Applied nutritional investigation

No effects of low and high consumption of dairy products and calcium supplements on body composition and serum lipids in Puerto Rican obese adults

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Abstract

Objective: Epidemiologic studies have shown that a high calcium intake is related to lower body weight, fat, and serum lipids in obese individuals. However, clinical studies have shown inconclusive results. The present study was conducted to determine if dairy or calcium supplementation alters body composition or serum lipids in Puerto Rican obese adults without dietary energy restriction or exercise.

Methods: A 21-wk randomized clinical trial was conducted in 30 obese adults, aged 21–50 y, with usual calcium intakes < 700 mg/d. Subjects were randomly assigned to the following: high dairy (w 1300 mg/d of calcium from dairy products by substituting foods); high calcium (w 1300 mg/d of calcium; w 700 mg/d from diet and 600 mg/d from a supplement); or placebo. Subjects were asked to continue their established dietary intake (except for the high dairy group) and their physical activity during the study. Body weight was measured monthly; body fat, bone, and serum lipids (total cholesterol, high-density lipoprotein, low-density lipoprotein, and triacylglycerol) were measured at baseline and at 21 wk. Pairwise differences in study endpoints among the groups were assessed using ANOVA and post-hoc analysis.

Results: Grand mean calcium intake was 1200±637 (median 1187) mg/d in the high dairy group, 1171±265 (median 1165) mg/d in the high calcium group, and 668±273 (median 691) mg/d in the control group, which was significantly lower compared to the two treatment groups (P < 0.001). There were no significant group effects in any of the outcome variables.

Conclusion: A high dairy or calcium diet alone did not alter body composition or serum lipids profile in a sample of Puerto Rican obese adults.

Introduction

Most epidemiologic studies have shown a consistent inverse relationship between dietary calcium intake and body weight and body fat [1–5], and an improvement in lipid profile [2]. However, these associations have not been fully confirmed by clinical trials.

Previous clinical trials testing the role of dietary calcium (from dairy products or from supplements) on body composition have also included energy-restricted diets and/or exercise in obese individuals, with conflicting results. Studies in obese individuals testing calcium supplementation (from supplements or dairy product) with energy restriction found a significant decrease in body weight and body fat in white adults (n = 32) [6] and black males (n = 29) [7]. Others have not found significant changes in body composition with dairy product supplementation in obese adults (mostly women) [8,9] or in premenopausal obese women (n = 58) [10] or with calcium supplementation in obese women (n = 63) [11], in pre- and postmenopausal women (n = 176) [12] or in premenopausal women (n = 58) [10] under energy-restricted diets. Still, others have also not found these effects in normal weight postmenopausal women with calcium supplementation while consuming their usual diets (n = 1471) [13]. Furthermore, a recent study in obese individuals (primarily women) did not find a significant decrease in body weight and

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body fat either, while consuming a calcium supplement with their usual diets for 2 y (n = 340) [14]. There is only one study published to date testing the effects of dairy product supplementation on body composition without energy-restricted diets or exercise [15]. No significant changes were seen in this study; however, it was performed in normal weight young women (n = 133).

Some trials have also shown a significant improvement in serum lipids profile with calcium supplementation on energy-restricted diets in obese women (n = 13–56) [16,17] or in normal older women (n = 223) [18] compared to placebo. However, others have not found similar results in overweight individuals (n = 72–193) [8,19] and in hypertensive (n = 43) or nonhypertensive adults (n = 27) [20].

Studies propose that a possible mechanism explaining the effects of calcium and dairy products on body composition is mediated by parathyroid hormone and 1,25(OH)2D levels. These hormones decrease fat breakdown and increase fat synthesis, possibly by increasing intracellular calcium in adipocytes [21]. Another mechanism proposed is the increase in fecal fat excretion by a diet high in calcium and dairy protein [22].

