

DAIRY'S ROLE IN A HEALTHY WEIGHT

THE SUPPORTING EVIDENCE CONTINUES TO GROW

Obesity has risen at epidemic rates over the past 20 years. Currently, 65% of U.S. adults are overweight or obese, which significantly increases the risk of heart disease, type 2 diabetes, cancer and other diseases. Halting this epidemic is a public health priority.

While we're a nation that's overfed, many Americans are also undernourished. For instance, about two-thirds of adults in this country fail to get the calcium they need – primarily due to the decline in dairy consumption. Long known for its benefits to bone health, dairy foods may also help promote a healthy weight.

Whether you are dieting or not, enjoying three cups of milk or milk products every day as recommended by the Dietary Guidelines improves overall nutritional quality of the diet.

Randomized Clinical Trials

Randomized clinical trials have found a significant relationship between calcium/dairy product intake and reduced body weight and/or fat in overweight and obese adults. The studies report that dairy foods exert a significantly greater effect on body weight, fat and inches around the waist compared to calcium supplements or a low-dairy diet. The body of research also includes mechanistic studies that measure dairy's effect on energy expenditure, fat oxidation, fat absorption (and resulting decreased calorie absorption) and satiety.

- In a 24-week study of 32 obese adults, those who consumed 3 servings of milk, yogurt or cheese a day while on a balanced, modestly reduced-calorie diet, lost significantly more weight and fat than those who consumed similar amounts of calcium through supplements or consumed little or no dairy. Participants on the high-dairy diet (1200-1300 mg calcium) lost 70% more body weight and 64% more body fat than those on the low-dairy diet.
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 Research*. 2004. 12: 582-590.
- A 12-week study of 34 obese adults on a balanced, modestly reduced-calorie diet found that those who consumed a calcium-rich diet supplied by 3 servings of yogurt a day lost 22% more weight, 66% more body fat and 81% more trunk fat compared to those who simply reduced calories and consumed little or no dairy. The participants who ate 3 servings of yogurt also lost significantly more inches around the waist compared to those on the low-dairy diet.
Zemel MB, Richards J, Mathis S, Milstead A, Gehardt L, Silva E. Dairy augmentation of total and central fat loss in obese subjects. *International Journal of Obesity*. 2005. 29:391-397.
- Two randomized controlled studies were conducted in otherwise healthy obese African-American adults. The first clinical study, a 24-week study of 29 obese adults, found that those who consumed 3 servings of dairy per day on a balanced, modestly reduced-calorie diet lost twice as much weight and fat while preserving lean body mass compared to participants who consumed less than 1 serving of dairy per day. The second clinical study, a 24-week study of 34 obese adults, found that those who consumed 3 servings of dairy per day on a weight-maintenance diet (consumption of adequate calories to maintain weight) lost more total body fat and trunk fat and gained lean mass compared to participants who consumed less than 1 serving of dairy per day. In both studies, 3 servings of dairy a

day decreased circulating insulin levels, suggesting an association between dairy intake and reduced risk of symptoms of type 2 diabetes. In addition, in the weight maintenance study, consuming 3 servings of dairy per day produced a significant decrease in blood pressure.

Zemel MB, Richards J, Milstead A, Campbell P. Effects of calcium and dairy on body composition and weight loss in African-American adults. *Obesity Research*. 2005 13: 1218-1225.

- A 12-month study of 155 women (aged 18-30 years) found that normal weight subjects showed no effect on body composition under energy balance (study was not designed for weight loss). Women were randomly assigned to one of three groups: 1) control: women followed normal diet of less than 800 mg of calcium a day; 2) medium-dairy: women substituted dairy products to achieve intake of 1000-1100 mg of calcium a day and maintain their current calorie intake; and 3) high-dairy: women substituted dairy products to achieve intake of 1300-1400 mg of calcium and maintain their calorie intake. No significant differences were shown between the three groups in body weight fat mass, or lean mass after one year on non-calorie restricted diets. Throughout the intervention, the medium- and high-dairy groups had slightly higher (not statistically higher) mean calorie intakes than the control group, which may indicate a lack of appropriate substitution by the dairy groups. In contrast to weight loss studies in obese subjects using dairy within a detailed dietary prescription, this study was conducted in normal weight individuals who were simply instructed to substitute dairy into their diet for foods of equivalent caloric value.

Gunther CW, Legowski PA, Lyle RM, McCabe GP, Eagan MS, Peacock M, Teegarden D. Dairy products do not lead to alterations in body weight or fat mass in young women in a 1-y intervention. *American Journal of Clinical Nutrition*. 2005. 81: 751-756.

- In a 12-month study of 19 normal-weight women (aged 18-30 years), the participants who consumed 3-4 servings of dairy each day burned more fat and calories from a meal compared to women who consumed a low-dairy diet (1-2 servings per day). The participants' ability to burn fat and calories after a meal was measured at the beginning and end of the trial to determine the impact of increasing dairy and calcium consumption during the one-year intervention. The researchers speculate that the potential mechanism for the increased fat burning is related to parathyroid hormone. They observed that increases in dairy decreased parathyroid hormone. This finding builds on other research demonstrating the role of calcium regulating hormones as potential mediators of the relationship between an increase in dietary calcium and greater fat burning.

Gunther CW, Lyle RM, Legowski PA, James JM, McCabe LD, McCabe GP, Peacock M, Teegarden D. Fat oxidation and its relation to serum parathyroid hormone in young women enrolled in a 1-y dairy calcium intervention. *American Journal of Clinical Nutrition*. 2005;82:1228-1234.

