calcium tertile vs. 7.5 ± 3.3% and 6.4 ± 3.9% in the medium and lowest tertiles, respectively ($P = 0.03$). We excluded from the final models

Table 1—*Daily nutrients intake from dairy products by diet group at baseline and after 6 months of intervention*

	Baseline*			6 months*†		
	MGI	LGI	MMD	MGI	LGI	MMD
Protein (g)	27.1 ± 18.2	23.3 ± 14.2	26.0 ± 19.5	20.1 ± 10.8	17.8 ± 12.0	20.4 ± 9.9
Total fat (g)	20.2 ± 14.0	18.0 ± 13.1	18.5 ± 16.9	11.2 ± 9.4	10.6 ± 9.0	11.1 ± 7.9
Carbohydrates (g)	26.5 ± 21.8	22.8 ± 17.2	26.0 ± 36.9	23.9 ± 26.2	24.8 ± 29.6	23.7 ± 19.4
Dairy product energy (kcal)	396.0 ± 252.2	346.3 ± 212.7	374.7 ± 363.0	276.2 ± 203.6	265.5 ± 225.3	276.6 ± 150.0
Calcium (mg)	672.7 ± 433.5	573.8 ± 348.2	569.0 ± 293.3	450.2 ± 190.5	419.8 ± 210.7	467.7 ± 234.3
Magnesium (mg)	67.6 ± 43.7	58.8 ± 36.4	64.1 ± 63.3	54.6 ± 53.1	48.1 ± 39.8	48.4 ± 24.6
Total cholesterol (mg)	60.7 ± 42.0	53.4 ± 37.5	57.6 ± 61.4	35.0 ± 27.9	35.2 ± 40.9	34.8 ± 23.5
Saturated fat (g)	12.2 ± 8.4	10.8 ± 7.8	10.5 ± 6.3	6.4 ± 3.9	6.1 ± 3.9	6.7 ± 4.8
Monounsaturated fat (g)	6.5 ± 4.5	5.8 ± 4.1	6.0 ± 5.7	3.9 ± 3.3	3.6 ± 3.2	3.7 ± 2.4
Polyunsaturated fatty acids (g)	0.8 ± 0.6	0.7 ± 0.54	1.3 ± 5.1	0.7 ± 2.7	0.6 ± 2.2	0.4 ± 0.3

Data are means ± SD. *No significant difference between the diet groups at baseline and at 6 months. †No significant differences between the diets in the changes in dietary intake from baseline.

other suspected and known risk factors such as smoking, sex, and physical activity, as their presence in the models made no clinical or statistically significant difference.

The results of the logistic regression model describing the factors affecting weight change percentage higher and lower than the median value (8%) are presented in Table 3. The final model includes the variables non-dairy calcium intake, changes in energy intake from baseline, intake of dietary fiber, dairy calcium intake, and diet regimen. The latter two were entered as dummy variables, the first compared with lowest calcium intake and the second with the MGI.

CONCLUSIONS — We have demonstrated in our study that higher low-fat dairy intake among overweight type 2 diabetic patients on isocaloric-restricted regimens enhances the weight loss process. This remained true even after controlling for change in total energy, calcium intake from nondairy products, and diet type. An inverse relationship between dietary calcium (mainly from dairy products) and indexes of obesity has been suggested by epidemiological and experimental data (2–5,27,28) over the past two decades.

Zemel et al. (29), in a study aimed to reduce blood pressure, used two servings of yogurt per day for a 1-year period. The yogurt supplementation was sufficient to raise daily calcium intake from ~400 to 1,000 mg/day and resulted in a significant decrease in both serum insulin (from 22 ± 3 to 14 ± 4 μU/ml, $P < 0.03$) and body fat (from 32.3 ± 2.6 to 27.4 ± 3.1 kg, $P < 0.01$). Other studies showed the effect of dairy foods in cross-sectional designs (5,30) and clinical trials among obese adults of different age-groups (2,31–33). Among middle-aged and older women, intake of calcium and dairy products was associated with lower prevalence of the metabolic syndrome (34). However, none of these studies examined the effect of dairy foods on weight loss among type 2 diabetic patients as we have done in this study.

