Original Article

Investigation of the Effect of High Dairy Diet on Body Mass Index and Body Fat in Overweight and Obese Children

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ABSTRACT

Objective. To investigate whether an increase in dairy food consumption improves the changes in BMI and adiposity in children on an energy restricted diet.

Methods. Overweight and obese children (n = 120, age: 12-18 Yr, BMI: 27-40 kg/m^2) were randomized to receive a calorie restricted diet providing a 500 kcal/d deficit from total energy expenditure and two (n = 40), three (n = 40) or four (n = 40) servings of dairy products/day. Anthropometric measurements in addition to serum hs-CRP and lipid profile were measured at baseline and after 12 wk.

Results. Among the 96 children who completed the study, significant reductions in overall BMI, BMI z-score, weight, total body fat percentage and total body fat mass were observed ($p < 0.001$) but these reductions were not significantly affected by increasing dairy intake ($p > 0.05$). Overall waist/hip ratio, Serum vitamin D and lipid profile did not change significantly ($p > 0.05$) apart from a significant increase in HDL-cholesterol ($p < 0.001$) which was independent of dairy intake ($p > 0.05$).

Conclusion. Increased intake of dairy products does not lead to an augmented change in BMI, weight and body fat in overweight and obese children beyond what is achieved by calorie restriction. **[Indian J Pediatr 2009; 76 (11) : 1145-1150]**
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Whether dairy consumption is a determinant of the extent of body weight and fat loss in overweight and obese subjects during an energy restricted diet is controversial. Recently, several observational and cross-sectional studies have reported an inverse relationship between dairy consumption and body weight or body fat level.[1-5] Furthermore, dairy foods or calcium appear to decrease the risk of hypertension,[6] coagulopathy,[7] coronary artery disease,[8] stroke[9] and insulin resistance.[3] Although the possible anti-obesity effects of high calcium/dairy consumption has been supported by a number of studies, the mechanism by which these effects are exerted is still unclear. One mechanism has been proposed by Zemel *et al*.[2] According to this hypothesis intracellular calcium plays a key role in the etiology of obesity and associated metabolic disorders. Low calcium diets lead to an increase in intracellular calcium in adipocytes through the stimulation of calcitrophic hormones (parathyroid hormone and calcitriol). This may then result in stimulation of lipogenesis, suppression of lipolysis, adipocyte lipid filling and thereby increased adiposity whereas high calcium diets reverse this process *via* suppression of calcitrophic hormones.[10,11] Therefore, one of the potential targets for the prevention of obesity and also improving weight and fat loss in obese and overweight subjects may be the suppression of calcitrophic hormones by increasing dietary calcium intake. However, it must be noted that whist this hypothesis is supported by *in vitro* data and data from a specific obese mouse model, some

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studies in humans have failed to show any effects of calcium intake on lipogenic or lipolytic enzymes in humans.[4,12-17] Another proposed mechanism for the potential anti-obesity effect of calcium and dairy products is that increased dietary calcium may bind to fatty acids in colon, thereby inhibiting fat absorption and increasing fecal fat loss.[18-21] It has been suggested that calcium derived from dairy foods may be more effective than calcium derived from dietary supplements in the prevention of obesity and acceleration of weight loss, because of the additional bioactive substances in dairy products that act synergistically with calcium to decrease adiposity.[22,23]

However, despite current epidemiological data indicating a role of dietary calcium in regulating body weight, clinical and interventional trials designed to evaluate the effect of high calcium intake on body weight and body fat loss have been equivocal, both in studies with and without calorie restriction.[4,10,17,24-33] Because of the relatively small number of studies and the conflicting results, the relation between the intake of calcium or dairy products and the modifications in body fat or weight remains unclear. The purpose of this present study was to determine whether dairy consumption enhances weight and fat loss induced by caloric restriction in overweight and obese children.

