

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/m²) 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 stroke⁹ 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 calcitropic 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 calcitropic 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 calcitropic hormones by increasing dietary calcium intake. However, it must be noted that whilst 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/m², 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 VacutainerTM tubes containing fluoride-oxalate.

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

Parameter	Low Dairy (N = 35)		Normal Dairy (N = 28)		High Dairy (N = 33)		ANOVA (p)
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	
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
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
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
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
BMI (kg/m ²)	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
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
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
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
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
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
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
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
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
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
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
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
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

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

Ninety-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 vitamin 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 groups³⁶ 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 Bernard⁴¹, none of the seven dairy trials⁴²⁻⁴⁶ or eight calcium supplementation trials⁴⁷⁻⁵³ 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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REFERENCES

1. Lovejoy JC, Champagne CM, Smith SR, de Jonge L, Xie H. Ethnic differences in dietary intakes, physical activity, and energy expenditure in middle-aged, premenopausal women: the Healthy Transitions Study. *Am J Clin Nutr* 2001;

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- 74: 90-95.
- Zemel MB. Role of calcium and dairy products in energy partitioning and weight management. *Am J Clin Nutr* 2004; 79: 907S-912S.
 - Pereira MA, Jacobs DR, 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.
 - 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. *Obesity Res* 2004; 12: 582-590.
 - 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.
 - Ascherio A, Hennekens C, Willett WC *et al.* Prospective study of nutritional factors, blood pressure, and hypertension among US women. *Hypertension* 1996; 27: 1065-1072.
 - Mennen LI, Balkau B, Vol S *et al.* Tissue-type plasminogen activator antigen and consumption of dairy products. The DESIR Study. *Thromb Res* 1999; 94: 381-388.
 - Ness AR, Smith GD, Hart C. Milk, coronary heart disease and mortality. *J Epidemiol Community Health* 2001; 55: 379-382.
 - Iso H, Stampfer MJ, Manson JE *et al.* Prospective study of calcium, potassium, and magnesium intake and risk of stroke in women. *Stroke* 1999; 30: 1772-1779.
 - Zemel MB, Shi H, Greer B, DiRienzo D, Zemel PC. Regulation of adiposity by dietary calcium. *FASEB J* 2000; 14: 1132-1138.
 - Xue B, Greenberg AG, Kraemer FB, Zemel MB. Mechanism of intracellular calcium inhibition of lipolysis in human adipocytes. *FASEB J* 2001; 15: 2527-2529.
 - Boon N, Hul GB, Viguier N, Sicard A, Langin D, Saris WH. Effects of 3 diets with various calcium contents on 24-h energy expenditure, fat oxidation, and adipose tissue message RNA expression of lipid metabolism-related proteins. *Am J Clin Nutr* 2005; 82: 1244-52.
 - Hamoui N, Anthonie G, Crookes PF. Calcium metabolism in the morbidly obese. *Obes Surg* 2004; 14: 9-12.
 - Parikh SJ, Edelman M, Uwaifo GI *et al.* The relationship between obesity and serum 1,25-dihydroxy vitamin D concentrations in healthy adults. *J Clin Endocrinol Metab* 2004; 89: 1196-1199.
 - Melanson EL. The effects of low- and high-dairy diets on resting energy expenditure and substrate oxidation. *Exp Biol* 2004; A846 (abstr).
 - Zemel MB. Role of dairy products in modulating weight and fat loss: a multi-center trial. *Exp Biol* 2004; A845 (abstr).
 - 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 Obes Relat Metab Disord* 2005; 29: 391-397.
 - Welberg J, Monkelbaan JF, deVries EG *et al.* Effects of supplemental dietary calcium on quantitative and qualitative fecal fat excretion in man. *Ann Nutr Metab* 1994; 38: 185-191.
 - Jacobsen R, Lorenzen JK, Toubro S, Krog-Mikkelsen I, Astrup A. Effect of short-term high dietary calcium intake on 24-h energy expenditure, fat oxidation, and fecal fat excretion. *Int J Obes* 2005; 29: 292-301.
 - Papakonstantinou E, Flatt WP, Huth PJ, Harris RBS. High dietary calcium reduces body fat content, digestibility of fat, and serum vitamin D in rats. *Obes Res* 2003; 11: 387-394.
 - Shahkhalili Y, Murset C, Meirim I *et al.* Calcium supplementation of chocolate: effect on cocoa butter digestibility and blood lipids in humans. *Am J Clin Nutr* 2001; 73: 246-252.
 - Shah H. Effects of milk-derived bioactives: an overview. *Br J Nutr* 2000; 84: 3-10.
 - Pihlanto-Leppala A, Koskinen P, Piilola K, Tupasela T, Korhonen H. Angiotensin I-converting enzyme inhibitory properties of whey protein digests: concentration and characterization of active peptides. *J Dairy Res* 2000; 96: 53-64.
 - Shapses SA, Heshka S, Heymsfield SB. Effect of calcium supplementation on weight and fat loss in women. *J Clin Endocrinol Metab* 2004; 89: 632-637.
 - Zemel MB, Richards J, Milstead A, Campbell P. Effects of calcium and dairy on body composition and weight loss in African-American adults. *Obes Res* 2005; 13: 1218-1225.
 - Harvey-Berino J, Gold BC, Lauber R, Starinski A. The impact of dairy product consumption on weight loss. *Obes Res* 2005; 13: 1720-6.
 - Gunther CW, Legowski PA, Lyle RM *et al.* Dairy products do not lead to alterations in body weight or fat mass in young women in a 1-yr intervention. *Am J Clin Nutr* 2005; 81: 751-756.
 - Ricci TA, Chowdhury HA, Heymsfield SB, Stahl T, Pierson RN, Jr Shapses SA. Calcium supplementation suppresses bone turnover during weight reduction in postmenopausal women. *J Bone Miner Res* 1998; 13: 1045-1050.
 - Jensen LB, Kollerup G, Quaade F, Sorensen OH. Bone mineral changes in obese women during a moderate weight loss with and without calcium supplementation. *J Bone Miner Res* 2001; 16: 141-147.
 - Bortolotti M, Rudelle S, Schneiter P *et al.* Dairy calcium supplementation in overweight or obese persons: its effect on markers of fat metabolism. *Am J Clin Nutr* 2008; 88: 877-885.
 - Lorenzen JK, Molgaard C, Michaelsen KF, Astrup A. Calcium supplementation for 1 y does not reduce body weight or fat mass in young girls. *Am J Clin Nutr* 2006; 83: 18-23.
 - Thompson WG, Rostad HN, 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.
 - Haub MD, Simons TR, Cook CM, Remig VM, Al-Tamimi EK, Holcomb CA. Calcium-fortified beverage supplementation on body composition in postmenopausal women. *Nutr J* 2005; 4: 21-26.
 - Teegarden D. Calcium intake and reduction of fat mass. *J Nutr* 2003; 133: 249S-251S.
 - Mirmiran P, Esmailzadeh A, Azizi F. Dairy consumption and body mass index: an inverse relationship. *Int J Obes (Lond)* 2005; 29:115-121.
 - Barr SI. Increased dairy product or calcium intake: is body weight or composition affected in humans? *J Nutr* 2003; 133: 245S-248S.
 - Phillips SM, Bandini LG, Cyr H, Colclough-Douglas S, Naumova E, Must A. Dairy food consumption and body weight and fatness studied longitudinally over the adolescent period. *Int J Obes Relat Metab Disord* 2003; 27: 1106-1113.
 - Carruth BR, Skinner JD. The role of dietary calcium and other nutrients in moderating body fat in preschool children. *Int J Obes Relat Metab Disord* 2001; 25: 559-566.
 - Skinner JD, Bounds W, Carruth BR, Zeigler P. Longitudinal calcium intake is negatively related to children's body fat indexes. *J Am Diet Assoc* 2003; 103: 1626-1631.

