# Relation between calcium intake and weight management

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There is a growing body of evidence supporting the relationship between increased calcium intake and a reduction in body weight more specifically pertaining to a loss of body fat.

In the following is provided a summary on the studies conducted to elucidate the topic and the findings of the studies. In brief is also an overview of the suggested mechanism of actions.

## Animal studies linking dietary calcium with body weight

The first studies linking calcium intake with changes in body weight date back to the 1980's. These studies were done on rats and showed a lower net weight gain in rats fed high calcium diets (2.8%,wt:wt) compared to rats fed low calcium diets (0.4%,wt:wt) (1,2).

In an attemp to elucidate the mechanism behind the observed effect, a more recent study was conducted in which transgenic mice with an overexpression of the agouti gene in adipocytes were placed on diets differing in calcium content (3). Agouti protein is an obesity gene expressed in adipocytes. Agouti stimulates calcium influx in cells and also stimulates the expression and activity of fatty acid synthase, a key enzyme in de novo lipogenesis, and inhibits lipolysis. The mice received either a low calcium diet (0.4 % Ca), calcium supplemented diet (1.2% Ca) or dairy supplemented diets (1.2 or 2.4 % Ca). Compared to the control diet group weight gain was reduced by 26 % by the 1.2%-Ca diet, by 29 % by the 1.2% dairy Ca diet and by 39 % by the 2.4% dairy Ca diet. This study suggests that an increased calcium intake decreases body weight gain in mice. Another interesting observation in this study is that it suggests intake of dairy products to have a greater effect than calcium supplements.

## Mechanism of action

Based on the animal studies it was suggested that the mechanism by which calcium influences body weight is related to the influx of calcium in adipocytes and the calcium concentration of these.

Reduced dietary calcium intake is shown to be followed by a raise in the levels of the calcitrophic hormone 1,25(OH)2-D. This is followed by an increase in intracellular Ca2+ in adipocytes which results in a stimulation of lipogenesis and an inhibition of lipolysis. In addition to this animals overexpressing the agouti protein also stimulate the expression and activity of the fatty acid synthase, which is a key enzyme in de novo lipogenesis (3).

To determine if the relation found in animals is similar in humans, weight changes in humans have been observed in relation to intake of calcium, both as supplemented and dairy derived calcium.

## Dairy calcium intake and energy intake

Based on the data from the National Health and Nutrition Examination Survey (NHANES III) Zemel et al. found a significantly inverse relationship between intake of calcium and dairy products and obesity. The relative risk of high body adiposity was greatest in those subjects with the lowest calcium intake. The calcium intake in this study was corrected for energy intake and this indicated, that a high calcium intake decreases adipocyte fat storage for any given level of energy intake (3).

In another study the objective was to relate the longitudinal intake of dairy products and calcium to children's body composition at 70 months. Mean calcium intakes ranged from 791-968 mg/day for males and 698-808 mg/day for females.

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Mean longitudinal intakes of calcium (mg/d) were significantly and negatively related to lower body fat (%,g). Intakes of dairy products were negatively associated with body fat (g). In this study dairy foods were the major dietary source of calcium. The investigators therefore question whether other components of milk/dairy foods contribute to the found effect and if a calcium supplement would produce the same effect as seen with the dairy foods consumption (4).

In a similar study of 235 men and 235 women the association between daily calcium intake and body composition, as well as plasma lipoprotein-lipid concentrations were studied.

Calcium intake in women and men were 861.8 +/-22.8 and 1016.4 +/- 30.3 mg/d, respectively. Most of the dietary calcium was derived from dairy products. In women 61.8% of the daily calcium and in men 59.5 % was derived from dairy products. There was found a significant negative correlation between body weight, body fat % and dietary calcium intake > 600 mg/d. The observation was mainly done in women.

This is the first study to show differences in the lipoprotein profile by daily dietary calcium intake. The ratio of total/HDL cholesterol was significantly greater in women consuming < 600 mg/d than in women consuming 600-1000 and > 1000 mg/d (5).

In a study determining how intolerance of lactose and dairy products influence calcium intake in lactose maldigesting African American women it was found that low calcium intake is associated with higher BMI. The daily calcium intake was 780 +/- 305 and 388 +/- 150 mg/day in lactose tolerant and intolerant women respectively. In lactose tolerant women 45% of dietary calcium came from milk and dairy products and in lactose intolerant women only 12 %.

A negative linear correlation was found between calcium intake and BMI. BMI was significantly higher in lactose intolerant vs. tolerant women. (29.6 +/-4.7 vs. 25.6 +/-5.4) (6).

In an exercise intervention study investigating the relationship between micronutrients (calcium) intake and body weight over two years, it was found that regardless of exercise group calcium intake

had a negative relationship with changes in total body fat and weight. Mean Daily calcium intake was 781 +/- 212 mg/d of which 69% was dairy calcium. Significant correlations were found between calcium intake and change in body fat and weight.