MATERIALS AND METHODS

One hundred and twenty overweight or obese children were recruited to participate in the study. Inclusion criteria included an age between 12 and 18 yr, BMI between 27 and 40 kg/m^2, a low-calcium diet (current calcium consumption $\geq$ 500 mg/d and current dairy product consumption $\geq$ 2 serving/d, as determined by food frequency and diet history), no more than 3-kg weight change over the preceding 12 wk, and no recent (12 wk) changes in exercise frequency or intensity. Subjects were excluded from participation if they required the use of oral anti-diabetic agents or insulin; used anti-obesity pharmacotherapeutic agents and/or herbal preparations intended for the management of obesity; had a history of significant endocrine, hepatic, or renal disease; or suffered any form of malabsorption syndrome. Only data on subjects who completed the study are included in the analysis. Participants were randomized to one of the following outpatient dietary regimens for 12 wk: 1) a calorie restricted, low calcium diet providing a 500 kcal/d deficit from total energy expenditure and two servings of dairy products/day (n = 35); 2) a calorie restricted diet similar to that of group 1 and three servings of dairy products/day (n = 28); or 3) a calorie restricted diet similar to that of groups 1 and 2 and four servings of dairy products/day (n = 33). For each subject, total energy expenditure was calculated by an expert dietician according to the Harris-Benedict formula, then adding an individual activity factor, and subtracting 2100 kJ from the total. Discrepancies between estimated total energy expenditure and baseline caloric intake were resolved, if necessary, by repeat diet records reviewed by the project dietitian.

Although the diets were individualized to achieve a 500 kcal/person per day deficit, comparable advice was given to patients in all treatment groups, and diets were monitored weekly. Twenty-four-hour dietary recalls at baseline and during the diet period were used to assess energy and calcium intake.

This research was approved by the Mashhad University of Medical Sciences (MUMS) Ethics Committee; informed consent was obtained from all subjects, and the research was conducted in accordance with the ethical standards outlined in the Helsinki Declaration. All assessments were performed at baseline and at the end of the study after 12 wk.

For all patients, anthropometric parameters including weight, height, and waist circumference were measured using a standard protocol. Waist circumference was measured at the level of midway between the lower rib margin and the iliac crest. Subjects were asked to breathe normally, and to breathe out gently at the time of the measurement. The hip circumference measurement was taken at the point yielding the maximum circumference over the buttocks. Height, body weight, waist and hip circumference were measured with the subjects dressed in light clothing after an overnight fast. The body weight of each subject was measured with a standard scale to an accuracy of ±0.1 kg, and height was measured to an accuracy of ±0.1 cm.

Total body fat mass and percentage were assessed using a stand-on Bio Impedance Analyzer (BIA) (Tanita-305 body fat analyzer, Tanita Corp., Tokyo, Japan). the precision of this BIA was good (CV was < 1%), but sensitive to physiological factors such as exercise and food intake with an effect of up to 2.6% on the body fat percent estimate. Therefore, the BIA was used under constant conditions, fasted, before exercise and the same device was used in all subjects.

Blood samples were collected in the morning from each subject after an overnight fast. After being allowed to clot, the blood was then centrifuged at 2500 rpm for 15 min at room temperature to obtain serum. Hemolyzed samples were excluded from analysis. Serum was stored at 80 °C prior to analysis. Samples for lipid profile and measurement of serum hs-CRP were taken into plain Vacutainer tubes, and those for measurement of glucose were taken into Vacutainer™ tubes containing fluoride-oxalate.

TABLE 1. Comparison of Anthropometric and Biochemical Factors of all Study Participants