The effects of dairy or calcium supplementation are not clear without energy-restricted diets or exercise in body composition and blood lipids in obese individuals. In addition, none of these studies have been performed in Hispanics. Therefore, the objective of the present study was to determine whether dairy or calcium supplementation alters body composition or serum lipids in Puerto Rican obese adults without energy-restricted diets or without an exercise intervention.

Materials and methods

We conducted a single-center, randomized, double-blind (single-blinded for the dairy group), placebo-controlled trial for 21 wk to test the effects of calcium supplementation and dairy intake on body fat and serum lipids in obese Puerto Ricans. The study was conducted from October 2007 to April 2008 at the Clinical Research Center (CRC) of the Medical Sciences Campus of the University of Puerto Rico.

Subjects

Forty-six sedentary obese male and female adults, aged 22–50 y, were recruited for the study through flyers, local newspaper, and radio advertisements in the San Juan area in Puerto Rico. Following preliminary screening by telephone, volunteers were invited to the CRC for an orientation meeting. A detailed description of the study was provided and written consent forms were obtained from each subject. Study eligibility criteria included being 21–50 y old, obese (defined by a body mass index (BMI), of 30 kg/m2) [23], absence of chronic conditions, not taking calcium supplements or taking any medication regularly (including birth control pills, weight-reducing pills, insulin, cholesterol-reducing pills, and others), and not lactose intolerant. Women were ineligible if they were pregnant (verified by a urine-based pregnancy test) or lactating. In students who regularly (including birth control pills, weight-reducing pills, insulin, cholesterol-reducing pills, and others), and not lactose intolerant. Women were ineligible if they were pregnant (verified by a urine-based pregnancy test) or lactating. In

Body weight was measured monthly with a calibrated scale (Detecto Inc., Northbrook, IL, USA). Height was measured at baseline using a wall-mounted tape. Measurements were taken while subjects wore light clothing, no shoes or accessories, by the CRC-trained personnel, who were blinded to the study treatments. BMI was calculated using the following formula: kg/m2. Lean body mass, total and trunk fat mass, and total and trunk percentage fat were assessed at baseline and at 21 wk by dual energy x-ray absorptiometry (Hologic DP-W; Hologic, Bedford, MA, USA). Total bone mineral content (TBMC) and total bone mineral density (TBMD) were also assessed from dual energy x-ray absorptiometry measurements.

Blood samples were collected at baseline and at 21 wk, between 0700 and 1100 after a 12-h fast. Then they were immediately centrifuged at 12 000 g for 10 min, and serum was stored at –80°C. Cholesterol (total, low-density lipoprotein (LDL), and high-density lipoprotein (HDL)) and triacylglycerol levels were determined by a colorimetric assay using a commercial kit (Vitros Chemical Products, Ortho Clinical Diagnostics, Raritan, NJ, USA).

Assessment of dietary intake and compliance to the protocol

Subjects were provided individual instruction, counseling, and assessment to ensure treatment adherence. Dietary compliance was closely monitored throughout the study by the three following instruments: monthly calendar, food records, and a food frequency questionnaire (FFQ). The monthly calendar was completed daily by each subject and returned to the research team on the next monthly visit. Subjects in the high elemental calcium group or placebo group were asked to include if the tablet was consumed on each day, while subjects in the high dairy group were asked to include the number of dairy products servings consumed per day.

Food records were completed for 3 d at baseline and at 21 wk. Subjects were advised to record all foods and beverages consumed throughout the day during 2 d of the week and 1 d of the weekend. Subjects were also asked to specify time and place of each meal, type of foods, preparations, and brands as precisely as possible, and to record the amount of each food and beverage consumed. Detailed oral and written instructions were given to each subject to take home. In addition, each subject received a portion size picture booklet, which included food models of common foods, measuring cups and spoons, different sized bowls, glasses, plates, and mounds, to help subjects estimate portion sizes. Each record was carefully reviewed by a registered dietitian for completeness and accuracy of recording and analyzed using the Nutritionist Pro Nutrient Analysis Software (2007, Axyma System, Stafford, TX, USA). In addition, subjects completed a 24-h food recall at A4504017. Each subject gave written consent for protocol participation and received monetary compensation for their travel and meal expenses.
each monthly visit using the same instrument of the food record to monitor compliance.