- In a 48-week study, 72 obese adults followed three different balanced, modestly reduced-calorie diets: a "high-dairy" diet that included 4 servings of dairy (milk, yogurt or cheese) each day; a "high-dairy/high fiber/low glycemic index" diet that included 4 servings of dairy each day; and a "moderate-dairy" or standard diet that included 2 servings of dairy foods each day. While the groups lost similar amounts of weight and body fat, the participants in the high-dairy groups who most closely followed the prescribed diet and exercise plan consumed about 100 to 150 more calories each day. Even with the higher calorie intake, they lost the same amount of weight as the dieters who consumed 2 servings of dairy a day and fewer calories.

Thompson WG, Holdman NR, 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. *Obesity Research*. 2005; 13:1344-1353.

- Researchers found that when exercising adults on a slightly reduced-calorie diet consumed 3-4 servings of dairy foods each day, their metabolism changed so that they burned more fat versus consuming one serving of dairy under the same conditions. The study included 19 overweight men and women (aged 20-50 years) who usually exercised less than three hours a week. Over the course of seven weeks, the subjects participated in four one-week periods in which they consumed either a

low-dairy diet or a diet including 3-4 servings of dairy foods each day. Several times during the study, participants' rate of fat oxidation (burning) was measured over a 24-hour period in a room calorimeter. The researchers conclude that reducing calories and exercising while consuming adequate dairy foods can help improve the body's ability to burn fat, which may lead to the loss of body fat.

Melanson EL, Donahoo WT, Dong F, Ida T, Zemel MB. Effect of low- and high-calcium dairy-based diets on macronutrient oxidation in humans. *Obesity Research*. 2005;13:2102-2112.

- Twelve healthy, nonobese men were fed three diets of equal calorie levels: high-calcium/high-dairy, high-calcium/low-dairy and low-calcium/low-dairy. At the end of 7 days, there were no significant differences between the diets in 24-hour energy expenditure, fat oxidation or gene expression of proteins related to fat metabolism. However, the hormonal form of vitamin D (1,25-dihydroxyvitamin D3), which is involved in fat cell metabolism, was significantly lower after the high-calcium/high-dairy diet compared to the low-calcium/low-dairy diet as expected, suggesting vitamin D may in fact play a role. The researchers conclude that beyond a vitamin D related mechanism, dairy/calcium intake may also affect dietary fat absorption, resulting in fecal fat and energy losses.
Boon N, Hul GBJ, Viguerie N, Sicard A, Langin D, Saris WHM. 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. *American Journal of Clinical Nutrition*. 2005; 82: 1244-52.
- Researchers monitored the diet progress of 44 study participants, who were either on a high-dairy, reduced-calorie diet (3-4 servings of dairy/1200-1400 mg calcium) or lower dairy, reduced-calorie diet (about 1 serving/400-500 mg calcium). Participants in both groups lost 20-24 pounds after 12 months. (Note: A post-hoc analysis indicated that there may not have been enough study completers to detect statistically-significant differences in weight loss between the two groups.)
Harvey-Berino J, Gold BC, Lauber R, Starinski A. The impact of calcium and dairy product consumption on weight loss. *Obesity Research*. 2005;13:1720-1726.
- Researchers in Denmark studied the short term effects of three diets, low calcium/normal protein, high calcium/normal protein, and high calcium/high protein on 24-hour energy expenditure, fat oxidation, and fecal fat excretion in 10 healthy, nonobese adults under energy balance conditions. The calcium level in the diets had no effect on 24-hour energy expenditure or fat oxidation, but fecal fat and energy excretion increased significantly during the high calcium/normal protein diet compared to the other two diets. The decreased fat and calorie absorption may explain one of the mechanisms by which high-calcium diets produce weight loss and suggests that dietary protein level may be important.
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. *International Journal of Obesity*. 2005; 29: 292-301.
- To test effects of calcium and vitamin D on feelings of hunger and satiety and subsequent food intake, researchers fed 11 overweight adults a low-dairy calcium or high-dairy calcium breakfast and measured 24-hour food intake following the test breakfast. In this single blind, cross-over study, 24-hour food intake was significantly lower after the high-dairy calcium breakfast, demonstrating an effect of dairy calcium on subsequent energy intake.
Chan She Ping-Delfos W, Soares MJ, Cummings NK. Acute suppression of spontaneous food intake following dairy calcium and vitamin D. Nutrition Society of Australia Annual Conference. *Asia Pacific Journal of Clinical Nutrition*. 2004;13. Abstract.
- In a study of 51 normal weight women who reduced their caloric intake and increased physical activity over four months, researchers found that the women who also increased their milk intake by at least 200ml/day, nearly one cup, lost more body fat and gained more lean muscle mass compared to the women that did not increase milk intake.

Hirota T, Kawasaki I, Ikeda H, Aoe T, Hirota K. Intake of vitamin D and milk was associated with increase in muscle mass and decrease in body fat during dieting in young women. American Society for Bone and Mineral Research Annual Meeting. 2005. Abstract M272.

- In a 12-week multi-center trial of 68 overweight and obese adults consuming a reduced-calorie diet, the participants who consumed 3 servings of dairy a day lost more body fat compared to those who ate an equal amount of calcium through supplements or a low-dairy diet. All participants lost weight and body fat, but people on the high-dairy diet lost nearly twice as much body fat, more trunk fat and more inches around the waist compared to the other groups.

Zemel MB, Teegarden D, Van Loan M, Schoeller DA, Matkovic V, Lyle RM, Craig BA. Role of dairy products in modulating weight and fat loss: A multi-center trial. *FASEB Journal*. 2004. 18: A845. Abstract.

