



## THE ROLE OF DAIRY FOODS IN WEIGHT MANAGEMENT



### SUMMARY

The cause of overweight and obesity is multifactorial and successful prevention or treatment depends on multiple actions. Although attention has focused primarily on reducing energy (calorie) intake and/or increasing energy expenditure (physical activity), a promising beneficial role for dietary calcium and dairy products in weight management has recently emerged.

In some randomized controlled trials of overweight or obese adults following moderately reduced-calorie diets, increasing consumption of calcium or dairy products from 1 serving or less/day to 3 servings/day (i.e., from inadequate to adequate) has been shown to decrease body weight and body fat beyond that achieved with a reduced-calorie diet alone. Moreover, dairy foods appear to exert a greater beneficial effect on body weight and body fat than calcium alone. Also, consuming 3 servings of dairy foods a day as part of a weight maintenance diet has been demonstrated to improve body composition in overweight adults. Findings from a recent multi-center trial in overweight and obese adults indicate that diets rich in dairy foods increase weight loss by targeting the body fat compartment during energy restriction.

In adults, many, but not all, observational studies support an association between higher calcium or dairy food intake and reduced body weight or body fat. This inverse association has been demonstrated in young and older adults, in women and men, and in those of different racial and ethnic backgrounds.

Most investigations of dairy foods or calcium intake and body weight or body fat in children and adolescents are observational studies. Although these studies cannot prove a cause and

effect relationship, they indicate that increasing intake of dairy foods or calcium to recommended levels has no adverse effect on body weight or composition, and, in fact, may help promote a healthy body composition or prevent an unhealthy weight gain. Using data obtained from U.S. children participating in the Framingham Children's Study, researchers recently found that adequate dairy food intake during preschool years protected against excess body fat gain throughout childhood and in early adolescence.

The ability of calcium or dairy foods to regulate energy metabolism likely involves multiple mechanisms which influence the availability of energy and energy expenditure. Most attention has focused on increasing energy utilization by affecting fat oxidation and hormonal control of fat metabolism. Findings demonstrating that dairy sources of calcium decrease body weight and accelerate fat loss to a greater extent than calcium alone suggest that other bioactive components (e.g., protein) in addition to calcium in dairy foods may be involved.

More research is needed to clarify the anti-obesity effect of dairy products, including the underlying mechanism(s). Although the beneficial effects on body weight or body fat are likely to be modest in comparison to modifications in energy intake and expenditure, consuming 3 servings a day of dairy foods such as reduced-fat or nonfat milk, yogurt, or cheese, may nonetheless substantially contribute to a healthy body weight and composition which, over time, may help reduce the nation's epidemic of overweight and obesity.



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## INTRODUCTION

Overweight and obesity continue to be leading public health concerns (1-3). In the U.S., two-thirds (66.3%) of adults 20 years of age and older are overweight (body mass index or BMI of 25 to 29.9 kg/m<sup>2</sup>) or obese (BMI of 30 kg/m<sup>2</sup> or higher) (1). Among children and adolescents aged 2 through 19 years, 17.1% are overweight (1). The prevalence of overweight and obesity in adults and overweight in children has risen dramatically over the past several decades (1,3). Researchers estimate that if current trends continue, nearly half of children in North and South America will be overweight by 2010 (2).

Excess body fat increases the risk of premature death, coronary heart disease, type 2 diabetes, hypertension, stroke, gallbladder disease, osteoarthritis, respiratory problems, and some types of cancer (e.g., endometrial, colon, kidney, postmenopausal breast) (3,4). Because of these health outcomes, as well as the adverse economic consequences of overweight and obesity, efforts are focused on prevention (3).

Consuming excess energy (i.e., too many calories) intake in relation to energy expenditure (e.g., physical activity) is the major factor responsible for overweight and obesity (5). For obese adults, even modest weight loss has substantial health benefits (5). Emerging scientific evidence indicates that small beneficial changes in body weight and/or adiposity may be achieved by increasing intake of calcium and dairy products. This *Digest* reviews this scientific evidence in adults and children, as well as findings providing biologically plausible mechanisms by which dietary calcium and dairy products may favorably affect body weight and composition. For more information on this topic, readers are referred to several reviews (6-19), as well as a previous *Digest* (20).