40. 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: 1905-1909.
41. Lanou AJ, Barnard ND. Dairy and weight loss hypothesis: an evaluation of the clinical trials. *Nutr Rev* 2008; 66: 272-279.
42. Lappe JM, Rafferty KA, Davies KM, Lypaczewski G. Girls on a high-calcium diet gain weight at the same rate as girls on a normal diet: a pilot study. *J Am Diet Assoc* 2004; 104: 1361-1367.
43. Cadogan J, Eastell R, Jones N, Barker ME. Milk intake and bone mineral acquisition in adolescent girls: randomised, controlled intervention trial. *BMJ* 1997; 315: 1255-1260.
44. Chan GM, Hoffman K, McMurry M. Effects of dairy products on bone and body composition in pubertal girls. *J Pediatr* 1995; 126: 551-556.
45. Du X, Zhu K, Trube A *et al*. School-milk intervention trial enhances growth and bone mineral accretion in Chinese girls aged 10-12 years in Beijing. *Brit J Nutr* 2004; 92: 159-168.
46. Lau EMC, Lynn H, Chan YH, Lau W, Woo J. Benefits of milk powder supplementation on bone accretion in Chinese children. *Osteoporos Int* 2004; 15: 654-658.
47. Bonjour JP, Carrie AL, Ferrari S *et al*. Calcium-enriched foods and bone mass in prepubertal girls: a randomized, double-blind, placebo-controlled trial. *J Clin Invest* 1997; 99: 1287-1294.
48. Cameron MA, Paton LM, Nowson CA, Margerison C, Frame M, Wark JD. The effect of calcium supplementation on bone density in premenarcheal females: a co-twin approach. *J Clin Endocrinol Metab* 2004; 89: 4916-4922.
49. Dibba B, Prentice A, Ceesay M, Stirling DM, Cole TJ, Poskitt EME. Effect of calcium supplementation on bone mineral accretion in Gambian children accustomed to a low-calcium diet. *Am J Clin Nutr* 2000; 71: 544-549.
50. Johnston CC, Miller JZ, Slemenda CS *et al*. Calcium supplementation and increases in bone mineral density in children. *N Engl J Med* 1992; 327: 82-87.
51. Lee WTK, Leung SSF, Leung DMY, Tsang HSY, Lau J, Cheng JCY. A randomized, double-blind controlled calcium supplementation trial and bone and height acquisition in children. *Br J Nutr* 1995; 74: 125-139.
52. Lee WTK, Leung SSF, Wang SH *et al*. Double-blind, controlled calcium supplementation and bone mineral accretion in children accustomed to a low-calcium diet. *Am J Clin Nutr* 1994; 60: 744-750.
53. Lloyd T, Andon MB, Rollings N *et al*. Calcium supplementation and bone mineral density in adolescent girls. *J Am Med Assoc* 1993; 270: 841-844.
54. Kant AK. Reported consumption of low-nutrient-density foods by American children and adolescents: nutritional and health correlates, NHANES III, 1988 to 1994. *Arch Pediatr Adolesc Med* 2003; 157: 789-796.