Comparison of the effects of cows’ milk, fortified soy milk, and calcium supplement on weight and fat loss in premenopausal overweight and obese women

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KEYWORDS
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Weight loss;
Obese;
Overweight

Abstract Background and aims: Recent studies suggest that calcium metabolism and perhaps other components of dairy products may contribute to shifting the energy balance and thus play a role in weight regulation. We compared the effects of cows’ milk, calcium fortified soy milk and calcium supplement on weight and body fat reduction in premenopausal overweight and obese women.

Methods and Results: In this clinical trial, 100 healthy overweight or obese premenopausal women were randomized to one of the following dietary regimens for 8 weeks: (1) a control diet providing a 500 kcal/day deficit, with 500—600 mg/day dietary calcium; (2) a calcium-supplemented diet identical to the control diet with 800 mg/day of calcium as calcium carbonate; (3) a milk diet providing a 500 kcal/day deficit and containing three servings of low-fat milk; (4) a soy milk diet providing a 500 kcal/day deficit and containing three servings of calcium fortified soy milk. At baseline and after 8 weeks, weight, waist circumference, and hip circumference were measured. Three 24-h dietary records and physical activity records were also taken. Comparing the mean differences in weight, waist circumference, body mass index (BMI) and waist-to-hip ratio (WHR) using repeated measure of variance analysis showed that changes in waist circumference and WHR were significant among the four groups (p = 0.029 and p = 0.015, respectively). After adjustment for baseline values, changes in weight and BMI were also significant (p = 0.017 and p = 0.019, respectively). Weight reductions in high milk, soy milk, calcium supplement and control groups were 4.43 ± 1.93 (kg), 3.46 ± 1.28 (kg), 3.89 ± 2.40 (kg) and 2.87 ± 1.55 (kg), respectively. The greatest changes were seen in the high dairy group in all variables.

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Introduction

Obesity is recognized as one of the most significant public health problems in the world [1–3]. It is a risk factor for chronic diseases such as heart disease, cancer, stroke and diabetes [4–7]. Weight loss is associated with improvement in risk factors for cardiovascular disease (CVD) and diabetes mellitus [4,5,8]. Although much effort has been devoted to study the effects of macronutrients on weight control, the role of micronutrients has not been well studied [5]. Recent findings indicate that calcium metabolism and perhaps other components of dairy products may contribute to shifting the energy balance and thus play a role in weight regulation [5,9–12]. Low calcium diets lead to an increase in 1,25-dihydroxy vitamin D which in turn stimulates calcium influx into adipocytes, resulting in stimulation of lipogenesis, inhibition of lipolysis and expansion of adipocyte triglyceride stores. Suppressing 1,25-(OH)2-D levels by increasing dietary calcium would be predicted to inhibit adiposity and promote weight loss [10,12–14].

Calcium in the form of dairy products may be more effective than elemental calcium [15–17]. It seems that bioactive compounds [18] and high concentrations of branched chain amino acids in dairy products [19] are responsible for this effect.

To study this, we decided to compare the effects of cows’ milk, calcium fortified soy milk and calcium supplement on weight and body fat reduction in premenopausal overweight and obese women.

Methods

Study population

One hundred healthy premenopausal overweight or obese women ranging in age from 20 to 50 years volunteered to participate in this randomized clinical trial while 85 completed the study. There were no significant differences between those who completed the study and those who did not for any parameters. Inclusion criteria were as follows: body mass index (BMI) more than 25 kg/m2 (range 25–40); taking no medications or supplements which might affect metabolism of calcium, vitamin D or weight loss; absence of menopause; stable body weight (body weight change less than 3 kg for the last 2 months); absence of coronary-artery, diabetes, hypertension, thyroid, and kidney diseases. The subjects were not pregnant and non-lactating with no allergy to milk or soy milk and were not lactose intolerant. We also made sure that the subjects had not participated in any other studies within the last 6 months of screening. The study was approved by the ethics committee of the National Nutrition and Food Technology Research Institute. Each potential participant was informed of the risks and benefits associated with this study and provided written signed consent.