- In a 48-week study of 44 obese postmenopausal women in Korea, researchers found that calcium supplementation induces body weight and fat loss with favorable changes in fat distribution, including reduced abdominal visceral fat. Subjects received a daily calcium supplement providing 300 mg calcium in addition to the average basal dietary calcium intake ~400 mg. Researchers compared the subjects with low (less than 400 mg per day) versus high (more than 400 mg per day) baseline dietary calcium intakes when analyzing the outcomes measures. Those subjects with low baseline calcium intakes were more obese than those with higher calcium intakes at the start of the study, but they achieved more weight and fat loss and improvement of insulin sensitivity after the 48-week calcium supplementation. The researchers conclude that obesity and calcium intake at baseline may partially determine the magnitude of the response to calcium supplementation.

Kim D, Rhee Y, Ahn C, Cha B, Kim K, Lee H, Lim S. Effects of calcium supplementation on body composition and fat distribution in Korean obese postmenopausal women. American Society for Bone and Mineral Research Annual Meeting. 2005. Abstract SA422.

Observational Studies

Epidemiological, or observational, studies do not confirm a cause-and-effect relationship, but they are valuable in identifying associations and guiding researchers to investigate a connection further. Multiple observational studies show that people who consume more calcium and dairy foods weigh less and/or have less body fat than those who consume little or no dairy. Researchers speculate that a low calcium diet may be a risk factor for obesity. One expert suggested that correcting the country's calcium deficit may reduce the incidence of overweight and obesity by 60-80%.

- In this reevaluation of five clinical studies originally designed to measure bone health, researchers found that a higher intake of calcium (primarily from dairy foods) was associated with a lower BMI and body weight. Results from this study indicate that women weighed an average of 18 pounds less for every 1,000 mg of calcium consumed.
Davies KM, Heaney RP, Recker RR, Lappe JM, Barger-Lux MJ, Rafferty K, Hinders S. Calcium intake and body weight. *Journal of Clinical Endocrinology & Metabolism*. 2000; 85: 4635-4638.
- In young adult women (ages 18-31 years) enrolled in a two-year exercise program, calcium from dairy foods was associated with lower body weight and body fat in women consuming fewer than 1900 calories per day. The researchers concluded that the effect of calcium was specific to dairy calcium because total calcium and dairy, when adjusted for calories, predicted changes on body weight and body fat, whereas non-dairy calcium did not.
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. *Journal of the American College of Nutrition*. 2000; 19(6):754-760.

- Researchers studied the relationship between consumption of specific types of food, e.g., meat, fish, bread and dairy and metabolic syndrome via food frequency questionnaires in nearly 5,000 men and women. Metabolic syndrome is a condition characterized by insulin resistance, central obesity, high blood pressure, high blood glucose and triglycerides, and low HDL cholesterol. Dairy product consumption was associated with lower diastolic blood pressure in both men and women. The consumption of 1-4 portions per day of dairy was related to lower serum triglycerides, fasting blood glucose and lower incidence of metabolic syndrome in men.
Mennen LI, Lafay L, Feskens EJM, Novak M, Lepinay P, Balkau B. Possible protective effect of bread and dairy products on the risk of the metabolic syndrome. *Nutrition Research*. 2000; 20:335-347.
- Researchers analyzing data from NHANES III found that in men and women, increased calcium intake is associated with lower body fat. These data are consistent with animal studies that suggest increased dietary calcium may affect the rate of energy metabolism and reduce the risk of obesity.
Zemel MB, Shi H, Greer B, Dirienzo D, Zemel PC. Regulation of adiposity by dietary calcium. *FASEB Journal*. 2000; 14:1132-1138.
- Researchers tracked the lifestyle habits of nearly 150 middle-aged, premenopausal women as part of the Healthy Transitions Study and found that body fat was inversely associated with calcium intake, in both white and African-American subjects. This correlation was stronger for white subjects compared to African-American subjects, who also had lower intakes of calcium.
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. *American Journal of Clinical Nutrition*. 2001; 74:90-95.
- Results from the CARDIA study indicate that increased dairy consumption may protect overweight individuals from becoming obese or developing insulin resistance syndrome (also known as metabolic syndrome), which is associated with increased abdominal fat. Obesity and insulin resistance syndrome are major risk factors for type 2 diabetes and cardiovascular disease. This 10-year prospective study examined the dietary habits of more than 3,000 adults aged 18 to 30 years. Increased dairy consumption was equally beneficial to African Americans and Caucasians, and both reduced-fat and full-fat dairy products were effective.
Pereira MA, Jacobs JD, Van Horn L, Slattery ML, Kartashov AI, Ludwig DS. Dairy consumption, obesity, and the insulin resistance syndrome in young adults: The CARDIA Study. *Journal of the American Medical Association*. 2002; 287:2081-2089.
- Data from more than 550 women were reevaluated to assess the effects of calcium on weight gain. While calcium is only one factor that potentially affects obesity, findings from this reanalysis indicate that increasing calcium intakes to recommended levels may reduce the incidence of overweight and obesity by 60-80% in a population. This estimate and conclusion are based on data projection.
Heaney RP. Normalizing calcium intake: projected population effects for body weight. *Journal of Nutrition*. 2003; 133:268S-270S.
- Using data from adults in the Quebec Family Study, researchers found that a higher calcium intake was significantly associated with lower body weight and fat in women and found a similar trend in men. Women in the study who consumed inadequate amounts of calcium were more likely to be overweight. After controlling for age, energy intake, percent dietary fat and protein, and social economic status, women consuming less than 600 mg of calcium a day had greater body weight, BMI, percentage body fat, fat mass, waist circumference and abdominal fat tissue compared to those consuming 600 mg of calcium or more. Dairy foods provided about 60% of the calcium in the study subjects' diets.
Jacqmain M, Doucet E, Despres JP, Bouchard C, Tremblay A. Calcium intake, body composition, and lipoprotein-lipid concentrations in adults. *American Journal of Clinical Nutrition*. 2003; 77:1448-1452.

