Influence of Calcium and Vitamin D Supplementation on Weight and Fat Loss in Obese Women

Michał Holecki^a Barbara Zahorska-Markiewicz^a Andrzej Więcek^b Katarzyna Mizia-Stec^c
Teresa Nieszporek^b Agnieszka Żak-Gołąb^a

^aDepartment of Pathophysiology,

^bDepartment of Nephrology, Endocrinology and Metabolic Diseases,

^cDepartment of Cardiology, Medical University of Silesia, Katowice, Poland

Key Words

Weight loss · Calcium · Vitamin D

Summary

Background: Dairy products not only reduce the risk of hypertension and cardiovascular diseases but may play a role in the treatment of obesity. As there is some evidence that calcium (Ca) and vitamin D may play a role in effective weight management, we decided to evaluate the influence of Ca and vitamin D supplementation on weight and fat loss in obese women. **Material and Methods:** Forty obese women were enrolled in this study. Subjects were divided into 2 groups comparable with body mass index (BMI) and age. Group 1 was provided with calcium carbonate and 1-(OH)-vitamin D supplementation. Group 2 was provided with only a diet. Subjects participated in a 3-month weight reduction therapy (balanced diet, modification of life style, and regular physical exercise). Blood samples (serum concentration of Ca, phosphorus (P), parathormone (PTH), 25-(OH)-D₃) and clinical characteristics (weight, height, BMI, body composition) were taken at baseline and after the 3-month program. **Results:** No significant differences of body weight, body fat content, serum parathormone, 25-(OH)-D₃ concentration, and plasma total Ca and P concentration were observed between analyzed groups both before and after the treatment. Additionally, we did not observe any significant influence of Ca and vitamin D supplementation on weight and fat loss. **Conclusion:** Ca plus vitamin D supplementation during a 3-month low caloric diet has no additional effect on weight and fat loss in obese women.

Introduction

Obesity is a chronic disorder of multi-factorial etiology, that is known as a major problem all over the world, and is one of the well-established risk factors of increased cardiovascular morbidity and mortality. Based on American data, it is a known fact that the proportion of obese women increased dramatically during the last decade of the 20th century (by nearly 50%) [1]. Nowadays, prevention of weight gain should be the most important goal of public health. A combination of both dietary intervention and physical activity is the easiest and most common strategy of obesity treatment.

Dietary calcium (Ca) intake plays an important role not only in the maintenance of skeletal integrity but also in modulating the risk of developing chronic diseases. Dairy products not only reduce the risk of hypertension and cardiovascular diseases but may also play a role in the treatment of obesity [2, 3]. There is some evidence that Ca and vitamin D may be a decisive factor in effective weight management [4, 5]. A number of epidemiological studies have identified an inverse relationship between fat content and Ca intake [6–8], however, most interventional studies have not supported this finding, neither in adults nor in children [9–11]. As the topic is still controversial and results divergent, we decided to evaluate the influence of Ca and vitamin D supplementation on weight and fat loss in obese women again (a short overview of the current literature is given in table 1).

Material and Methods

A total of 40 obese women were enrolled in this study. All of them were diagnosed with simple obesity without concomitant diseases. None of them had undergone ovariectomy. All subjects were informed about the nature of the study, and signed their informed consent forms. The inclusion criteria included body mass index (BMI) > 30 kg/m², age 45–55 years,

Table 1. Mini-review of the literature including negative and positive effects of Ca and/or vitamin D supplementation on weight and/or fat loss