Study interventions

Subjects were studied for a 2-week run-in period for baseline dietary and physical activity assessment and then randomized to one of the following dietary regimens for 8 weeks: (1) a control diet providing a 500 kcal/day deficit with 500–600 mg/day dietary calcium; (2) a calcium-supplemented diet identical to the control diet with 800 mg/day of calcium (as calcium carbonate); (3) a milk diet providing a 500 kcal/day deficit and containing three servings (220 ml) of low fat milk (1.5%); (4) a soy milk diet providing a 500 kcal/day deficit and containing three servings of calcium fortified soy milk. Total calcium content of the milk diet and the soy milk diet was between 1200 and 1300 mg/day.

Daily caloric requirements were calculated by using the Harris–Benedict equation [2]. An activity factor and meal plan based on a 500 kcal/day deficit from estimated caloric requirements were given to each individual [9]. The diets for all groups were designed to provide comparable levels of macronutrients as follows: 55% carbohydrate, 18% protein and 27% fat. At baseline and at 2-week intervals, weight, waist circumference, and hip circumference were measured and 24 h-dietary records [20] as well as physical activity records (2 weekdays and 1 weekend day) were taken. Body fat mass was measured at the beginning of the study and at week 8 using Bodystat bioelectric impedance analysis (BIA) model Quadscan4000.

Weight was recorded in light clothing to the nearest 0.1 kg, using a digital scale. Height was measured bare foot to the nearest 0.1 cm using a stadiometer. Then BMI was calculated as weight (kg)/height2 (m). Waist and hip circumferences were measured to the nearest 0.1 cm using a plastic measuring tape at the smallest circumference below the rib cage and above the umbilicus [21] and the largest circumference between the waist and the knees, respectively [22].

Statistical analysis

Dietary records were analyzed using Nutritionist 4 software (N IV). Statistical analyses were performed using SPSS software version 15. One-way ANOVA was used to compare the characteristics of subjects in the four groups at baseline, and to compare the changes in weight, BMI, waist and hip circumference, and body fat mass among the four groups. The paired t-test was used to estimate the effect of intervention in each group. A p-value <0.05 was considered significant.

Results

Of the 100 women meeting the general eligibility criteria, 15 dropped out before completing the weight loss period (5, 3, 3, and 4 persons in the control, calcium supplement, high milk, and soy milk groups, respectively).
Comparison of the effects of cows’ milk, fortified soy milk, and calcium supplement on weight and fat loss in premenopausal overweight and obese women, Nutr Metab Cardiovasc Dis (2009), doi:10.1016/j.numecd.2009.11.013

Table 1 - Baseline characteristics of subjects under study.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Control (n = 20)</th>
<th>Ca group (n = 22)</th>
<th>High milk (n = 22)</th>
<th>Soy milk (n = 21)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>38.25 ± 9.49a</td>
<td>35.77 ± 8.70</td>
<td>38.27 ± 10.43</td>
<td>37.54 ± 9.27</td>
<td>0.78</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>76.78 ± 9.6</td>
<td>78.16 ± 11.43</td>
<td>76.24 ± 10.57</td>
<td>80.05 ± 13.32</td>
<td>0.69</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>30.78 ± 3.13</td>
<td>31.54 ± 4.12</td>
<td>30.01 ± 3.55</td>
<td>31.09 ± 4.13</td>
<td>0.58</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>90.5 ± 2.02</td>
<td>90.77 ± 1.93</td>
<td>86.84 ± 1.93</td>
<td>92.45 ± 1.97</td>
<td>0.23</td>
</tr>
<tr>
<td>WHR</td>
<td>0.81 ± 0.01</td>
<td>0.80 ± 0.01</td>
<td>0.78 ± 0.01</td>
<td>0.81 ± 0.01</td>
<td>0.12</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>30.78 ± 1.69</td>
<td>32.05 ± 1.61</td>
<td>30.59 ± 1.61</td>
<td>32.57 ± 1.65</td>
<td>0.79</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>39.91 ± 1.04</td>
<td>40.57 ± 0.99</td>
<td>39.46 ± 0.99</td>
<td>40.18 ± 1.02</td>
<td>0.88</td>
</tr>
<tr>
<td>Energy (kcal/day)</td>
<td>1839.35 ± 169.54</td>
<td>1870.77 ± 201.79</td>
<td>1937.26 ± 177.79</td>
<td>1901.80 ± 148.12</td>
<td>0.32</td>
</tr>
<tr>
<td>Calcium (mg/day)</td>
<td>512.85 ± 172.71</td>
<td>532.29 ± 149.77</td>
<td>484.58 ± 131.07</td>
<td>509.61 ± 101.19</td>
<td>0.73</td>
</tr>
<tr>
<td>Physical activity (MET.h/day)</td>
<td>35.48 ± 4.37</td>
<td>33.90 ± 3.46</td>
<td>33.17 ± 3.04</td>
<td>34.27 ± 4.81</td>
<td>0.27</td>
</tr>
</tbody>
</table>

BMI, body mass index; MET, metabolic equivalent task units; WHR, waist-to-hip ratio.

a Mean ± standard deviation (all such values).