- Data from more than 800 adults enrolled in the HERITAGE Family Study was evaluated and found that high daily calcium intake (including from dairy foods) was associated with lower weight.
Loos R, Rankinen T, Leon A, Rao DC, Skinner J, Wilmore J, Bouchard C. Calcium intake and body composition in the HERITAGE Family Study. *Obesity Research*. 2003; 11(S): 597-P.
- Researchers at the University of Colorado measured whole-body fat oxidation during a 24-hour period in 35 non-obese healthy adults. In their retrospective analysis of data from these subjects, a higher dietary calcium intake over the 24-hour period was associated with burning significantly more body fat, even during sleep.
Melanson EL, Sharp TA, Schneider, J, Donahoo WT, Grunwald GK, Hill JO. Relation between calcium intake and fat oxidation in adult humans. *International Journal of Obesity*. 2003; 27: 196-203.
- Researchers at Tufts University found that a diet high in fruit, vegetables, reduced-fat dairy and whole grains, and low in red and processed meat, fast food and soda, was associated with smaller gains in BMI and waist circumference in adults.
Newby PK, et al. Dietary patterns and changes in body mass index and waist circumference in adults. *American Journal of Clinical Nutrition*. 2003; 77:1417-1425.
- A study that used data from the Quebec Family Study investigated weight/fat changes in relation to participants' consumption of foods from various food groups. Only participants who ate more from the dairy group and from the fruit group (but not in combination) gained less weight over time.
Drapeau G, et al. Modifications in food-group consumption are related to long-term body-weight changes. *American Journal of Clinical Nutrition*. 2004; 80: 29-37.
- Following an analysis of food patterns consumed by 459 healthy adults participating in the Baltimore Longitudinal Study of Aging, researchers at Tufts University suggest that a diet rich in reduced-fat dairy products and high-fiber foods may lead to smaller gains in BMI in women and smaller gains in waist circumference in both women and men. Diet was assessed by using 7-day dietary records, from which 40 food groups were formed and entered into a factor analysis.
Newby PK, et al. Food patterns measured by factor analysis and anthropometric changes in adults. *American Journal of Clinical Nutrition*. 2004; 80: 504-513.
- In this cross-sectional study of 827 men and women in Tehran (aged 18-74 years), researchers found that higher intakes of dairy products were associated with a lower prevalence of metabolic syndrome. Additionally, a higher intake of dairy was associated with a healthier diet, lower waist circumference and lower blood pressure.
Azadbakht L, Mirmiran P, Esmailzadeh A, Azizi F. Dairy consumption is inversely associated with the prevalence of the metabolic syndrome in Tehranian adults. *American Journal of Clinical Nutrition*. 2005; 82: 523-530.
- In the Amsterdam Growth and Health Longitudinal Study, researchers in the Netherlands followed a cohort of men and women from ages 13 to 36 years to investigate the longitudinal relationship between health and lifestyles considering physical activity, diet, smoking and alcohol consumption. The data indicate a weak inverse relation of calcium intake and BMI. The authors conclude that the findings may be in contrast with previous investigations (where stronger inverse relationships were found) because the average calcium intake is much higher in this Dutch population than in subjects assessed in other studies. They suggest there may be a threshold for calcium intake above which no additive beneficial effect exists. The calcium intake threshold in the Dutch study was about 800 mg per day.
Boon N, Koppes LLJ, Saris WHM, Van Mechelen W. The relation between calcium intake and body composition in a Dutch population. *American Journal of Epidemiology*. 2005; 162:27-32.
- Researchers analyzed data from 10,066 women (aged 45 years and older) participating in the Women's Health Study who were free of cardiovascular disease, cancer and diabetes. Results indicate

that higher intakes of calcium and dairy products were significantly associated with a lower prevalence of metabolic syndrome.

Liu S, Song Y, Ford ES, Manson JE, Buring JE, Ridker PM. Dietary calcium, vitamin D, and the prevalence of metabolic syndrome in middle-aged and older U.S. women. *Diabetes Care*. 2005; 28: 2926-2932.

- In one of the first reports on the relationships between milk intake and obesity in a South European country, researchers in Portugal found that milk intake was inversely related to BMI in men and in pre-menopausal women, but not in postmenopausal women. In this sample of 17,771 men and 19,742 women, subjects with the highest milk consumption were least likely to be obese. Obese or overweight subjects reported drinking less milk than normal weight subjects. The lack of relationship between milk intake and BMI in older women may be due to hormonal status, but more research is needed, the researchers concluded.

Marques-Vidal P, Goncalves A, Dias CM. Milk intake is inversely related to obesity in men and in young women: data from the Portuguese Health Interview Survey 1998-1999. *International Journal of Obesity*. 2006; 30:88-93.