Reference	Objective	Results	Conclusion
Lorenzen et al., 2006 [11]	whether Ca supplementation affects body weight and body fat in young girls (n = 110)	significant negative correlation between habitual dietary Ca intake and body fat (%); Ca supplementation had no effect on weight and percentage of body fat	Ca supplementation had no effect on body weight, height, or body fat over 1 year in young girls
Kamycheva et al., 2003 [22]	whether there is an association between BMI and Ca and vitamin D intake in 9,252 men and 9,662 women	positive correlation between BMI and Ca intake in men but not in women; negative relationship between BMI and vitamin D in both sexes	Ca and vitamin D may have opposing effects on body weight
Zhang et al., 2004 [19]	whether there is an effect of dietary Ca on body weight of lean and obese mice and rats	no effects of Ca manipulation on energy intake, body weight, or carcass fat content; no simple relation between calcitropic hormones and body weight	no effect of dietary Ca on body weight of lean and obese mice and rats
Boon et al., 2006 [20]	whether energy and substrate metabolism and adipose tissue mRNA expression may be altered by dietary Ca intake in healthy, non-obese volunteers (n = 12)	no significant differences in 24-h energy expenditure and fat oxidation between analyzed patients; no significant differences in gene expression in proteins between analyzed patients	dietary Ca content for 7 days does not influence substrate metabolism, energy metabolism, or gene expression in proteins related to fat despite changes in 1.25(OH) ₂ vitamin D concentration
Zemel et al., 2004 [15]	whether dairy products or Ca accelerate weight and fat loss induced by caloric restriction (n = 41)	loss of body fat was increased by high-Ca diet; fat loss was augmented by high-Ca and high-dairy diets	increased dietary Ca significantly augmented weight and fat loss secondary to caloric restriction
Melanson et al., 2003 [16]	whether total Ca intake and intake of Ca from dairy sources are related to whole body fat oxidation (n = 35)	Ca intake was positively correlated with fat oxidation over 24 h, during sleep and during light physical activity; Ca intake from dairy sources was similarly correlated with fat oxidation	higher Ca intake is associated with higher rates of whole body fat oxidation; effects were apparent over 24 h, during sleep and, to a lesser extent, during light physical activity
Davies et al., 2000 [17]	whether there is an association between Ca intake and body weight (analysis of 5 clinical studies (n = 780))	1,000-mg difference in Ca intake is associated with 8-kg difference in mean body weight; Ca intake explains approximately 3% of the variance in body weight	increased Ca intake was consistently associated with reduced indices of adiposity
Heaney et al., 2002 [18]	to evaluate the effect of Ca intake on body weight and body fat; data from 6 observational studies and 3 controlled studies	each 300-mg increment in regular Ca intake is associated with approximately 1 kg less body fat in children and 2.5–3.0 kg lower body weight in adults	consistent effect of higher Ca intake, expressed as lower body fat and/or body weight and reduced weight gain in midlife
Lin et al., 2000 [33]	investigation of relationship between micronutrients and dairy product intake and changes in body weight and composition over a period of 2 years (n = 54)	significant inverse correlation between Ca intake, adjusted for energy, and change in both body weight and body fat mass	subjects with high Ca intake, corrected for total energy intake and lower vitamin A intake, gained less weight and body fat over 2 years
Lovejoy et al., 2001 [34]	to compare dietary intake and energy expenditure between middle-aged, premenopausal African American (n = 97) and Caucasian women (54)	inverse correlation between Ca intake and both BMI and percent body fat in Caucasian but not African-American women	paper does not provide the information needed to estimate the extent of the Ca effect
Garrow et al., 1989 [35]	to measure total weight and lean tissue loss in obese women, comparing 2 diets – one a mixed-food, energy-restricted diet, and the other consisting solely of milk	weight loss was not significantly different for the 2 regimens, but milk diet resulted in substantially less lean tissue loss	high milk intake increases the effectiveness of a weight reduction program

stable body weight over the last 3 months, no evidence of present or recent (last 3 months) infectious diseases or drug therapy, correct lipid profile and fasting serum glucose level. Exclusion criteria included smoking cigarettes and drinking more than 2 alcoholic drinks a week.