Table 2 - Estimates of the daily intake of energy, macronutrients, calcium and fiber of subjects during the study period.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Control (n = 20)</th>
<th>Ca group (n = 22)</th>
<th>High milk (n = 22)</th>
<th>Soy milk (n = 21)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal/day)</td>
<td>1221.21 ± 153.73a</td>
<td>1239.60 ± 180.09</td>
<td>1297.89 ± 137.83</td>
<td>1280.18 ± 140.09</td>
<td>0.36</td>
</tr>
<tr>
<td>Carbohydrates (%)</td>
<td>54.78 ± 3.58</td>
<td>56.04 ± 2.78</td>
<td>55.04 ± 4.12</td>
<td>55.04 ± 2.23</td>
<td>0.62</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>17.63 ± 1.34</td>
<td>17.40 ± 2.78</td>
<td>17.59 ± 2.21</td>
<td>17.75 ± 1.06</td>
<td>0.92</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>27.21 ± 3.77</td>
<td>26.45 ± 2.80</td>
<td>27.36 ± 3.25</td>
<td>26.70 ± 2.22</td>
<td>0.74</td>
</tr>
<tr>
<td>Fiber (g/day)</td>
<td>14.34 ± 3.76</td>
<td>14.37 ± 4.11</td>
<td>13.77 ± 2.35</td>
<td>14.70 ± 2.22</td>
<td>0.82</td>
</tr>
<tr>
<td>Calcium (mg/day)</td>
<td>495.46 ± 163.87</td>
<td>1320.53 ± 219.36</td>
<td>1302.00 ± 107.56</td>
<td>1327.60 ± 96.07</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

a Mean ± standard deviation (all such values).

Discussion

The results of this study demonstrated that a low energy diet (500 kcal/day deficit) for 8 weeks can lead to a significant reduction in weight, BMI, waist circumference, WHR, body fat mass and percent body fat. A modest weight loss in obese individuals (5%–10% of initial body weight) is likely to improve their health in the short term by reducing the severity of comorbidities associated with obesity [23].

Our findings also indicate that a high milk diet can lead to a higher reduction in weight, BMI, waist circumference, and WHR. Zemel et al. showed that 18 subjects receiving 3 cups of yogurt per day (1100 mg/day calcium) lost more weight (6.63 kg vs. 4.99 kg), body fat (4.43 kg vs. 2.75 kg), and abdominal circumference (3.99 cm vs. 0.58 cm) while attenuating loss of fat-free mass (1353 g vs. 1968 g) in comparison with 16 subjects in a low calcium control group (400–500 mg/day) [24]. Zemel et al. also studied the effect of an energy-restricted diet (providing either 400–500 mg/day from dairy products or 1200 mg/day calcium) [24]. Zemel et al. also studied the effect of an energy-restricted diet (providing either 400–500 mg/day from dairy products or 1200 mg/day calcium) [24].

Baseline characteristics of the subjects are shown in Table 1. It is apparent that there were no significant differences between the age, weight, BMI, or energy and calcium intake of the subjects in the four groups. Comparison of the mean of physical activity levels among the four groups at baseline using one-way ANOVA showed no significant difference (p = 0.28). Also there was no significant difference between the physical activity levels of subjects at baseline and during the study period.

Estimates of the energy, macronutrients, calcium and fiber intakes during the study period, from food records are shown in Table 2 which indicates there were no differences in the energy, macronutrients and fiber intakes among the four groups. Also, it is shown that the percentages of carbohydrate, protein and fat intake were very close to the recommended amounts of 55%, 18%, and 27%, respectively.

As shown in Table 3, body weight, BMI, waist circumference, waist-to-hip ratio (WHR), body fat mass and percent body fat of all groups decreased significantly after 8 weeks of weight loss intervention (p < 0.001 for all), while the amount of these reductions was significantly different among the four groups just for waist circumference (p = 0.028), WHR (p = 0.015) and weight change (% of initial) (p = 0.026). After adjustment for baseline values by using analysis of covariance, however, changes in weight and BMI were significantly different among the four groups (p = 0.017 and p = 0.019, respectively).