Compliance was also monitored with a validated semi-quantitative FFQ of foods and beverages rich in calcium [25]. It was completed at each visit by face-to-face interviews with the investigator from the second visit (week 4). The FFQ consisted of a list of 26 items identified from the baseline food records and from other typical Puerto Rican foods rich in calcium. The FFQ was divided into the three following sections: dairy products and other calcium rich foods, prepared foods rich in calcium, and supplements. Each food item included a fixed commonly used portion size. The frequency of each food item was assessed for the previous month and included eight frequency responses, ranging from “Three or more servings per day” to “Rarely or never.” These compliance instruments were carefully revised for each subject, and if necessary, subjects were encouraged to comply with the protocol throughout the study.

Assessment of physical activity

Physical activity was also closely monitored to ensure that subjects were not changing their usual level of physical activity during the study. The Framingham Physical Activity Index questionnaire was used [26], which has been previously validated in Puerto Rican adults [27]. A person who reports sleeping all day will be assigned an index of 24, while a very active person will have an index of 72. This questionnaire was completed at baseline and at wk 21 during 3 d at home. Detailed oral and written instructions were provided. Each questionnaire was carefully reviewed by a member of the research team for completeness and accuracy. It was also completed at each monthly visit to record the level of physical activity of the previous 24 h by face-to-face interviews with the investigator. Subjects were reminded at each monthly visit to maintain the same level of daily activity recorded at baseline throughout the study.

Statistical analysis

Sample size was calculated using the following as the main outcome variables: fat mass and body weight changes. When the sample size in each of the three groups is 7, a one-way analysis of variance (ANOVA) will have 90% power to detect a change of 5% in fat mass at the 0.05 level. We increased the sample size to 10 per group to allow for dropouts.

Means and standard error were computed for all the continuous variables. The data were checked for normality and log transformations were applied to nonnormal variables (LDL and triacylglycerol levels). A repeated measures ANOVA was performed to test for changes in energy and calcium intake and physical activity from baseline and throughout the study, with post-hoc multiple pairwise by Bonferroni. Pairwise differences in study endpoints among the three treatment groups were assessed using ANOVA and post-hoc multiple pairwise by Bonferroni. We also used analysis of covariance, with measures of body composition or serum lipids at the end of the trial as the independent variable, treatment group as the independent variable, and baseline body composition or serum lipids measurements as the covariates.

Study data were collected and managed using REDCap (Research Electronic Data Capture) tools hosted at RCM-UPR [28]. REDCap is a secure, web-based application designed to support data capture for research studies. Statistical significance was set at P < 0.05. The Statistical SPSS software program (version 15.0, 2006, SPSS Inc, Chicago, IL, USA) and Microsoft Excel for Windows 2007 (Redmond, WA, USA) were used for all the statistical analyses. All data are presented as mean ± SE.

Results

A total of 25 subjects completed the 21 wk of the study, 20 females and 5 males. Initial characteristics of the subjects who completed the study are shown in Table 1. No significant differences were observed in baseline characteristics between the three treatment groups.