- In a cross-sectional study of 582 men and women, people who consumed more calcium had a lower percent of body fat and trunk fat than individuals who consumed less calcium.
Martin G, et al. Calcium intake is correlated with percent body fat and percent trunk fat, but not serum lipids, in the Newfoundland population. *Obesity Research*. 2004; 12(10): A217; 851-P. Abstract.
- A cross-sectional study from Iran found that people who ate more dairy foods including milk, yogurt and cheese were less likely to be overweight or obese than those who consumed fewer dairy foods.
Mirmiran P, Esmailzadeh A, Azizi F. Dairy consumption and body mass index: An inverse relationship. *International Journal of Obesity*. 2005; 29:115-121.
- A controlled, clinical trial of young women designed to investigate the effects of calcium on bone health demonstrated that calcium supplementation (1500 mg/day) resulted in less gain in fat mass over a three-year period, compared to a lower-calcium control group.
Barger-Lux MJ, et al. Calcium supplementation may attenuate accumulation of fat in young women. *Journal of Bone Mineral Research*. 2001; 16:S219. Abstract.
- A study of overweight, previously-sedentary adults showed that weight and fat loss, resulting from a 9-month exercise intervention program without dietary restriction, was associated with increased calcium consumption in men.
Bailey B, et al. The influence of calcium consumption on weight and fat alterations following 9 months of exercise in men and women. *Obesity Research*. 2004; 12(10S): A34; 133-OR. Abstract.
- A study involving 175 pre-menopausal and 70 postmenopausal women indicates that calcium intake is associated with the maintenance of normal body weight, the prevention of visceral fat gain (the fat that surrounds internal organs) and insulin sensitivity.
Choquette S, et al. The effect of calcium intake on body weight, weight regain and insulin resistance. *Obesity Research*. 2004; 12(10): A170; 667-P. Abstract.
- A study originally designed to look at blood pressure found that when individuals consumed a diet high in dairy foods, fruits and vegetables, they had a significantly higher resting metabolic rate and utilized more fat for energy than when they consumed a diet high in only fruits and vegetables. As these subjects were not restricting their caloric intakes, this suggests a positive role for dairy foods in weight maintenance.
De Jonge L, et al. Increased resting metabolic rate and fat oxidation after a diet rich in dairy products. *Obesity Research*. 2004; 12(10): A127; 496-P. Abstract.

- Men and women in Israel with the highest calcium and milk intakes were the most likely to have a BMI in the normal range. Women with the highest calcium intakes had the smallest waist circumference.
Dicker D, et al. On the relationship between dietary calcium intake, body mass index and waist size. Presented at the 13th European Congress on Obesity. *International Journal of Obesity and Related Metabolic Disorders*. 2004; Supplement 1(28): S59. Abstract.
- A report from the Czech Republic found that adults on a balanced, modestly reduced-calorie diet lost more weight when their diet included more calcium and more protein.
Kabrnova K, et al. Association of changes in macronutrient and calcium intakes with body weight change in obese subjects. Presented at the 13th European Congress on Obesity. *International Journal of Obesity and Related Metabolic Disorders*. 2004; Supplement 1(28): S138. Abstract.
- In a study involving 103 women and the effect of calorie and calcium intake on weight regain after weight loss, researchers found that high dietary calcium intake led to less weight regain during a year follow-up.
Ochner, C and Lowe, MR. Opposing effects of calcium and caloric intake on weight regain after diet. Presented at the 13th European Congress on Obesity. *International Journal of Obesity and Related Metabolic Disorders*. 2004; Supplement 1(28): S143. Abstract.

Mechanistic Support - Animal and Cellular Studies

Researchers have conducted cellular, animal and human studies to better understand the specific mechanism responsible for dairy's impact on body weight and fat. While more research is needed to understand all the mechanisms that may be involved in the dairy-weight relationship observed in human studies, current scientific evidence suggests that a combination of calcium and other dairy components may participate in the body's natural regulatory system for burning fat to support weight management. Preliminary studies indicate five plausible mechanisms including vitamin D-related up-regulation of fat burning in fat cells and decreased fat storage, parathyroid hormone effects on fat burning, increased satiety, decreased fat (and calorie) absorption and branch chain amino acids and inhibition of fat synthesis.

- Data from this in vitro study indicate that 1 α ,25-dihydroxyvitamin D₃ (the active form of vitamin D) allows the influx of calcium into human fat cells, which in turn stimulates the storage of fat and inhibits the breakdown of fat. The researchers conclude that intake of dietary calcium may directly inhibit this mechanism, and therefore may contribute to dietary calcium's anti-obesity effect.
Shi H, Norman AW, Okamura WH, Sen A, Zemel MB. 1alpha, 25-Dihydroxyvitamin D3 modulates human adipocyte metabolism via nongenomic action. *FASEB Journal*. 2001; 15:2751-2753.
- A study found that calcium, particularly calcium from dairy foods, promotes weight and fat loss in calorie-restricted mice by adjusting energy metabolism. More specifically, the study found that the high-calcium diet suppressed the influx of calcium into fat cells, which stimulated fat breakdown, inhibited fat storage and increased energy wasting through body heat.
Shi H, Dirienzo D, Zemel MB. Effects of dietary calcium on adipocyte lipid metabolism and body weight regulation in energy-restricted aP2-agouti transgenic mice. *FASEB Journal*. 2001; 15:291-293.
- A study demonstrated that 1 α ,25-dihydroxyvitamin D₃ (the active form of vitamin D) has an inhibitory effect on uncoupling protein 2 (UCP2), a protein found in fat cells that may help the body "burn energy." The researchers concluded that suppression of 1 α ,25-dihydroxyvitamin D₃ via a high-calcium diet may result in up-regulation of UCP2, and therefore may contribute to the anti-obesity effect of dietary calcium.

Shi H, et al. 1 alpha, 25-dihydroxyvitamin D3 inhibits uncoupling protein 2 expression in human adipocytes. *FASEB Journal*. 2002; 16(13):1808-10.