Post Hoc tests showed that the changes in waist circumference and WHR were significantly higher in the high milk (p < 0.01) and soy milk (p < 0.05) groups versus the controls. Also reductions in weight and BMI were significantly greater in the high milk group compared to the controls (p < 0.01). There were no significant differences between body weight and BMI changes in the soy milk and calcium supplement groups and the controls. Weight change (% of initial) in the high milk group was significantly greater than in the soy milk group (p < 0.05) and the controls (p < 0.01).
that increasing dietary calcium significantly augmented weight and fat loss secondary to caloric restriction [9]. After conducting a clinical trial on 256 obese diabetic patients, Shahar et al. reported that dairy calcium intake was associated with weight loss percentage. Among the high tertile of dairy calcium intake, the odds ratio for weight loss of >8% was 2.4, \( p = 0.04 \), compared with the first tertile, after controlling for non-dairy calcium intake, diet type, and the change in energy intake from baseline. They concluded that a diet rich in dairy calcium intake enhances weight reduction in type 2 diabetic patients [11].

In contrast, in a 6-month trial by Harvey et al., 54 obese adults were randomly assigned to either a high- or low-dairy treatment along with energy restriction (500 kcal/day). There was no significant difference in weight loss between the groups. The authors speculated that differences in baseline calcium intake and degree of adiposity at onset may have affected the response to dietary regimens [25]. Also when Bowen et al. randomly assigned 50 overweight Australian adults to an energy-restricted diet, who derived 34% of calories from protein either largely from dairy products (2400 mg Ca/day) or mixed sources (500 mg Ca/day), there was no significant difference in weight loss between the groups over 12 weeks. Considering the fact that calcium supplementation is more effective when its usual intake is low, the participants’ baseline calcium intake of about 800 mg/day is a possible reason for the result [26].

Our findings showed that reductions in waist circumference and WHR were more pronounced in the soy milk group than the controls. Results of two randomized clinical trials on obese or overweight women showed that soy protein-rich food [27] and soy isoflavones [28] did not have any beneficial effects on weight loss. Also data from a review article by Cope et al. suggest that soy foods are as good as other protein sources for promoting weight loss [29]. So it is assumed that higher reductions of WHR and waist circumference in the soy milk group compared to the controls are related to the difference in calcium intake between the two groups.

To date, numerous observational studies have identified a strong inverse relationship between body weight and dietary calcium and dairy product intake [30]. High dietary calcium intake is associated with reduced 1,25-vitamin D levels which in turn act in decreasing calcium influx into the cell and, thus, the intracellular levels of the ion. These modifications eventually stimulate lipolysis and inhibit lipogenesis in the adipocytes [13,16,17]. Some recent findings in animals and in humans suggest that there may be greater effects on body weight from dairy-containing foods than might be predicted from their calcium level alone [10]. It has been suggested that milk is rich in bioactive compounds that may also act independently from calcium in modulating body fat accumulation and in this regard, milk bioactive substances have been shown to act as angiotensin converting enzyme inhibitors [16,17]. Also the branched chain amino acid content of dairy protein and specific bioactive whey-derived peptides are candidates for additional effects of milk [17].

We also found that weight change (% of initial) in the high milk group was significantly greater than that of the soy milk group. On the other hand, Lukaszuk et al. reported that consumption of either 720 ml of soy milk or 720 ml of skim
milk for 8 weeks had similar effects on body weight, and abdominal circumference reductions [31]. Considering that Lukaszuk et al. added 6.5 g/day protein (containing leucine but no whey) to their soy milk diet, and considering the effect of branched chain amino acids [17], specifically leucine [32] on weight loss, it is assumed that weight reduction in the soy milk group was augmented by the added protein.

The fact that calcium fortified soy milk did not exert body weight changes as much as low fat milk, might be due to the presence of branched chain amino acids and bioactive compounds (such as angiotensin converting enzyme inhibitors) in cows’ milk which merits future studies.

In conclusion, our results showed that consumption of low-fat milk enhanced the beneficial effect of an energy-restricted diet on central and general obesity and therefore a diet rich in dairy calcium could be tried in obese persons.

Conflict of interest

There is no conflict of interest.

Acknowledgments

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