The best predictor of absolute changes in body fat and weight was total calcium intake divided by calories and dairy calcium intake divided by calories. When subjects were categorised according to energy intake the lower energy intake group (<1876 kcal/d) both total calcium and dairy calcium intake were predictive of negative changes in body weight and fat loss. When energy intake exceded 1876 kcal/d no correlation was seen with daily calcium intake. The findings were shown independent of exercise group assignment.

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The conclusion of the study is that higher calcium intake is associated with loss or lower gain of body fat regardless of exercise, but related to energy intake, which shows that the impact of calcium on body weight has a limit (7).

In an abstract Zemel et al. presented the results from a study of 32 obese adults maintained for 24 weeks on a balanced deficit diet differing in the calcium content. The subjects were randomised to a control (4-500 mg/d), high calcium (800+4-500 mg/d) or high dairy (1300 m/d) diets. Increasing calcium intake showed significant weight loss. The control patients lost 6.4 +/- 2.5 % of body weight. Weight loss in the high calcium group was 26 % higher than control and in the dairy group the loss was 70 % higher than control. The variation in calcium intake also seemed related to fat loss from the trunk region. Fat loss from the trunk region in the high calcium and high dairy group represented 50.1 +/-6.4 and 66.2 +/- 3.0 % of the total fat loss. In controls it was 19.0 +/- 7.9 %.

This study shows that increasing dietary calcium significantly increases weight and fat loss secondary to energy restriction and that the percentage lost from the trunk region increases with increasing calcium intake.

Compared to an equivalent amount of supplemental calcium, dairy products seem to exert a substantially greater effect on weight loss (8).

Summerbell et al. observed weight loss in obese patients when put on a control, milk only or milk plus diet for 16 weeks. The diets were as follows: control – a conventional balanced diet. Energy level app. 3,4 MJ/d. Milk only – combination of full cream, semi-skim milk and unsweetened yoghurt. Energy level app. 3.4 MJ/d. Milk plus – milk only diet with a single food added unlimited by choice of patient. Energy level mean. 5.6 MJ/d.
By week 16 the mean weight loss on control, milk only and milk plus diets was 1.7, 9.4 and 7.0 kg respectively.

This study supports the findings of Zemel et al.(abstract) in showing significant weight loss in patients on a dairy diet compared to a conventional diet where energy supply is equivalent in both diets. It seems that the milk has an additional effect to the energy restriction on weight loss, but the effect may not be contributed to the calcium in it self (9).

Five clinical studies which were originally set to evaluate skeletal end points were reevaluated to explore associations between calcium intake and body weight.

All subjects were women in the 3., 5. and 8.decade. Significant negative associations between calcium intake and weight were found for all 3 groups.

The estimated relation is a 0.82 kg weight reduction for each 100-mg calcium intake increment resulting in an 8 kg weight loss observed over 4 y. It was suggested that calcium intake can explain as much as 3 % of the variance adult body weight (10).

# Summary

The number of studies showing significant relation between increased dietary calcium intake and loss of body weight and fat are numerous and growing.

The mechanism behind the weight changing effect of calcium has been shown to be related to the intracellular calcium concentration of adipocytes. A decrease in the dietary calcium intake is followed by an increased influx of calcium into the adipocytes. Hereby the lipogenesis is stimulated at the same time as lipolysis is inhibited, whereby fat storage in the adipocytes is enhanced.

It seems very evident that dietary calcium has an effect on both reduced body weight gain and increased body weight and fat loss. In the majority of studies the calcium has been consumed through dairy products. When comparing the control groups with dietary dairy groups the weight loss was significantly higher in the dairy groups. The similar finding was done when calcium supplemented groups were compared with dairy groups. This has lead to the suggestion, that although consumption of calcium supplements in it self seems effective in inducing body weight and fat loss, the effect of calcium seems even greater when the calcium is consumed through dairy products. The reason why this is remains to be clarified. This could point in the direction that dairy calcium is more effective than supplemental calcium. Another explanation could be that the additional effect of dairy products compared to supplemental calcium is related to biologically active peptides in the dairy products, which either exert an effect on their own or in synergy with the milk calcium.

In order to obtain the weight reducing effect of calcium a minimum daily intake seems necessary. Based on the study by Jacqmain et al. a suggestive minimum intake could be 600 mg/day.
Based on other findings there seems to be restrictive precautions as well regarding energy intake. Thus the study by Lin et al. seems to suggest, that in order for calcium intake to have an impact on weight change the energy intake should not exceed 1876 kcal/day.

An additional benefit to the effect of calcium on inducing weigth loss is that the weight loss seems to be pertaining mainly to the trunk region. Although obesity in it self, especially in cases where BMI exceeds 30, is a potential health hazard it is a widely accepted fact, that fat deposition in the trunk region is more health hazardous than fat deposited else where on the body.

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