Table 2—*Characteristics of participants at baseline and the percent change in health indicators after 6 months by dairy calcium intake tertiles using general linear model analysis with age and change in energy intake from baseline in the model*

	Baseline characteristics				Percent change from baseline			
Variable	Tertile 1	Tertile 2	Tertile 3	P*	Tertile 1	Tertile 2	Tertile3	P†
Age (years)	55.9 ± 5.4	57.4 ± 5.1	55.9 ± 5.7	0.31	—	—	—	
Weight (kg)	84.3 ± 13.5	84.5 ± 11.4	89.1 ± 12.3	0.43	−6.4 ± 3.9	−7.5 ± 3.3	−8.5 ± 2.9	0.03
BMI (kg/m^2)	31.1 ± 2.9	31.5 ± 2.4	31.4 ± 3.2	0.77	−6.4 ± 3.9	−7.5 ± 3.3	−8.5 ± 2.9	0.03
Waist circumference (cm)	110.7 ± 10.2	111.0 ± 7.8	112.3 ± 9.6	0.07	−5.9 ± 3.5	−6.5 ± 3.1	−7.0 ± 2.5	0.12
A1C (%)	8.4 ± 0.8	8.3 ± 1.0	8.3 ± 0.9	0.81	−21.7 ± 7.8	−19.7 8.3	−22.6 ± 7.7	0.17
Glucose (mg/dl)	184.5 ± 34.6	185.8 ± 33.4	184.0 ± 30.8	0.95	−37.6 ± 10.9	−39.3 10.0	−38.8 ± 11.4	0.71
Total cholesterol (mg/dl)	213.4 ± 37.8	205.8 ± 30.3	210.9 ± 35.6	0.48	−15.9 ± 16.0	−16.5 ± 13.5	−19.3 ± 13.1	0.42
HDL cholesterol (mg/dl)	42.5 ± 8.5	42.3 ± 8.3	39.9 ± 7.4	0.14	−1.0 ± 14.2	−3.2 ± 14.0	−1.4 ± 16.1	0.65
LDL cholesterol (mg/dl)	123.4 ± 32.5	117.2 ± 29.7	123.7 ± 32.3	0.45	−16.9 ± 21.4	−16.1 ± 19.9	−19.9 ± 18.2	0.59
Triglyceride (mg/dl)	243.0 ± 67.7	236.8 ± 47.5	241.6 ± 59	0.95	−37.0 ± 17.8	−45.9 ± 13.4	−43.0 ± 18.4	0.02
Systolic blood pressure (mmhg)	140.5 ± 15.6	142.5 ± 15.1	140.3 ± 13.2	0.69	−11.5 ± 9.6	−12.5 ± 8.6	−13.5 ± 9.2	0.52
Diastolic blood pressure (mmhg)	87.8 ± 7.5	91.4 ± 8.3	89.8 ± 7.5	0.06	−12.3 ± 9.9	−16.2 ± 9.6	−14.8 ± 8.9	0.19

Data are means ± SD unless otherwise indicated. **P* for the differences between the groups at baseline. †*P* for the differences in the percent change in health variables from baseline by calcium tertile.

Table 3—*Logistic regression model to predict percent weight loss above the median value (>8 %) in 6 months*

Model	Weight change >8% OR	*P*	95% CI
Change in energy intake from baseline	1.0	0.49	0.99–1.02
LGI*	0.97	0.07	0.94–1.01
MMD*	1.6	0.15	0.85–3.01
Non-dairy calcium intake	1.0	0.67	0.99–1.01
Middle tertile of dairy calcium intake†	1.5	0.36	0.65–3.41
Highest tertile of dairy calcium intake†	2.4	0.04	1.10–5.50
Dietary fiber intake	1.0	0.19	0.98–1.11

*Each diet compared with MGI. †Each compared with lowest tertile of dairy calcium intake.

