

# Calcium intake, body composition and plasma lipid-lipoprotein concentrations in adults

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What is the impact of calcium/dairy food on fat balance?

## Fat balance



$$\text{Fat balance} \approx \text{Energy balance}$$

(Flatt JP. Am J Clin Nutr 1987)

## Implications of a regulation of fat balance

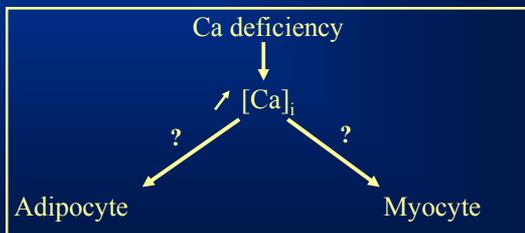
1. Body fat gain is likely the price to be paid to compensate for suboptimal diet composition and body's functionality.
2. Any nutrient, bioactive ingredient, and stimulus having the potential to promote a negative fat balance deserves consideration in the prevention and treatment of obesity.

## What is the impact of calcium/dairy food on fat balance?

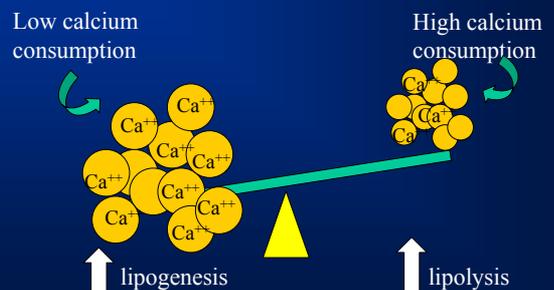
- Mechanistic considerations and animal/human laboratory studies
- Population studies
- Intervention studies

## Calcium paradox disease: Calcium deficiency prompting hyperparathyroidism and cellular calcium overload

Fujita T and Palmieri GMA  
 J Bone Miner Metab 18: 109-125, 2000

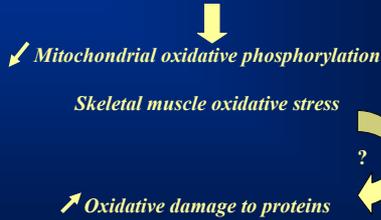


## Relationship between calcium intake and intra-adipocyte calcium



Adapted from Zemel *et al.* FASEB J 2000;14:1132-8.

Intracellular calcium overload



Adapted from: Wroegemann K and Nylen EG. *J Mol Cell Cardiol* 10: 185-95, 1978 and Itoh M et al. *Am J Physiol* 287: R33-8, 2004.

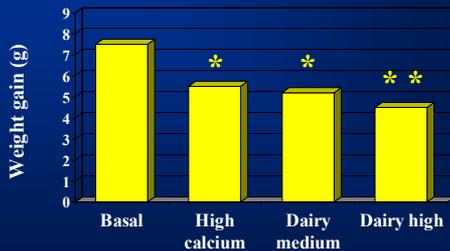
## Calcium promotes thermogenesis in mice expressing agouti in adipose tissue

Diet	Core Temperature Change
Basal energy-restricted diet	No effect on core temperature
High calcium energy-restricted diet	+0.48°C
Medium dairy energy-restricted diet	+0.57°C
High dairy energy-restricted diet	+0.67°C

p<0.05

Adapted from Shi et al. *FASEB J.* 2001;15:291-3

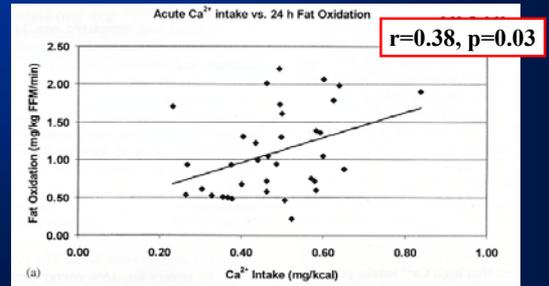
Effect of calcium and dairy products on 6wk weight gain in transgenic mice expressing agouti in adipose tissue



\* p<0.04 vs basal  
\*\* p<0.04 vs all diets

Adapted from Zemel et al. *FASEB J* 2000;14:1132-8.

## Relationship between 24-hour fat oxidation and acute calcium intake



Melanson EL et al. *Int J Obes* 2003;27:196-203.

## High calcium intake reduces body weight and digestibility of fat diet in rats (p<0.001)

	Control group	High calcium group
Fecal fat (%)	0.11±0.01	0.13±0.02
Fecal fat (g/5 days)	0.95±0.11	2.04±0.25

Adapted from Papakonstantinou, E et al. *Obes Res*, 2003, 11(3):387-94



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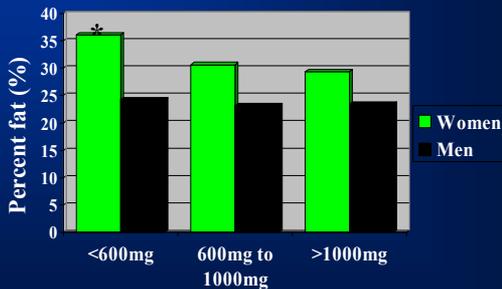
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Effects of calcium or dairy intake on the risk of being in the highest quartile of body fat for women

Quartile of calcium and dairy intake	Calcium intake (mg/day; mean $\pm$ SEM)	Dairy intake (serving/month; mean $\pm$ SEM)	Odds ratio of being in the highest body fat quartile
1	255 $\pm$ 20	14.4 $\pm$ 1.9	1.00
2	484 $\pm$ 13	38 $\pm$ 1.3	0.75
3	773 $\pm$ 28	57.2 $\pm$ 1.0	0.40
4	1346 $\pm$ 113	102.8 $\pm$ 3.6	0.16

Adapted from Zemel *et al.* FASEB J 2000;14:1132-8.