Parameter	Low Dairy (N = 35) Pre-treatment	Low Dairy (N = 35) Post-treatment	Normal Dairy (N = 28) Pre-treatment	Normal Dairy (N = 28) Post-treatment	High Dairy (N = 33) Pre-treatment	High Dairy (N = 33) Post-treatment	ANOVA (p) Time	ANOVA (p) Group	ANOVA (p) group x time
Age (year)	14.83 ± 2.09	-	15.07 ± 1.96	-	14.85 ± 2.06	-	-	-	-
Height (cm)	161.04 ± 6.89	-	160.50 ± 5.18	-	161.06 ± 7.39	-	-	-	-
Waist (cm)	92.27 ± 9.31	88.63 ± 7.28†	93.35 ± 8.87	91.25 ± 6.98	97.50 ± 10.03	94.95 ± 9.64*†	< 0.05	< 0.05	> 0.05
Hip (cm)	109.09 ± 6.65	107.30 ± 6.64*	110.30 ± 11.21	107.38 ± 6.99	110.47 ± 9.38	109.57 ± 8.71*	< 0.001	> 0.05	> 0.05
W/H ratio	0.85 ± 0.07	0.83 ± 0.06	0.85 ± 0.05	0.85 ± 0.05	0.88 ± 0.06	0.87 ± 0.05	> 0.05	> 0.05	> 0.05
Weight (kg)	76.57 ± 10.38	72.03 ± 10.22**	76.01 ± 13.21	71.10 ± 9.34***	80.33 ± 14.16	76.93 ± 12.64***	< 0.001	> 0.05	> 0.05
BMI (kg/m2)	29.68 ± 3.45	28.13 ± 3.27***	29.58 ± 4.25	28.66 ± 3.61**	30.96 ± 3.97	30.46 ± 4.29***	< 0.001	> 0.05	> 0.05
BMI z-score	1.81 ± 0.33	1.63 ± 0.42**	1.73 ± 0.46	1.72 ± 0.42**	1.92 ± 0.33	1.88 ± 0.35***	< 0.001	> 0.05	> 0.05
Total fat %	36.45 ± 5.60	34.66 ± 5.89***	37.74 ± 5.38	36.23 ± 5.06***	37.32 ± 5.07	35.36 ± 5.25***	< 0.001	> 0.05	> 0.05
Total fat mass (kg)	28.36 ± 7.41	24.96 ± 7.43***	29.05 ± 8.60	23.73 ± 4.66***	30.23 ± 7.17	27.97 ± 7.07***	< 0.001	> 0.05	> 0.05
Total cholesterol (mmol/l)	3.89 ± 0.87	3.76 ± 0.72	3.77 ± 0.67	3.78 ± 0.89	3.72 ± 1.14	3.80 ± 0.67	> 0.05	> 0.05	> 0.05
Triglycerides (mmol/l)	1.10 (0.74-1.57)	0.95 (0.79-1.56)	0.99 (0.65-1.12)	0.98 (0.78-1.38)	0.86 (0.58-1.20)	0.88 (0.71-0.97)	> 0.05	> 0.05	> 0.05
LDL-C (mmol/l)	2.07 ± 0.57	2.09 ± 0.51	2.08 ± 0.52	2.02 ± 0.58	2.15 ± 0.76	2.29 ± 0.61	> 0.05	> 0.05	> 0.05
HDL-C (mmol/l)	0.94 ± 0.20	1.09 ± 0.22**	1.01 ± 0.22	1.17 ± 0.32*	0.98 ± 0.16	1.22 ± 0.27***	< 0.001	> 0.05	> 0.05
hs-CRP (mg/l)	0.57 (0.51-0.66)	0.64 (0.59-0.73)*	0.63 (0.52-0.68)	0.63 (0.59-0.70)	0.56 (0.52-0.65)	0.68 (0.61-0.75)*	< 0.01	> 0.05	> 0.05
Vitamin D (ng/ml)	46.17 ± 22.47	51.07 ± 28.65†	29.32 ± 10.78	34.81 ± 13.27	32.14 ± 20.30	29.72 ± 18.32†	> 0.05	< 0.05	> 0.05
Calcium (mmol/l)	2.31 ± 0.23	2.35 ± 0.18	2.17 ± 0.25	2.27 ± 0.18	2.15 ± 0.29	2.36 ± 0.14**	< 0.01	> 0.05	> 0.05
Phosphorus (mmol/l)	1.08 ± 0.19	1.24 ± 0.43	1.29 ± 0.79	1.16 ± 0.15	1.12 ± 0.25	1.30 ± 0.16	> 0.05	> 0.05	> 0.05
Uric acid (mmol/l)	0.30 ± 0.06	0.30 ± 0.07†	0.24 ± 0.10	0.28 ± 0.07*	0.22 ± 0.06	0.27 ± 0.06**†	< 0.01	< 0.05	> 0.05

Values were expressed as mean ± SD or median and interquartile range. * Change over time within a group was significant by post-hoc Tukey test (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); † The pre-post changes differed between groups that were marked ($p < 0.05$).

A full fasted lipid profile comprising total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C) and low density lipoprotein (LDL-C) was determined for each patient. Serum lipid concentrations were measured by enzymatic methods. Serum level of vitamin D (25-hydroxy vitamin D) was measured by radioimmunoassay (Immunodiagnostic Systems, Ltd, Tyne and Wear, UK). CRP was measured by a PEG-enhanced immunoturbidimetry method with an Alycon analyzer (ABBOTT, Chicago, IL, USA).

All statistical analyses were performed using SPSS software (release 11.5, SPSS Inc., 2001). Values were expressed as mean ± SD or, in the case of non-normally distributed data, as median and inter-quartile range. Only subjects who completed the entire study (n = 96) were included in the data analysis. Comparison between pre- and post-treatment values was conducted by analysis of variance with repeated measures to determine the group effects (difference between change scores of the 3 dairy diet groups), time effects (difference between pre- and post-treatment values in each group) or group by time interactions. In the case of significant differences, Tukey correction was applied for multiple post-hoc comparisons. A two-sided p-value of < 0.05 was considered statistically significant.