Subjects were divided into 2 groups comparable with BMI and age. Group 1 comprised 20 obese women (mean body weight 91.2 ± 12.5 kg; BMI 36.9 ± 5.0 kg/m²; mean age 51.6 ± 6.5 years) who were provided with calcium carbonate ($2 \times 1,000$ mg) and 1-(OH)-vitamin D (0.25 µg per day) supplementation. Group 2 comprised 20 obese women (mean body weight 96.1 ± 12.2 kg; BMI 35.4 ± 4.48 kg/m²; mean age 49.1 ± 4.8 years) who were provided with only a diet. All of these subjects participated in a 3-month weight reduction therapy that consisted of a 1,000–1,200 kcal/day balanced diet (daily Ca consumption 500 mg), modification of lifestyle, and regular physical exercise (60 min, 3 times a week). Each patient was evaluated every 2 weeks by a doctor and a dietician. Each patient was asked to keep a dietetic diary. Patients from group 1 were provided with exact amounts of tablets (28 calcium carbonate tablets and 14 0.25-µg vitamin D tablets) at each visit.

Blood samples and clinical characteristics were taken at baseline and after the 3-month program. Body weight and height were measured, and BMI was calculated. Body composition was analyzed using the bioimpedance method (Bodystat 1500; Bodystat Ltd., Douglas, Isle of Man, British Isles). In all patients, before and after the 3-month weight reduction therapy, serum concentrations of Ca, phosphorus (P), parathormone (PTH), and 25-(OH)-D₃ were assessed. Blood samples were taken from each subject in the morning between 8.00 and 9.00 am, after an overnight fast. After clot formation, the samples were centrifuged ($1,000 \times g$) at room temperature for 10 min. The serum obtained was drawn into plastic vials and stored at -80 °C until the time of the assay. In our study, we did not take into consideration seasonal variation of parameters of the Ca-P metabolism, as the therapy was run from October to December. Usually, in women, the serum 25-(OH)-D₃ concentration decreases (approximately 20%) in winter, and returns to baseline levels in the summer [6]. 25-(OH)-D₃ was measured using the RIA method (BioSource Europe S.A., Nivelles, Belgium). The Electrochemiluminiscent ImmunoAssay 'ECLIA' (Roche, Meylan, France) was used for PTH assay. Total Ca and P were measured using a spectrophotometer. All values are expressed as means $\pm$ standard deviation (SD).

Statistical analyses were performed using the STATISTICA computer program (StatSoft Inc., Tulsa, OK, USA). The results were analyzed using the Kolmogorov-Smirnoff test and Spearman's correlation analysis. *p* values < 0.05 were considered to be significant.

Results

In group 1, the mean weight loss was 7.0 ± 2.6 kg ($7.8 \pm 2.0\%$). BMI decreased from 36.9 ± 5.0 kg/m² at baseline to 34.1 ± 4.5 kg/m² post-treatment (table 1). After weight reduction in obese subjects, P serum concentration significantly decreased. However, no significant changes of serum PTH, 25-(OH)-D₃ concentration, and total plasma Ca concentration were observed after weight loss (tables 2, 3) (figs. 1, 2). After treatment, a negative correlation was found between body weight and 25-(OH)-D₃ serum concentration ($r = -0.75$; $p = 0.0001$). In group 2, the mean weight loss was 8.4 ± 3.7 kg ($10.2 \pm 4.5\%$). BMI decreased from 35.4 ± 4.4 kg/m² at baseline to 32.1 ± 4.2 kg/m² post-treatment (table 2). Serum concentrations of PTH and 25-(OH)-D₃, and plasma total Ca and P concentration did not change significantly after weight reduction therapy (tables 2, 3) (figs. 3, 4).

