Original Research

Effects of Calcium and Resistance Exercise on Body Composition in Overweight Premenopausal Women

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Key words: dairy, bone, fat mass, resistance training

Objective: To examine the combined treatment effect of a mild energy restriction, high dairy calcium intake, and resistance exercise on promoting favorable body composition changes in overweight women with a low dairy intake. Combined treatment strategies may produce synergistic effects on increasing fat loss and preserving bone in a population at risk for obesity and osteoporosis.

Methods: Overweight, sedentary women consuming a diet low in dairy calcium (≤1 serving of dairy per day) were randomized either (1) to maintain a low-calcium diet (LOW; ≤ 500 mg; n = 15) or (2) to increase dairy calcium (HIGH; ≥1200 mg; n = 14) for 16 weeks. Both groups began resistance training 3 days per week and received dietary counseling to reduce energy intake by 250 kcal per day. Body composition was measured at the beginning and at the end of the study with dual energy x-ray absorptiometry. Two 24-hour dietary recalls were measured at baseline, midpoint, and end of study with Nutrition Data System for Research software.

Results: Participants were 36.8 ± 4.8 years of age, with an average body mass index of 29.1 ± 2.1 kg/m². Fat mass decreased significantly over time (LOW = 3.8 ± 4.1 kg and HIGH = 1.8 ± 2.1 kg) but was not significantly different by group. Mean energy reduction from baseline was 382 kcal (LOW) and 214 kcal (HIGH; p = 0.14). When change in energy intake was included as a covariate, there was still no significant difference in fat loss between groups. Change in lumbar spine bone mineral density (LOW = −1.5% and HIGH = 0.8%) was significant between groups (p = 0.02). The prescribed mean calcium intake was achieved for each study group (LOW = 454 ± 143 mg and HIGH = 1312 ± 183 mg), with no significant changes in protein intake over time (LOW = 0.9 g/kg and HIGH = 1.0 g/kg; p = 0.08).

Conclusion: These results suggest that increasing dairy calcium offers no added benefit in reducing body fat when combined with resistance training and energy restriction. However, increasing dairy calcium improves bone mineral density in premenopausal overweight women.

INTRODUCTION

The National Center for Health Statistics reports that 61% of United States women aged 30 to 44 years are overweight or obese, with the age-specific prevalence steadily increasing to 71% of women by the eighth decade of life [1]. In addition to the rise in female obesity rates, osteoporosis is also becoming more prevalent. It is estimated that osteoporosis in women will increase by 1.4 million by 2020 [2]. Since the rate of obesity and reduction of bone mineral density (BMD) increases with age, behavioral interventions designed to prevent their progression are needed prior to the development of disease-related comorbidities.

Studies have shown that modifiable behavioral factors such as diet and exercise can make a significant contribution to optimizing BMD [3]. Sufficient calcium intake is necessary for optimal bone health and prevention of age-related bone loss over time [4]. Exercise also plays a significant role in bone health because of the mechanical stress it places on bones [5].

Recent reports also show an association between dairy calcium intake and fat oxidation [6–11]. Trials by Zemel et al. [12–14] have shown a significant reduction in fat mass with increased intake of dairy products and concomitant energy
restriction. In addition, observational studies suggest an inverse relationship between dietary calcium and body weight and indices of adiposity [15,16]. However, not all studies support this relationship [17–20].

Interventions combining resistance exercise and increased dairy consumption on body composition in premenopausal women are limited in number [5,21]. A recent 12-week weight loss trial incorporating resistance training and aerobics [5] compared 4 supplement groups: calcium supplementation (calcium lactate or phosphate), skim milk, or placebo. The sample included women who normally consumed approximately 750 mg of calcium per day. There was no greater fat loss among women increasing their calcium intake compared with placebo. In comparison, White et al. [21] studied the effect of 3 supplemental yogurt servings per day in young women during resistance training for 8 weeks. Participating women reported a habitual calcium intake ≤800 mg per day. All groups significantly decreased percentage body fat over time, but only the yogurt group reported higher energy intake during the intervention. Given these findings, the question still remains as to whether these results would be similar in sedentary, untrained, premenopausal women normally consuming a low-calcium diet (<500 mg) participating in a longer 16-week progressive whole-body resistance training program.

Since weight is regarded as a modifiable risk factor for osteoporosis [22], intervention studies should be designed to counter diet-induced bone loss by minimizing energy restriction and promoting exercise as the primary strategy for healthful, bone-preserving, body composition change. Promoting dairy consumption as a third element may further enhance the body composition benefits of resistance training and energy restriction by augmenting fat loss while preserving BMD. Therefore, when offering a combination of resistance training and mild energy restriction in untrained, overweight women with low habitual calcium intake, the primary aims of this study were (1) to investigate if fat reduction is augmented by high dairy calcium and (2) to evaluate if BMD is preserved by high dairy calcium.

**MATERIALS AND METHODS**

**Participants**

Women were recruited using advertisements distributed at a local university campus and in the nearby community of a southeastern city. Potential volunteers were asked questions regarding dietary intake of dairy products, exercise, and medical history, and they completed a validated screening form designed to assess pre-exercise health status [23]. Inclusion criteria were (1) usual dairy intakes of less than or equal to 1 serving per day, (2) 29 to 45 years of age, (3) body mass index (BMI) of 25 to 30 kg/m², and (4) no resistance training in the previous 3 months.