## DAIRY PRODUCTS & WEIGHT MANAGEMENT IN ADULTS

**Clinical Trials.** Randomized controlled trials (considered to be the “gold standard” of study designs) in adults provide the strongest evidence of dairy foods’ and

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*A promising role for dairy products and their components (such as calcium and protein) in weight regulation and body composition continues to grow.*

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calcium's beneficial role in body weight and adiposity. In some clinical trials of overweight or obese adults (males, females, Caucasians, African Americans) following moderately reduced-calorie diets (i.e., 500 kcal/day deficit), increasing consumption of dairy foods from 1 serving or less/day to 3 servings/day (i.e., from inadequate to adequate) has been shown to enhance body weight and body fat losses, reduce abdominal (trunk) obesity, and minimize loss of lean body tissue (21-23). Moreover, dairy sources of calcium appear to exert a greater anti-obesity effect than calcium alone (21). In addition, consuming 3 servings of dairy foods a day as part of a weight maintenance diet has been demonstrated to improve body composition (i.e., reduce total body and fat trunk fat and increase lean body mass) and decrease insulin and blood pressure levels in overweight adults (23).

Dairy-rich diets appear to increase weight loss by targeting the fat compartment during energy restriction, according to findings from a multi-center 12-week randomized, placebo-controlled trial in overweight and mildly obese adults (24). In this trial, consuming 3 servings a day of dairy foods (~1,400 mg calcium/day) while restricting calories for weight loss (500 kcal/day energy deficit) resulted in significantly greater losses in body fat, trunk fat, and waist circumference than in groups receiving a low calcium (~600 mg/day) control diet or an elemental calcium-rich (~1,400 mg/day) diet (24). The elemental calcium-rich diet in this multi-center trial had no significant effect on weight loss or body composition compared to the low calcium control diet (24). However, the adequate dairy food diet resulted in a significantly greater body fat loss compared to the low calcium and high calcium diets (24).

As reviewed in a previous *Digest* (20), findings from other clinical trials (25-27) indicate that the effects of calcium or dairy food intake on body weight and/or composition depend on factors such as calorie intake, baseline calcium or dairy food intake, and initial body weight (i.e., overweight or normal weight). For example, when researchers investigated the effects of moderate (2 servings/day) versus adequate (4 servings/day) servings of dairy products

in obese adults consuming reduced-calorie diets, no significant differences in body weight or body fat losses were found (25).

**Observational Studies.** Although observational or epidemiological studies do not prove a cause and effect relationship, they help generate hypotheses or critical questions. An inverse association has been demonstrated between intake of dairy products or calcium and body weight or body fat across various study designs (cross-sectional, prospective, retrospective) and data bases such as NHANES III (National Health and Nutrition Examination Survey) (6), the Quebec Family Study (28), the Heritage Family Study (29), the Coronary Artery Risk Development in Young Adults (CARDIA) Study (30), the Tehran Lipid and Glucose Study (31,32), and the Portuguese Health Interview Study (33). This inverse association has been shown in young and older adults, in women and men, and in adults of different racial and ethnic backgrounds.

An investigation of 235 men and 235 women aged 20 to 65 years participating in the Quebec Family Study found that women who consumed less than 600 mg of calcium/day had significantly greater body weight, percentage of body fat, fat mass, BMI, waist circumference, and abdominal fat, after controlling for confounding factors (e.g., age, other dietary variables, socioeconomic status), than women who consumed more than 600 mg calcium/day (28). Although a trend for these associations was found in men, it was not significant after considering confounding factors (28). According to findings from the Heritage Family Study, a cross-sectional study of adults aged 17 to 65 years, a high calcium intake had a beneficial effect on body weight and/or body fat in men (both African American and Caucasian) and Caucasian women (29). Other cross-sectional studies have demonstrated an inverse association between dietary calcium intake and adiposity in African American women (34,35). In contrast to the above, a recent cross-sectional study in young Japanese women aged 18 to 20 years found no significant relationship between intake of calcium and dairy products and BMI (36).

Results from the CARDIA study, a 10-year longitudinal prospective investigation of




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*Some clinical trials in overweight and obese adults following reduced-calorie diets and in those on weight maintenance diets have shown that consuming 3 daily servings of dairy foods – milk, yogurt, or cheese – reduces body fat.*

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more than 3,000 adults aged 18 to 30 years, indicate that higher intake of dairy products may protect overweight individuals from becoming obese or developing insulin resistance syndrome (also known as metabolic syndrome) (30). Higher dairy food consumption was equally beneficial for African Americans and Caucasians, and both reduced-fat and full-fat dairy products were effective (30). Data from more than 10,000 women aged 45 years and older participating in the Women's Health Study demonstrated a significant reduction in abdominal obesity (a component of metabolic syndrome), measured by waist circumference, in women with higher calcium intakes (37). In contrast, other longitudinal studies report that dietary calcium or dairy food intake is not associated with changes in body weight (38,39). A recent retrospective study of more than 10,000 middle-aged adults found that women (but not men) who were current calcium supplement users had a significantly lower 10-year weight gain than non-users of calcium supplements (40).

Inconsistencies in findings from epidemiological studies may be explained by several factors such as the level and/or range of calcium or dairy foods consumed, baseline body weight or body fatness, energy intake, and methods used to assess dietary intake and body weight or body fat (16). For example, there may be a threshold level of dietary calcium above which higher calcium intake does not confer an additional benefit for body weight or body fat (16,41).