## Percent body fat according to daily calcium intake in adults



\* After adjustment, different from the other two groups in women,  $p < 0.05$

Adapted from Jacqmain *et al.* Am J Clin Nutr 2003;77:1448-52

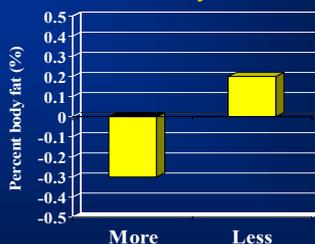
## Adjusted<sup>t</sup> correlations between daily calcium intake and plasma lipoprotein-lipid concentrations

Calcium intake	LDL-cholesterol	Total cholesterol	Total chol/HDL-chol
Women	-0.18**	-0.16*	-0.15*
Men	-0.26**	-0.26**	-0.24**

\*\* $p < 0.01$ , \* $p < 0.05$ ; t = adjusted for body fat mass and waist circ.

Adapted from Jacqmain *et al.* Am J Clin Nutr 2003;77:1448-52

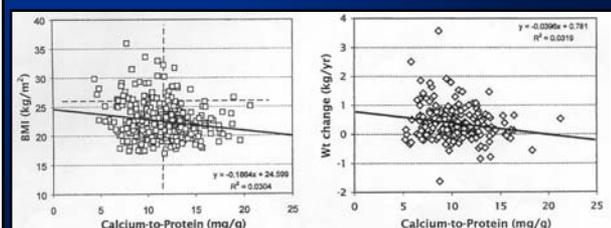
## Changes in percent body fat in relation to changes in milk/dairy intake



Ancova adjusting for age and percent body fat at Phase 2

Drapeau *et al.* Am J Clin Nutr. 2004; 80: 29-37

## Relationship between BMI, weight change and calcium intake in women



Davies *et al.* J Clin Endocrinol Metab 2000;85:4635-8.

## Longitudinal calcium intake and body fat in children

- Dietary calcium intake was negatively related to percent body fat.
- Consumption of carbonated beverages and other sweetened beverages were negatively related to calcium intake.

Adapted from Skinner *et al.* *J Am Diet Assoc* 2003;103(12), 1626-31.

## Relationship between dairy consumption and the incidence of IRS over 10 years in overweight individuals

Weekly dairy intake (servings)	Odds ratios for IRS (p<0.001)
0 to < 10	1.00
16 to < 24	0.58
24 to < 35	0.41
≥ 35	0.29

Adapted from Pereira *et al.* *JAMA*, 287(16), 2002.

## Combined effects of exercise and high calcium intake on body fat and plasma glucose/insulin concentrations

Male physically active-high calcium consumers display significantly lower levels of

Fat mass	-33.8%
Sum of 6 SS	-27.7%
Glucose AUC	-17.2%
Insulin AUC	-31.3%

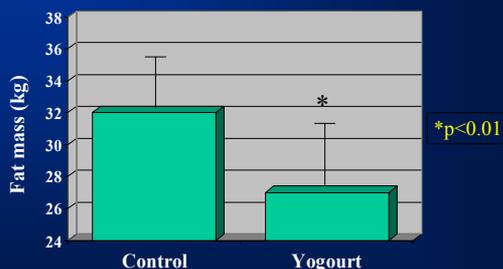
Compared to inactive-low calcium consumers.  
Tremblay A *et al.* Unpublished data.



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## Calcium and fat loss



Adapté de Zemel *et al.* *FASEB J* 2000;14:1132-8.

*Calcium and dairy acceleration of weight and fat loss during energy restriction in obese adults*

Zemel M, Thompson W, Milstead A, Morris K, and Campbell P.  
*Obes Res* 12: 582-590, 2004

**Objective**

To determine the effects of increasing dietary calcium in the face of caloric restriction in humans

**Key methodological points**

- Recruitment of obese low calcium consumers (500-600mg/d)
- Testing under balanced deficit conditions (500 kcal/d deficit)
- Three testing conditions including a supplemented calcium diet and a high dairy diet containing the same amount of calcium (1200 to 1300 mg/day)
- Duration of the intervention: 24 weeks

Zemel M et al, *Obes Res* 12: 582-590, 2004.

**Mean change in body weight and body fat**

	Treatment		
	Low calcium	High calcium	High Dairy
▲ weight (kg)	6.60	8.58	11.07
▲ fat (kg)	4.81	5.61	7.16
▲ fat/▲weight	0.73	0.65	0.65

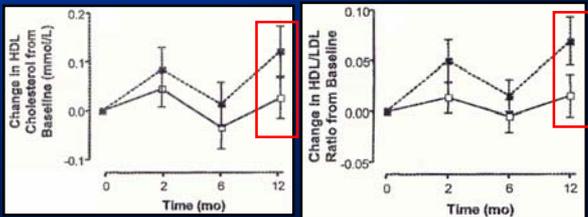
Adapted from Zemel M et al. *Obes Res* 12: 582-590, 2004.

**Additional benefits of the high dairy diet**

- Accentuation of trunk fat loss
- Improvement of glucose tolerance

Zemel M et al. *Obes Res* 12: 582-590, 2004

**Calcium citrate supplement and lipid concentration in women**



Reid et al. *Am J Med* 2002; 343-7



# Calcium deficiency

Calcium paradox

↑ [Ca]<sub>i</sub>

Adipocytes

Myocytes

↓ Mitochondrial functionality

Lipogenesis

Lipolysis

↓ Fat oxidation

↓ EE

Positive fat balance  
↑ Fat mass

↑ Plasma lipid-lipoprotein