Compliance to the treatments in subjects completing the study was carefully monitored by the three following instruments: monthly calendar, calcium intake from food records, and calcium intake from FFQ, as explained in the Methods section. The compliance estimated from the monthly calendar during the trial was on average 86 ± 14% in the high dairy group, 96 ± 6% in the high calcium group, and 91 ± 10% in the control group. Calcium intake, estimated from food records, significantly increased in the treatment groups after baseline and remained significantly higher compared to the control group thereafter (P < 0.05), while it did not change in the control group throughout the study (Fig. 1). Grand mean calcium intake from food records during the trial was 1200 ± 370 mg/d (median 1187 mg/d) in the high dairy group, 1171 ± 265 mg/d (median 1165 mg/d) in the high calcium group, and 668 ± 273 mg/d (median 691 mg/d) in the control group, which was significantly lower compared to the two treatment groups (P < 0.001). Calcium intake, estimated from FFQ, was also significantly higher in the intervention groups compared to the control group throughout the study (P < 0.05) (Fig. 1). Grand mean calcium intake from FFQ during the trial was 1337 ± 380 mg/d (median 1343 mg/d) in the high dairy group, 988 ± 250 mg/d (median 958 mg/d) in the high calcium group, and 463 ± 325 mg/d (median 385 mg/d) in the control group, which was also significantly lower compared to the treatment groups (P < 0.05). There was a significant correlation between calcium intake from the monthly food records and the FFQs (r = 0.52–0.80, P < 0.01). Energy intake was similar

Table 1

Baseline characteristic of the subjects by treatment groups (mean ± SE)

<table>
<thead>
<tr>
<th>Variable</th>
<th>High dairy group (n = 8)</th>
<th>High calcium group (n = 9)</th>
<th>Control group (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (%)</td>
<td>88 F, 12 M</td>
<td>78 F, 22 M</td>
<td>75 F, 25 M</td>
</tr>
<tr>
<td>Age (y)</td>
<td>38.3 ± 2.4</td>
<td>35.3 ± 2.2</td>
<td>39.5 ± 2.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>102.3 ± 5.7</td>
<td>115.2 ± 5.6</td>
<td>104.9 ± 4.5</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>159.4 ± 1.2</td>
<td>1647.7 ± 3.1</td>
<td>162.3 ± 1.8</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>39.9 ± 2.2</td>
<td>38.5 ± 1.9</td>
<td>36.7 ± 1.6</td>
</tr>
<tr>
<td>Ca intake (mg/d)</td>
<td>587.9 ± 30.7</td>
<td>533.8 ± 54.0</td>
<td>526.1 ± 50.4</td>
</tr>
<tr>
<td>Energy intake (kcal/d)</td>
<td>2005.0 ± 69.8</td>
<td>1935.2 ± 149.5</td>
<td>1974.2 ± 186.6</td>
</tr>
<tr>
<td>Physical activity index score</td>
<td>28.2 ± 0.6</td>
<td>29.3 ± 0.5</td>
<td>30.2 ± 0.8</td>
</tr>
</tbody>
</table>

There were no significant differences between the groups at baseline by ANOVA (P > 0.05).

- Estimated from baseline 3-d diet records.
- Estimated from baseline 3-d physical activity records.

(P < 0.05). The Statistical SPSS software program (version 15.0, 2006, SPSS Inc, Chicago, IL, USA) and Microsoft Excel for Windows 2007 (Redmond, WA, USA) were used for all the statistical analyses. All data are presented as mean ± SE.
between treatment groups throughout the study as estimated from the food records \( (P = 0.806; \text{Fig. 2}) \). Grand mean energy intake during the study was 1935 ± 529 kcal/d (median 1961 kcal/d) in the high dairy group, 2128 ± 672 kcal/d (median 2029 kcal/d) in the high calcium group, and 2003 ± 662 kcal/d (median 1900 kcal/d) in the control group. The physical activity index was also similar between treatment groups throughout the study \( (P = 0.764; \text{Fig. 3}) \). Grand mean physical activity index score during the study was 28.1 ± 2.5 (median 27.5) in the high dairy group, 27.6 ± 1.6 (median 27.2) in the high calcium group, and 27.8 ± 2.0 (median 27.2) in the control group, indicating a sedentary level.