Table 2. Results of weight reduction therapy in obese women from group 1 (diet plus supplementation) and group 2 (diet only)

	Group 1 mean $\pm$ SD	Δ	Group 2 mean $\pm$ SD	Δ
Weight, kg				
Before	96.1 ± 12.2		91.2 ± 12.5	
After	89.1 ± 11.7^a	7.0 ± 2.6	82.7 ± 11.5^a	8.4 ± 3.7
BMI, kg/m ²				
Before	36.9 ± 5.05		35.4 ± 4.48	
After	34.1 ± 4.5^a	2.8 ± 1.2	32.1 ± 4.2^a	3.3 ± 1.4
Fat content, %				
Before	50.3 ± 6.7		48.5 ± 8.5	
After	44.5 ± 5.4^a	5.8 ± 9.9	41.5 ± 5.7^a	7.0 ± 6.0

^a*p* < 0.0001 before vs. after.

Table 3. Serum levels of PTH, 25-(OH)-D₃, Ca, and P before and after weight reduction therapy in obese women from group 1 (diet plus supplementation) and group 2 (diet only)

	Group 1 mean $\pm$ SD	Δ	Group 2 mean $\pm$ SD	Δ
PTH, pg/ml				
Before	53.5 ± 21.1		49.6 ± 14.3	
After	48.4 ± 19.3	5.1 ± 17.7	43.9 ± 11.7	5.7 ± 16.3
25-(OH)-D ₃ , ng/ml				
Before	25.3 ± 13.0		35.2 ± 16.2	
After	29.4 ± 11.5	4.11 ± 9.2	38.9 ± 18.2	3.7 ± 8.8
Ca, mmol/l				
Before	2.2 ± 0.1		2.3 ± 0.1	
After	2.3 ± 0.1	0.05 ± 0.1	2.3 ± 0.1	0.001 ± 0.07
P, mmol/l				
Before	1.2 ± 0.2		1.1 ± 0.2	
After	1.0 ± 0.1^a	0.12 ± 0.2	1.2 ± 0.2	0.07 ± 0.3

^a*p* < 0.05 before vs. after.

Group 1 versus Group 2

No significant differences of body weight, body fat content, serum PTH and 25-(OH)-D₃ concentration, plasma total Ca and P concentration were observed between analyzed groups both before and after the treatment. Additionally, we did not observe any significant influence of Ca and vitamin D supplementation on weight and fat loss (tables 2, 3).

Discussion

In the last few years, much attention has been paid to the 'anti-obesity' influence of Ca and dairy food [12]. It was observed that a restricted but Ca-rich diet was associated with marked augmentation of body mass and fat loss in both mice

Fig. 1. Results of weight reduction therapy in obese women from group 1 (diet plus supplementation); * $p > 0.001$.

Fig. 2. Serum levels of PTH, 25-(OH)-D₃, Ca, and P before and after weight reduction therapy in obese women from group 1; * $p > 0.05$.

Fig. 3. Results of weight reduction therapy in obese women from group 2; * $p > 0.0001$.

and humans [13, 14]. In another study [15], it was found that an increase in dietary Ca content (during a restrictive diet) from 400 to 1,200 mg a day was associated with a 26 and 38% increase in weight and fat loss, respectively. Moreover, a Ca- and dairy-rich diet resulted in a 50–66% increase in total fat loss from the trunk region in comparison to 19% on a low-Ca diet [15]. There are many other data that support the anti-obesity effect of Ca supplementation. Melanson et al. [16] reported a positive correlation between Ca intake and whole body fat oxidation both during sleep and during moderate physical activity. Davies et al. [17] and Heaney et al. [18] who analyzed data from 9 studies reported that Ca intake was associated with reduced indices of adiposity. They observed that an increase in daily Ca intake by 300 mg was associated with a 3-kg lower weight in adults.