RESULTS

Ninthy-six subjects completed the study (age = 14.91 ± 2.03, BMI = 30.09 ± 3.89). Reasons for drop-out (5, 12 and 7 subjects for the low, normal and high dairy diet groups, respectively) included dissatisfaction with lack of weight loss, reluctance to comply with calorie restriction in the weight loss study and being unable to comply with weekly dietitian visits and food records.

Effect consumption on anthropometric parameters

The subjects' characteristics at baseline and at 12 wk according to dietary group (low, normal or high dairy) are presented in table 1. Significant reductions in overall BMI, BMI z-score, weight, total body fat percentage and total body fat mass were observed ($p < 0.001$) but these reductions were not significantly affected by an increased dairy food consumption ($p > 0.05$). For the Waist/hip ratio, no significant changes in the values were observed ($p > 0.05$).

Effect of dairy consumption on lipid profile

A comparison between lipid profile status at baseline and at the end of study showed that most of the lipid parameters were unaltered compared to the baseline levels ($p > 0.05$). The only exception was HDL-cholesterol concentrations that were significantly increased overall ($p < 0.001$). However, these increases were not affected by the dairy content of diet ($p > 0.05$)

and were therefore probably due to the weight reduction.

Effect of dairy consumption on serum hs-CRP and vitmin D status

Overall, serum hs-CRP levels were significantly increased during the study ($p < 0.01$) and these increases were independent of dairy amount in the diets ($p > 0.05$). Serum vitamin D levels did not change significantly in comparison to the baseline levels ($p > 0.05$).

DISCUSSION

The main finding of the present study is that high dairy diets do not enhance the impact of a calorie restricted diet on BMI or fat loss over a short intervention period of 12 wk. Recently, a growing body of observational and epidemiological studies have demonstrated a beneficial role for dietary calcium and dairy products in reducing body fat and acceleration of weight and fat loss during energy restriction in adults.[3,4,10,34,35] However, a review of randomized trials of dairy products or calcium supplementation in adults did not support a benefit, with two studies showing weight gain in older adults randomized to dairy groups and only 1 of 17 trials demonstrating more weight loss in calcium-supplemented groups[36] and a recent study in normal-weight girls, aged 8 to 12 yr at enrollment and followed up through adolescence, found no evidence of a relationship between body fat and dairy food or calcium consumption.[37] However, results from studies in children have not been consistent. There have been some studies that have reported a beneficial role for long term consumption of dairy foods in weight and body fat reduction and also found an inverse relationship between calcium-rich diets and measures of obesity in children.[38-40] Contrary to these findings, some other studies which were conducted in children found no difference between children on calcium-rich diets compared to those children on usual diets and were unable to find any significant relationship between calcium or dairy consumption with BMI, body weight and fat mass. According to a recent review by Lanou and Bernard[41], none of the seven dairy trials[42-46] or eight calcium supplementation trials[47-53] with children demonstrated an effect of dairy or calcium on body weight, or, where measured, rate of weight change or body fat.

Our results showed that consuming a high-dairy diet not only does not lead to further change in BMI or fat loss from what is achieved by calorie restriction. Furthermore the results of other recent studies investigating the anti-obesity effects of high dairy or calcium diets are in agreement with our findings.[4,17,25,26,32,42] A probable reason for the positive results of some studies in augmentation of weight and fat loss by high calcium diets is the nature of these studies. Many of these studies have been retrospective and retrospective studies are always influenced by reporting bias. Besides, the positive results in epidemiological studies may be because of the fact that calcium intake covaries with the intake of several other dietary nutrients and some of these nutrients are just as likely as calcium to influence obesity.[54] Finally as a limitation of this study, it is worth noting that assessment of compliance with the intervention in this study was based on self-reported dietary records which may not be an accurate indicator of true energy and dairy intake.

On the basis of the present study, it is unlikely that increasing dairy intake will produce an improved effect on body weight, BMI or fat percentage in overweight and obese children who are placed on a calorie restricted diet. Whether the same is true in adults will require additional investigation, but there seems to be little reason to hypothesize that these effects would be substantially different in other groups. However, our findings from this study should not detract from the many well-established beneficial effects of calcium and dairy intake on preventing other deleterious conditions such as osteoporosis and hypertension. Moreover, conducting studies with a longer period of time in follow-up and with a larger number of subjects may indicate more reliable results.

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Contributions: All authors made active contributions and were responsible for development of the study protocol. MGM and GF discussed core ideas of protocol design; ST, EL, MK and MD were responsible for sample collection and measurement; MN, MS and RV facilitated patients' recruitment; and AS performed analysis and interpretation of data. All authors were involved with the drafting of the research paper, have critically reviewed its content and have approved the final version submitted for publication.

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