Measures of body composition by treatment groups at baseline and after 21 wk are shown in Table 2. No significant group effects were observed on the mean 21-wk change in weight \( \left( P = 0.53 \right) \), total body lean mass \( \left( P = 0.73 \right) \), trunk body fat mass \( \left( P = 0.38 \right) \), total body percentage fat \( \left( P = 0.73 \right) \), trunk body percentage fat \( \left( P = 0.48 \right) \), TBMC \( \left( P = 0.76 \right) \), and total TBMD \( \left( P = 0.59 \right) \). No significant group effects were observed on the mean 21-wk change in weight \( \left( P = 0.40 \right) \), BMI \( \left( P = 0.41 \right) \), total body lean mass \( \left( P = 0.12 \right) \), total body fat mass \( \left( P = 0.67 \right) \), total body percentage fat \( \left( P = 0.26 \right) \), trunk body fat mass \( \left( P = 0.73 \right) \), trunk body percentage fat \( \left( P = 0.38 \right) \), TBMC \( \left( P = 0.48 \right) \), TBMD \( \left( P = 0.59 \right) \), total cholesterol \( \left( P = 0.97 \right) \), HDL levels \( \left( P = 0.56 \right) \), LDL levels \( \left( P = 0.96 \right) \), and triacylglycerol levels \( \left( P = 0.66 \right) \).

**Discussion**

The present study showed that increasing calcium intake (through dairy products or calcium supplements) for 21 wk without an energy restriction or exercise intervention in Puerto Rican obese individuals did not lead to significant changes in body composition or serum lipids profile.

Most studies reported to date have tested the effects of calcium supplementation (from dairy products or calcium supplements) on body composition and blood lipids with energy-restricted diets or exercise intervention plans in obese individuals with conflicting results. With a similar study design to the present study, the study by Zemel and collaborators [6] in obese individuals \( (n = 32) \) showed that diets high in calcium from supplements \( (1256 ± 134 \text{ mg/d of calcium}) \) or dairy products \( (1137 ± 164 \text{ mg/d of calcium}) \) while consuming energy-restricted diets for 24 wk significantly decreased body weight and fat mass compared to placebo \( (430 ± 94 \text{ mg/d of calcium}) \). However, the present study did not find similar results if subjects consumed their usual diets or isocaloric diets, without energy restriction. Nevertheless, our results are similar to those reported by Gunther et al. [15] in normal weight young women \( (n = 133) \) consuming a medium \( (1026 ± 311 \text{ mg/d of calcium}) \), high dairy \( (1131 ± 337 \text{ mg/d of calcium}) \), diet, or placebo \( (742 ± 322 \text{ mg/d of calcium}) \) for 1 y while maintaining isocaloric diets. No significant differences were observed in the mean 1-y change in fat mass or body weight between the groups in their study. However, a 6-mo follow-up study in the same population found that the high dairy group maintained a significantly higher calcium intake at 18 mo compared with the control group, and the regression analysis showed that mean calcium intake over the 18 mo predicted a negative change in fat mass \( (P < 0.05) \), after controlling for baseline BMI [29]. Another study conducted by Reid et al. [13] did not find significant changes in body weight and fat in normal weight postmenopausal women \( (n = 1204) \) with 1000 mg/d of calcium supplementation while consuming their usual diets. Furthermore, a recent study in obese individuals \( (n = 335) \) did not find significant changes in body weight or BMI with 1500 mg/d of calcium supplementation while consuming their usual diets.

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There were no significant differences between the groups by ANOVA (TBMC, total bone mineral content; TBMD, total bone mineral density).