- Rats fed high-calcium, high-dairy protein diets gained significantly less weight than controls and had 29% less carcass fat, while consuming the same amount of energy. Additionally, researchers found that rats fed the high-calcium, high-dairy protein diet had increased fecal excretion of dietary lipid and lower levels of serum 1,25-dihydroxyvitamin D -- offering clues to potential mechanisms for the dairy-calcium effect on weight.

Papakonstantinou E, Flatt WP, Huth PJ, Harris RBS. High dietary calcium reduces body fat content, digestibility of fat, and serum vitamin D in rats. *Obesity Research*. 2003;11:387-394.

- A review of studies of both human and animal fat cells helped demonstrate that the calcium in these cells plays a key role in regulating fat metabolism and storage. Specifically, calcitriol (the active form of vitamin D) increases in response to low calcium diets and has been shown to promote the influx of calcium into fat cells, which in turn inhibits fat breakdown and promotes fat storage.

Zemel MB. Mechanisms of dairy modulation of adiposity. *Journal of Nutrition*. 2003; 133:252S-256S.

- This research review concluded that dietary calcium may play an important role in the regulation of energy metabolism and may result in a reduction of body fat and an acceleration of weight and fat loss during caloric restriction. This review also concluded that dairy sources of calcium demonstrate substantially greater effects than supplemental or fortified sources. Suppression of the active form of vitamin D with high-calcium diets may reduce calcium in the fat cell, inhibit fat storage and increase fat breakdown.

Zemel, MB. Role of dietary calcium and dairy products in modulating adiposity. *Lipids*. 2003; 38(2):139-146.

- Mice allowed free access to diets high in calcium, specifically from dairy foods, had less fat and weight regain after a period of weight loss. An increase in proteins measured in the fat tissue (UCP2) and skeletal muscle (UCP3 and PPAR) suggests an upregulation of fat burning in the animals consuming calcium-rich dairy diets.

Sun X, Zemel MB. Calcium and dairy products inhibit weight and fat regain during ad libitum consumption following energy restriction in Ap2-Agouti transgenic mice. *Journal of Nutrition*. 2004; 134:3054-3060.

- Preliminary findings demonstrate that calcium from dairy foods increases the rate of weight loss in mice fed a low-fat diet and slows the rate of weight gain in mice fed a high-fat diet.

Serra F, et al. Dietary calcium helps to counteract obesity. Presented at the 13th European Congress on Obesity. *International Journal of Obesity and Related Metabolic Disorders*. 2004; Supplement 1 (28):S146. Abstract.

- Mice fed yogurt experienced less weight and fat gain versus mice fed a control diet, without a decrease in food intake, over four weeks.

Johnson M, Watts A, Allison D, Nagy T. Effect of dairy supplementation on body composition in mice. North American Society for the Study of Obesity Annual Conference. 2005. Abstract 197-P.

Research Reviews

Scientists have reviewed the body of literature on dairy and weight and concluded that getting 3 servings of dairy foods each day has the potential to impact weight loss and body composition.

- A research review of laboratory, clinical and population data concluded that increasing dietary calcium intakes may result in reductions in fat mass and blood pressure.
Zemel MB. Calcium modulation of hypertension and obesity: mechanisms and implications. *Journal of the American College of Nutrition*. 2001; 20:428S-435S.
- A review of data from six observational and three controlled trials revealed a consistent effect of higher calcium intake with lower body fat and/or weight and reduced weight gain at midlife. The data also suggest that increasing calcium intake by the equivalent of two dairy servings per day could reduce the risk of overweight substantially, possibly by as much as 70%.
Heaney RP, Davies KM, Barger-Lux MJ. Calcium and weight: clinical studies. *Journal of the American College of Nutrition*. 2002; 21: 152S-155S.
- A review article of selected randomized trials that were originally designed to primarily explore the relationship between dairy consumption or calcium intake and bone health, could not identify a clear pattern between body weight and dairy foods nor calcium. However, these studies were not specifically designed or powered to examine the dairy/weight relationship, and factors that can affect the dairy/weight relationship were not well controlled.
Barr SI. Increased dairy product or calcium intake: Is body weight or composition affected in humans? *Journal of Nutrition*. 2003; 133:245S-48S.
- Dietary calcium may play a role in regulating body weight, supporting the hypothesis that increasing dietary calcium or dairy intake may reduce future weight gain.
Parikh SJ, et al. Calcium intake and adiposity. *American Journal of Clinical Nutrition*. 2003; 77:281-287.
- This research review concluded that nutrients found in dairy, including calcium, may contribute to the reduction of body weight, body fat and insulin resistance syndrome.
Teegarden D, et al. Symposium: Dairy product components and weight regulation. *Journal of Nutrition*. 2003; 133: 243S-256S.
- This research review examined epidemiologic and clinical data supporting a relationship between dietary calcium intake and obesity. The author concluded that MDs and other primary care providers should include recommendations about adequate calcium intake in standard dietary counseling about weight management.
Schrager S. Dietary calcium intake and obesity. *Journal of the American Board of Family Practice*. 2005; 18:205-210.
- A review article concluded that dairy products, specifically milk, may be potential functional foods for enhancing weight loss or preventing weight gain. The author notes that weight control effects of milk could be even greater in a healthy, balanced diet that combines other possible functional foods such as tea and nuts along with energy restriction and increased physical activity.
St-Onge, MP. Dietary fats, teas, dairy, and nuts: potential functional foods for weight control? *American Journal of Clinical Nutrition*. 2005; 81:7-15.
- This review of observational and intervention studies concluded that substantial evidence exists for an association between dietary calcium or dairy product intakes and lower body fat or waist circumference. Specifically, the results of randomized clinical trials support the role of dairy foods in enhancing weight and fat mass loss, while the results for calcium are contradictory. The results of the

individual studies are impacted by multiple factors, such as total energy intake, protein amount and source, and/or vitamin D status. These factors may act synergistically to regulate energy balance or promote reduction or prevent gain of body fat. The author points out that if current recommendations for calcium intake were met through food sources in the promotion of optimal bone health, this might also help to reduce the incidence and development of overweight and obesity.