Dietary calcium plays a pivotal role in the regulation of energy metabolism. This was shown in obesity-prone transgenic mice, which demonstrated that low-calcium diets impeded body fat loss, whereas high-calcium diets suppressed fat accretion and weight gain on an obesity-promoting diet and markedly accelerated weight and fat loss during a caloric restriction regiment (35,36). Dairy calcium exerted significantly greater anti-obesity effects than supplemental calcium in these studies. Milk is also recognized as a rich source of bioactive compounds that may act (independently or synergistically) with the suppression of 1,25-dihydroxyvitamin D_3 to favorably affect nutrient portioning, metabolic efficiency, and fat loss (1,37). For example, milk proteins contain significant ACE-inhibitory activity. Recent data indicate that adipocyte lipogenesis is regulated, in part, by angiotensin II, and that adipocytes have an intact paractine/autocrine rennin-angiotensin system (37). Moreover, ACE inhibition mildly attenuates obesity in rodents. Thus, dairy-based ACE inhibition may explain, in part, the significantly greater effect exerted by dairy calcium than by non-dairy calcium on the percentage of weight loss in our participants.

We did not find any association between dairy calcium intake and other diabetes or CVD disease indexes such as waist circumference, A1C, HDL, LDL, and blood pressure, confirming findings from another study (2). The only significant change was detected in triglyceride levels among the second and the third highest tertiles, as was shown in the study of Jacqmain et al. (30). The lack of association between dairy calcium intake and other health indexes stands in contrast to findings from other studies that show a positive impact of dairy calcium on glucose tolerance (35), insulin resistance (15), and lipid profile (30), although none of these studies were conducted among diabetic patients.

We observed greater weight loss among people who consumed a lot of dairy calcium compared with low dairy calcium consumption, despite a significantly higher energy intake. The group with higher dairy calcium intake also consumed significantly more saturated fat and less polyunsaturated fat and vitamin E. It seems that people with lower calcium intake consumed more vegetable oils, while the high calcium group consumed more animal fat from dairy. In this study, we evaluated dietary intake both at baseline and after 6 months of intervention, in contrast with most studies assessing the association between calcium and weight loss. In a study by Zemel et al. (2), macronutrient intake was assessed, but no difference was shown between the different calcium intake groups in energy intake or energy percentage from fat, protein, and carbohydrates, despite the significant differences in weight and fat loss in the group with the higher dairy calcium intake.

The main limitation of our study is that it is an ancillary study. The main study was focused on comparing the effect of three isocaloric weight reduction regimens on CVD risk factors and diabetes indexes. We feel, however, that this limitation is largely offset by the high quality of dietary data obtained and the lack of differences between the diet groups at baseline and at 6 months in any parameter that might bias the association examined in this study, including dairy intake. In addition, we controlled for diet type by including the diet group variable in the multivariate model.

Dietary treatment for weight loss in most cases includes restriction of calories and food choice advice associated with various kinds of support. Most studies indicate that calorie restriction regimens are not highly effective, mainly because of poor compliance. Providing "a fair alternative" in terms of food choice that is both palatable and abundant may prove easier for obese type 2 diabetic patients and thus may improve compliance. Low-fat dairy products have several advantages over other sources of animal protein: lower fat content (0–5%), high calcium content, and presence of bioactive compounds.

Before recommending an increase in dairy consumption, it is important to take into consideration the possible negative effect of dairy products on prostate and breast cancer (38,39). Giovannucci et al. (39) hypothesized that the association shown in the Health Professionals Health Study between milk consumption and prostate cancer is due to the reduced production of vitamin D_3, an explanation that was used by Zemel et al. (31) to explain the positive effect on weight loss. In a recent study by Giovannucci et al. (39), it was shown that calcium intake exceeding 1,500 mg/day may be associated with a higher risk of advanced and fatal prostate cancer. Therefore, caution should be exercised when making dietary recommendations regarding the consumption of additional dairy foods beyond this limit. The association between dairy foods and breast cancer was assessed by Parodi (40). He reviewed 40 case control studies and 12 cohort studies regarding breast cancer and dairy intake but did not find any association between dairy product consumption and the risk of breast cancer. Therefore, it seems that this argument against increasing low-fat dairy consumption is somewhat weak. In conclusion, the recommendation of a diet rich in low-fat dairy products seems highly appropriate for weight loss among diabetic patients, in general, and female diabetic patients in particular.

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