However, the results of other studies contradict the above-mentioned data. Zhang and Tordoff [19] found no effects of Ca manipulation in the diet on energy intake and body weight, and no simple relationship between calcitropic hormones and body weight. Boon et al. [20] reported that dietary Ca content does not influence substrate metabolism, energy metabolism, or gene expression in proteins related to fat metabolism. In another study, Boon et al. [21] (who evaluated the effects of increasing serum calcitriol on energy and fat metabolism and gene expression) did not observe any significant differences in substrate and energy metabolism or mRNA concentrations of different lipid metabolism-related proteins despite a significant increase in serum 1,25-(OH)-D₃ concentration. A Norwegian cross-sectional study [22] reported a positive correlation between Ca and BMI in men but no

Fig. 4. Serum levels of PTH, 25-(OH)-D₃, Ca, and P before and after weight reduction therapy in obese women from group 2; *p > 0.05.

association of Ca and BMI in women. Shapes et al. [23] examined whether Ca supplementation affects body weight during weight loss therapy. They found no significant changes of body weight or body fat during a 25-week weight loss treatment with supplementation of 1 g calcium citrate malate. Lorenzen et al. [11] indicates that Ca supplementation for 1 year does not reduce body weight or fat mass. Also Lorenzen et al. [24] indicated that Ca did not affect appetite sensation, glucose metabolism, or gut hormone secretion. In agreement with previous studies, Caan et al. [25] also reported a minor effect of combined therapy of Ca plus cholecalciferol in the prevention of weight gain.

These results are in agreement with the results obtained in this study. We, too, did not find any significant influence of Ca and vitamin D supplementation on weight and fat loss. As the results of this and other studies are inconsistent, we claim that the influence of Ca/vitamin D supplementation on both prevention of weight gain and losing weight is still controversial and not fully established. We agree with Caan et al. [25] that 'further research should be undertaken to address the effect of Ca supplementation combined with caloric restriction and physical activity on weight gain protection'. However, we wonder if Ca per se or dairy products really affect body weight. The fact that a short-term increase in dietary Ca intake increases energy excretion (350 kJ/day) [26] may explain why a high-Ca diet produces weight loss. Maybe the explanation is that the source of Ca is more important and influences the effect on body weight. Zemel [27, 28] pointed out that Ca from

dairy products has a more profound effect on weight and fat loss compared to that found with Ca supplementation per se. This finding suggests that the effect is likely due to additional bioactive compounds which are found in dairy products. This additional factor in dairy may act independently or synergistically with Ca to block lipogenesis and promote lipolysis, but the mechanisms of this additional dairy effect are not clear.

What mechanisms underlie the changes mentioned above? The biological observations proved that a combination of Ca and vitamin D in the diet may regulate lipid metabolism in adipose tissue (mainly by influence on fatty acid oxidation and lipogenesis) [2, 29]. In 2004, Zemel et al. [13, 15] proposed an explanation for this phenomenon. The authors suggest that increased serum concentrations of 1,25-(OH)-D₃, as an effect of a low-Ca diet, enhance the intracellular Ca flow (via a specific membrane vitamin D receptor). High Ca concentrations in adipocytes may stimulate lipogenesis (stimulation of lipogenic gene expression) and suppress lipolysis. Additionally, calcitriol may also suppress the expression of adipocyte uncoupling protein 2 (UCP2), and in that way limit mitochondrial fatty acid transport and oxidation [29]. In contrast, an opposite situation may happen. Increased Ca content in a diet may suppress serum calcitriol levels, resulting in reduction of lipogenic gene expression and promotion of lipolysis and UCP2 gene expression, and in that way reducing lipid filling and adiposity. Moreover, Ca may decrease fatty acid absorption in the intestine and increase fecal fat loss [13, 30–32].

At present, we do know that adipocytes have an autocrine/paracrine renin-angiotensin system and that adipocyte lipogenesis is partly regulated by angiotensin II [16]. Therefore, angiotensin-converting enzyme inhibitors, which are found in dairy, may act together with Ca to attenuate adiposity [28]. We speculate that the goal of future investigations should be the influence of dairy products (that are rich in Ca) on body weight and fat content during weight reduction therapy. All these matters need further investigation.

Conclusion

Ca plus vitamin D supplementation during a 3-month period of low caloric diet has no additional effect on weight and fat loss in obese women.

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