Teegarden D. The influence of dairy product consumption on body composition. *Journal of Nutrition*. 2005; 135:2749-2752.

Studies of Children and Adolescents

While the majority of dairy/weight management studies have been conducted with adults, researchers have found that dairy may play a role in promoting a healthy weight and body composition or preventing an unhealthy weight gain among children and adolescents. Some studies have shown that a higher intake of dairy foods is associated with a lower percentage of body fat among children and teenagers.

- Researchers evaluated dairy intake in relation to changes in body fat in 99 children followed over 12 years from ages 2-3 to 12-13 in the Framingham Children's Study. Children who consumed the fewest dairy servings per day had statistically greater gains in BMI and body fat than those who consumed more dairy from childhood to early adolescence. The researchers concluded that low levels of dairy may be associated with a greater acquisition of body fat during childhood.
Moore LL, Singer MR, Bradlee ML, Gao DI, Hood M, Ellison RC. Low intakes of dairy products in early childhood may increase body fat acquisition. *Obesity Research*. 2003; 11(S): 130-OR.
- Researchers followed 196 non-obese 8-12 year-old girls for 10 years. They found no evidence that dairy food or calcium consumption is associated with changes in BMI or body fat during adolescence. The researchers concluded that there is no scientific basis for teenagers who are concerned about weight gain or body fat levels to exclude the recommended amounts of dairy foods from their diets.
Phillips SM, Bandini LG, Cyr H, Cloclough-Douglas S, Naumova E, Must A. Dairy food consumption and body weight and fatness studied longitudinally over the adolescent period. *International Journal of Obesity*. 2003; 27:1106-13.
- In children followed from ages 2 to 8, a higher dietary calcium intake from calcium-rich foods like milk, cheese and yogurt was associated with a lower percentage of body fat.
Skinner JD, Bonds W, Carruth BR, Ziegler P. Longitudinal calcium intake is negatively related to children's body fat indexes. *Journal of the American Dietetic Association*. 2003; 103:1626-1631.
- Researchers at Creighton University evaluated the influence of diet on weight gain during 2 years of a study originally designed to investigate the effects of a calcium-rich diet on bone health. Participants were randomly assigned to a calcium-rich diet supplying at least 1,500 mg of calcium per day (primarily from dairy foods) or their usual diet. While the girls on the calcium-rich diet consumed about 150 more calories per day, they did not have greater increases in body weight, BMI or fat mass compared to girls consuming their usual diets at approximately 900 mg of calcium per day.
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. *Journal of the American Dietetic Association*. 2004; 104:1361-1367.
- Children who ate more dairy foods and had moderate intake of dietary fat gained less weight and fat than children who ate fewer dairy foods and had low or high intakes of dietary fat.
Moore LL, Singer MR, Bradlee ML, Ellison RC. Dietary predictors of excess body fat acquisition during childhood. *Circulation*. 2004; 109(7):5, No. 3.
- In adolescent Asian and Caucasian girls ages 9-14, total and dairy calcium intake, but not non-dairy calcium, was associated with lower body fat. One milk serving was associated with decreased body

fat measured by skinfold thickness while soda intake was associated with greater body weight. Researchers concluded that decreasing soda and increasing dairy consumption among girls, particularly Asians, may help maintain body fat and weight during adolescence.

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. *Journal of Nutrition*. 2004; 134(8):1905-1909.

- A study of 1701 children from 3rd to 7th grade in nine schools in Chile found a significant association between obesity and low intake of dairy products. While intake of energy-dense foods and TV watching time appeared as risk factors, only dairy consumption was associated with a significant inverse association with obesity.
Olivares S, Kain J, Lera L, Pizarro F, Vio F, Moro'n C. Nutritional status, food consumption and physical activity among Chilean school children: A descriptive study. *European Journal of Clinical Nutrition*. 2004. 58:1278-1285.
- In a two-year observational study of 46 New Zealand children (ages 3-10 years) who were “milk avoiders,” researchers found that low calcium intakes at baseline were associated with an elevated BMI, short stature and low bone mineral density compared to a reference population of milk drinkers. Increasing milk intake resulted in some catch-up in height at the two-year follow-up for the milk avoiders, but the group remained short in stature, with BMI values that were higher than the reference population.
Rockell JE, Williams SM, Taylor RW, Grant AM, Jones IE, Goulding A. Two-year changes in bone and body composition in young children with a history of prolonged milk avoidance. *Osteoporosis International*. 2005; 16:1016-1023.
- A study in Italy evaluated the relationship between milk consumption and body mass in nearly 900 children ages 5-11 years. The researchers found an association between higher milk consumption and lower BMI z-scores, when controlling for sex, age, physical activity, birth weight, parental overweight and education.
Barba G, Troiano E, Russo P, Venezia A, Siani A. Inverse association between body mass and frequency of milk consumption in children. *British Journal of Nutrition*. 2005; 93:15-19.
- Researchers followed 12,829 children ages 9 to 14 from the Growing Up Today Study from 1996 to 1999. Using food frequency questionnaires and self-reported height and weight, they found that children who consumed more than 3 servings of milk per day gained significantly more in BMI than those who drank fewer servings. However, when the analysis was adjusted for energy, milk intake had no significant effect on increase in BMI and total energy was found to be the most important predictor of increase in BMI. The authors concluded that milk itself was not responsible for the weight gain in this cohort, but rather added calories. In a previous report of the Growing Up Today Study (Rockett HR, Berkey CS, Field AE, Colditz GA. Cross-sectional measurement of nutrient intake among adolescents in 1996. *Preventive Medicine*. 2001; 33:27-37), the same researchers reported that overweight participants consumed fewer dairy products than non-overweight youths.
Berkey CS, Rockett HR, Willett WC, Colditz GA. Milk, dairy fat, dietary calcium, and weight gain: A longitudinal study of adolescents. *Archives of Pediatric and Adolescent Medicine*. 2005; 159:543-550.
- In this review, the authors examined the current evidence exploring the role of dairy intake in relation to obesity and metabolic syndrome in children and adolescents. They found that there is some biological evidence for a beneficial role of dairy, but these physiological pathways have not been examined in children and adolescents. They concluded that more research is needed to determine whether any effects of dairy are independent of other eating patterns, such as intake of sweetened beverages or overall energy intake.
Huang TT, McCrory, MA. Dairy intake, obesity, and metabolic health in children and adolescents: knowledge and gaps. *Nutrition Reviews*. 2005; 63:71-80.