## **DAIRY PRODUCTS AND A HEALTHY BODY COMPOSITION IN CHILDREN & ADOLESCENTS**

**Observational Studies.** Observational studies (cross-sectional and prospective) indicate that recommended intakes of dairy foods or calcium are not associated with adverse effects on children's and adolescents' weight or body composition, and, in fact, may play a role in promoting a healthy body composition or preventing an unhealthy weight gain (19).

Frequency of consuming milk was associated with a lower BMI in 884 children aged 5 to 11 years who participated in a cross-sectional study in southern Italy (42).

A cross-sectional analysis of baseline data from a longitudinal study in Hawaii including 323 Asian and Caucasian young adolescent girls aged 9 to 14 years demonstrated that total calcium intake was associated with significantly lower body fat and a trend toward lower body weight after adjusting for confounding factors (43). Calcium from dairy foods had a stronger association than total calcium in relation to iliac (upper hip) skinfold thickness, whereas non-dairy calcium was not associated with weight or iliac skinfold thickness. In other cross-sectional studies in children or adolescents in Chile (44), Brazil (45), the U.S. (46), and Portugal (47), calcium or dairy food intake was inversely associated with overweight or body fat.

Longitudinal data from 99 U.S. children participating in the Framingham Children's Study found that low dairy food intake during the preschool years (3 to 6 years) predicted excess body fat gain throughout childhood and in early adolescence (10 to 13 years of age) (48). Dietary intake was assessed using three-day diet records and children were classified into tertiles of dairy intake. Children in the lowest tertile of dairy food servings per day had significantly greater gains in BMI and body fat (sum of four skinfolds) from childhood to early adolescence than did children in the upper two tertiles of dairy intake. This study provides evidence that dairy food intake does not adversely affect body fat change in growing children and that adequate intake of dairy foods is associated with protection against excess body fat gain throughout childhood (48). Earlier longitudinal studies in children followed from the first few years of life through 8 years of age also found that calcium or dairy food intake was inversely associated with body fat accumulation (49,50). In a longitudinal study of young children (average age of 8 years) in which bone health was the main outcome, milk avoiders had low calcium intakes, were shorter in stature, and had elevated BMIs (51).

In contrast to the above findings, other longitudinal studies report no association between calcium or dairy food intake

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*An adequate intake of dairy foods during preschool years protects against excess body fat gain throughout childhood and in early adolescence, according to a recent study.*

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and body fat in children (52-54). Similar to epidemiological studies in adults, a number of confounding factors, such as total energy intake, the amount and range of calcium and dairy food intake, and differences in measuring dietary intake, may influence the outcome of these studies. In a 3-year longitudinal observation study of 5,388 boys and 6,943 girls aged 9 to 14 years, children who drank the most milk (i.e., more servings than currently recommended) gained more weight than children consuming fewer servings, but this was due to the extra calories consumed (54). Also, children in this study self-reported their weight and completed a food frequency questionnaire to provide information on their food intake during the previous year. Use of these methods requires caution in the interpretation of results.

**Clinical Trials.** For the most part, clinical trials of dairy food or calcium intake and body composition in children and adolescents have been secondary analyses of data from bone health studies and most used calcium supplements or a form of calcium derived from milk (19,55). In trials that used dairy products, either a neutral or a beneficial effect of dairy food intake on body weight or body composition is reported (19,55-57). A two-year pilot study demonstrated that pubertal girls could increase their calcium intake to at least 1,500 mg/day, primarily from dairy foods, without increasing their body weight or body fat (56). A randomized, double-blind, placebo-controlled intervention study in 110 Danish girls aged 12 years old found that a high habitual calcium intake (i.e., 1,000 to 1,304 mg/day) primarily from dairy foods was significantly associated with a lower percentage of body fat than in those consuming less than 713 mg of calcium/day (57). However, modest calcium supplementation (500 mg a day as calcium carbonate) had no effect on body weight or percentage of body fat over the year. The researchers suggest that the effect of calcium on body weight may be exerted only if consumed as part of a meal or may be due to other components in dairy foods (57).

## POTENTIAL MECHANISMS

Experimental animal, *in vitro*, and human studies indicate that multiple mechanisms likely underlie the ability of calcium and dairy foods to regulate energy metabolism. Increased consumption of calcium and dairy foods may influence energy balance by reducing the availability of energy and/or increasing the utilization of energy leading to a net energy deficit (6,15,16). Mechanisms proposed to explain the ability of calcium or dairy foods to reduce energy availability include decreasing the absorption of fatty acids through the formation of calcium soaps in the intestine and increasing satiety, whereas energy utilization may be increased by an effect on lipid oxidation and hormonal control of fat metabolism (6,15,16).