Table 3
Changes in body composition and serum lipids by treatment groups in the study (mean ± SE)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Baseline</th>
<th>21 wk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High dairy group (n = 8)</td>
<td>High calcium group (n = 9)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>102.3 ± 5.7</td>
<td>102.6 ± 6.2</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>39.9 ± 2.2</td>
<td>40.1 ± 2.4</td>
</tr>
<tr>
<td>Total body lean mass (kg)</td>
<td>53.8 ± 1.8</td>
<td>53.9 ± 2.1</td>
</tr>
<tr>
<td>Total body fat mass (kg)</td>
<td>44.2 ± 4.3</td>
<td>43.68 ± 4.4</td>
</tr>
<tr>
<td>Total body fat (%)</td>
<td>42.9 ± 2.1</td>
<td>42.5 ± 2.2</td>
</tr>
<tr>
<td>Trunk body fat mass (kg)</td>
<td>17.5 ± 1.1</td>
<td>17.01 ± 1.1</td>
</tr>
<tr>
<td>Trunk body fat (%)</td>
<td>39.5 ± 1.5</td>
<td>38.7 ± 1.2</td>
</tr>
<tr>
<td>TBMC (g)</td>
<td>2258.8 ± 212.6</td>
<td>22543 ± 219.9</td>
</tr>
<tr>
<td>TBMD (g/cm²)</td>
<td>1.120 ± 0.054</td>
<td>1.129 ± 0.061</td>
</tr>
<tr>
<td>Total cholesterol (mg/dL)</td>
<td>175.8 ± 8.6</td>
<td>175.9 ± 9.4</td>
</tr>
<tr>
<td>HDL cholesterol (mg/dL)</td>
<td>40.0 ± 1.9</td>
<td>42.8 ± 2.0</td>
</tr>
<tr>
<td>LDL cholesterol (mg/dL)</td>
<td>112.3 ± 9.1</td>
<td>114.1 ± 9.3</td>
</tr>
<tr>
<td>Triacylglycerol (mg/dL)</td>
<td>118.0 ± 14.2</td>
<td>95.4 ± 11.8</td>
</tr>
</tbody>
</table>

Table 2
Changes in body composition and serum lipids by treatment groups in the study (mean ± SE)

There were no significant differences between the groups by ANOVA (P > 0.05).

Dietary interventions for low habitual calcium intake

Studies have suggested that the source of calcium intake (i.e., dairy versus supplements) may influence the effects on body weight and fat mass. Zemel et al. has shown in rodents [21] and in obese adults [6] that dairy products have greater effects on reducing body weight and fat mass than the same level of calcium intake from supplements. Dairy products are rich in bioactive compounds [30], which could explain these effects. In addition, dairy products are usually enriched with vitamin D, which could mediate the effect of calcium on body fat as shown in animal studies [31]. However, this has not been observed in human studies [32,33]. The present study did not find significant differences in body composition and serum lipids profile between the high dairy group and the high elemental calcium group. Nevertheless, subjects in the high dairy group appeared to have smaller increases in body fat and serum lipids, although it was not statistically significant. The small sample size may have been too small to detect these differences.

There are several strengths and limitations of the study. Strengths of this study include the following: design, calcium dose, and compliance measures. The design of the study, a randomized, double-blinded (single-blinded for the high dairy group), placebo-controlled trial with two calcium sources without energy-restricted diets or exercise intervention, allowed studying the effects of calcium alone on body composition and serum lipids under their usual free-living conditions. The total dose aimed in the study (four dairy products servings for the high dairy group and 1200 mg/d for the high calcium group) are similar to the US Dietary Guidelines and US DRI. In addition, these doses are comparable to those used in previous reports in obese individuals [6–9,11]. Compliance to the diet and other lifestyle variables were measured repeatedly by means of different methods (monthly calendar, food records, FFQ, monthly calls and visits to the CRC), which helped in monitoring and improving adherence to the protocol intervention. One of the limitations of the study was the small sample size. However, the sample size calculations provided a power of 90% to detect a difference of 5% in fat mass change between the control and intervention groups.

Conclusion

A high dairy or calcium diet alone did not alter body composition or serum lipids profile in this group of Puerto Rican obese adults, without energy-restricted diets or an exercise intervention plan.

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