- A study of 3,044 Portuguese children (ages 7-9 years) found an inverse relationship between calcium intake and BMI in girls.
Moreira P, Padez C, Mourao I, Rosado V. Dietary calcium and body mass index in Portuguese children. *European Journal of Nutrition*. 2005; 59:861-867.
- Researchers found that a diet rich in calcium and dairy products was linked to lower body fat, yet calcium supplements had no effect on body weight or body fat during a one-year intervention. This randomized, double-blind intervention study looked at the impact of calcium supplementation on body weight and body fat in young girls. The 110 subjects (12-year-old girls) were randomly assigned to receive 500 mg of calcium carbonate or a placebo for one year. Food frequency questionnaires were used to assess habitual intake of dietary calcium. While the low-dose calcium supplementation had no effect on body weight or body fat, the habitual intake of dietary calcium (from milk and dairy products) was associated with lower body fat. In their analysis of the results, the researchers suggest that the effect of calcium on body weight may only be exerted if it is consumed as part of a meal. Additionally, they speculate that the weight management effect may be due to other ingredients in dairy products, and calcium may simply be a marker for a high dairy intake.
Lorenzen JK, Molgaard C, Michaelsen KF, Astrup A. Calcium supplementation for 1-y does not reduce body weight or fat mass in young girls. *American Journal of Clinical Nutrition*. 2006; 83:18-23.
- By reviewing diet questionnaires of overweight and normal-weight 10- to 14- year-old students, Hungarian researchers found that the heaviest children had the lowest intake of calcium from dairy foods.
Lelovics, Z and Tarnavolgyi, G. Relation between calcium intake and obesity. Presented at the 13th European Congress on Obesity. *International Journal of Obesity and Related Metabolic Disorders*. 2004; Supplement 1(28): S169. Abstract.
- Obese Greek adolescents ages 11, 13, and 15 years were found to skip breakfast more and eat less fruits and milk than normal weight Greek students.
Tsakalou Z, et al. Prevalence of obesity/overweight and eating habits in Greek adolescents. Presented at the 13th European Congress on Obesity. *International Journal of Obesity and Related Metabolic Disorders*. 2004; Supplement 1(28): S203. Abstract.
- In a two-year prospective study of young girls (initially 10 years old), total calcium intake and dairy intake was associated with lower percent body fat and percent trunk fat in peripubertal girls, but did not predict change in percent body fat over two years.
Barr, S. Calcium intake is associated with percent body fat in peripubertal girls, but does not predict change in percent body fat over two years. North American Society for the Study of Obesity Annual conference. 2005. Abstract 68-OR.
- Using baseline data from the Youth and Adolescents Osteo Outcomes Study, researchers analyzed calcium intake and body composition of 280 Caucasian and African American adolescents (aged 8-18 years). The results revealed that less than 15 percent of adolescent girls and 37 percent adolescent boys get the recommended amounts of calcium. Low calcium intakes were associated with a higher body fat.
Lucchesi M, McClanahan B, Ward K, Lancot J, Clemens L. Calcium intake and body composition in children. North American Society for the Study of Obesity Annual Conference. 2005. Abstract 234-P.
- Using data from the Framingham Children's Study, researchers found that children with the lowest intakes of fruit and dairy products had the greatest yearly gains in waist circumference from preschool to early adolescence.
Moore, L, Qureshi MM, Bradlee ML, Singer M. Early childhood food pyramid intake and change in central adiposity. North American Society for the Study of Obesity Annual Conference. 2005. Abstract 69-OR.

- In this randomized, cross-over study, six children (ages 9-10 years) were given either 3 servings per day of milk or a sweetened fruit drink – referred to as a “single-nutrient beverage” – for one week. After the one-week supplementation period, the post-meal energy expenditure and the thermic effect of food were higher with the consumption of milk compared to the sweetened fruit drink. While the authors acknowledge that these results are preliminary, they comment that the findings suggest a metabolic adjustment induced by milk and a potential long-term effect of milk consumption on energy balance.

St-Onge MP, Claps N, Kostelli A, Heymsfield S. A mixed nutrient beverage leads to greater thermic effect of food compared to a single nutrient beverage after one week of supplementation. *FASEB Journal*. 2005; 971.5. Abstract.

For more information about the science supporting dairy and a healthy weight, visit:

www.nationaldairycouncil.org