Studies in laboratory rats (58) and humans (59) have demonstrated that increasing dietary calcium leads to a greater fecal fat loss than achieved with a lower calcium intake. However, the contribution of this effect to overall energy balance is unclear (11,16). Calcium or dairy products may influence the availability of energy through an effect on satiety (16). Some preliminary evidence indicates a satiety effect of milk and certain whey-derived peptides (60).

Most of the research examining the anti-obesity effect of dairy foods and calcium has focused on their impact on energy utilization. Randomized clinical trials (61,62) and a cross-sectional study (63) demonstrate that dairy calcium is associated with higher fat oxidation. In a recent study of eight overweight or obese adults, postprandial fat oxidation increased following a high calcium intake compared to a low calcium intake regardless of the calcium source (64).

The ability of dietary calcium to regulate, at least acutely, levels of the hormones,  $1,25(\text{OH})_2\text{D}$  and parathyroid hormone (PTH), and influence adipocyte fatty acid metabolism is the mechanism most often cited to explain calcium's effect on energy utilization (16). *In vitro* studies in human fat cells (adipocytes) and

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*Multiple mechanisms likely explain the ability of dairy products and their components (e.g., calcium, protein) to favorably alter energy metabolism and support a healthy body weight and body composition.*

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animal studies (e.g., in agouti mice) provide evidence supporting this mechanism (6,10,15,16,65-67). Both PTH (66) and  $1,25(\text{OH})_2\text{D}$  (6,67) influence adipocyte intracellular ionic calcium levels. A low intake of dietary calcium increases  $1,25(\text{OH})_2\text{D}$ , which stimulates the influx of calcium across the adipocyte membrane. The rise in intracellular ionic calcium leads to a coordinated decrease in lipolysis (fat breakdown) and an increase in fat storage (i.e., increased *de novo* lipogenesis) via increased expression and activity of the enzyme, fatty acid synthase (6,13). Thus, the response to a low calcium intake is an increase in intracellular ionic calcium which leads to stimulation of lipogenic gene expression and thus lipogenesis, and suppression of lipolysis, resulting in adipocyte lipid filling and increased adiposity (15). Increased levels of  $1,25(\text{OH})_2\text{D}$  on low calcium diets also suppress adipocyte apoptosis (cell death) (15). The resultant increase in adipocyte number may further contribute to increased adiposity on low calcium diets (15).

Conversely, a high calcium intake exerts an anti-obesity effect by suppressing  $1,25(\text{OH})_2\text{D}$ , which reduces the influx of ionic calcium into adipocytes. The decrease in intracellular ionic calcium leads to increased lipolysis, energy utilization, and apoptosis, and inhibition of fat storage (15,67). This framework for a plausible mechanism by which dietary calcium regulates body weight has yet to be determined using *in vivo* techniques (15). Nevertheless, in humans, polymorphisms in the nuclear vitamin D receptor (nVDR) gene are associated with increased risk of obesity and alterations of the vitamin D endocrine system have been reported (15). Also, blood levels of PTH have been shown to be positively associated with BMI and body fat mass in humans (16,62).

Findings demonstrating that dairy sources of calcium attenuate weight and fat gain and accelerate fat loss to a greater degree than calcium (6,21,24,65) indicate that dairy products may contain bioactive components (e.g., protein) in addition to calcium that alter energy metabolism (68,69). Bioactive components such as

dairy proteins may act independently or synergistically with calcium to contribute to the anti-obesity effect of dairy products (10,12). The high concentration of leucine and other branched chain amino acids in dairy protein, especially whey protein, may contribute to the beneficial effect of dairy foods on body weight by repartitioning dietary energy from adipose tissue to skeletal muscle (i.e., sparing lean tissue during weight loss) (10,70). Identification of components of dairy products that may contribute to dairy's anti-obesity effect is an area of ongoing research.

## CONCLUSION

The 2005 Dietary Guidelines for Americans (5) states that "adults and children should not avoid milk and milk products because of concerns that these foods lead to weight gain." For everyone 9 years of age and older, the Guidelines recommends 3 cups a day of low-fat or fat-free milk or equivalent milk products (i.e., cheese, yogurt). For children 2 to 8 years, 2 cups a day of milk or equivalent milk products is recommended (5).

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  - National Dairy Council. 3-a-day of dairy for a healthy weight. *Dairy Council Digest* 76(6), 2005.
  - National Dairy Council. Dairy foods' role in achieving a healthy weight. *Dairy Council Digest* 75(2), 2004.
- [www.healthyweightwithdairy.com](http://www.healthyweightwithdairy.com)
- [www.3aday.org](http://www.3aday.org)

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# UNDERSTANDING NUTRITION CLAIMS ON FOOD LABELS

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