Women who were pregnant or lactating, consumed calcium supplements, consumed more than 1 serving per day of dairy products, reported an aversion to dairy products, or who reported previous history of orthopedic injury, gastrointestinal disease, endocrine disorders, or any other medical condition that could compromise the safety of participation were excluded. Women who were on medications that could confound study results were also excluded, including steroids, diuretics, calcium channel blockers, insulin or anti-diabetic agents, synthetic thyroid hormones, and over-the-counter weight loss supplements. The study was approved by the University Institutional Review Board, and all eligible participants gave informed written consent prior to engaging in baseline measures. All institutional and governmental regulations concerning the use of human volunteers were followed during this research. Participants were not given any financial compensation for participating in the study. Study incentives included free exercise training, dietary counseling, and discussion of personal results at study conclusion.

**Study Design**

This study was a 16-week randomized intervention trial. After baseline measurements of diet, muscular strength, weight, and body composition, participants were randomized to either a continuation of their low-calcium diet (<500 mg/d; LOW) or a high-dairy–based calcium diet (≥1200 mg/d; HIGH) group. Random numbers that corresponded to each of the study groups were generated by statistical software and individually placed in sealed envelopes for group assignment. Participants assigned to LOW were asked to maintain their typical low-calcium intake, whereas HIGH participants were instructed to increase their dietary calcium by increasing their dairy intake. Measurements of diet, strength, and anthropometrics were reassessed at study midpoint and endpoint.

All volunteers participated in 3 days per week whole-body resistance training for 16 weeks and were asked to refrain from engaging in additional exercise or using dietary supplements throughout the 16-week intervention. The primary goals of this intervention were to reduce fat mass while maximizing the conservation of BMD. Therefore, a modest weight loss of approximately 0.25 kg/wk was our goal and was attempted with a prescribed daily energy deficit limited to 250 kcal. Participant weight was documented weekly and used as a tool to assess diet adherence. In addition to monitoring body weight changes, participants met with the study dietitian 3 times per week prior to the exercise sessions to discuss dietary adherence and address diet-related questions.

**Anthropometric Measurements**

Average height from 2 measurements was taken without shoes on a stadiometer (Accustat Genentech, San Francisco, CA) at baseline. Body weight was measured weekly on a stationary balance beam scale in light exercise clothing without...
shoes. Typical clothing consisted of exercise shorts and shirts and remained similar throughout the study. Total and regional body composition at baseline and endpoint were assessed by dual energy x-ray absorptiometry (DXA; Lunar-Prodigy Advance Plus, General Electric). DXA measures included total body mass (kg), fat mass (kg), trunk fat (g), and BMD (g/cm²). Fat mass index (FMI) was calculated from fat mass and height measurements (FMI = fat mass [kg] + height [m²]). FMI is a better indicator of fat mass changes over time than percentage body fat [24]. Waist circumference (Gulick II tape measure) and sagittal diameter (Rosscraft Campbell Caliper 20) were measured to assess changes in central adiposity over time. Waist circumferences were measured at the narrowest part of the waist per American College of Sports Medicine (ACSM) guidelines [23] at all 3 study time points.

Exercise Intervention

Resistance training occurred 3 times per week for the entire 16-week study protocol. Participants chose to train on a Monday-Wednesday-Friday or Tuesday-Thursday-Saturday schedule. The resistance exercises for each training session included dumbbell chops (for total body warm-up and core stimulation), followed by dumbbell squats, dumbbell bench press, dumbbell rows, and dumbbell dead lift. Participants completed all training sessions in the Human Performance Lab under the close supervision of trained research personnel.

Participants began the program with 2 weeks of exercise familiarization followed by 14 weeks of progressive overload training. During the familiarization period, participants completed all exercises with 2 sets of 10 repetitions at 60%–70% of their baseline 1 repetition max (1-RM). Training progression from weeks 3 to 16 was governed by baseline and midpoint strength assessment, ability to perform goal range of 8–12 repetitions per set, and ability to maintain proper exercise form throughout each exercise set. Starting at week 3, training advanced to 3 sets per exercise, and participants gradually progressed to training loads of 80%–100% of baseline 1-RM. For the second half of the intervention (weeks 9–16), participants continued to perform 3 sets per exercise within the repetition range noted above and gradually progressed to training at loads of 80%–100% of midpoint 1-RM.

Strength Assessment

Strength was assessed with 1-RM testing for all lifts at baseline, midpoint, and at the end of 16 weeks [25]. Lifts included dumbbell bench press, squats, dead lift, and rows. Participants began with a warm-up of 5 to 10 repetitions at 40%–60% of the participant’s perceived capacity for 1 lift. After a short rest period of 2 minutes, 3 to 5 repetitions were completed at 60%–80% of the participant’s perceived capacity for the same lift. Finally, successive 1-RM attempts were performed until failure with the goal of determining the true 1-RM within 3 to 5 trials. Verbal encouragement was given at each attempt to maximize performance.

Diet Intervention

After randomization to either low-calcium (≤500 mg/d) or high-calcium (≥1200 mg/d) diets, participants received individualized counseling from a registered dietitian (RD) and were instructed on the use of an exchange system diet to guide prescriptions for energy and daily calcium intake. The prescribed diet was based on the American Diabetes Association exchange system [26] and provided approximately 15% of total energy intake from protein, 55% to 60% from carbohydrate, and 25% to 30% from fat. Diets were individualized and designed by the study RD during initial counseling sessions to promote a modest energy reduction (−250 kcal) from baseline energy needs. The primary method for accomplishing this deficit was encouraging participants to reduce their sugar and fat intake while attempting to increase nutritious food variety and appeal.

Participants in the high–dairy calcium group received a high-calcium food list and were given examples on how to incorporate these foods into their daily exchange plan to maintain their daily dietary intake goal of ≥1200 mg. The primary strategy for increasing calcium intake was through encouraging the consumption of at least 3 servings of low-fat dairy foods per day. Participants in the low-calcium group were instructed not to consume any dairy products or calcium supplements and to avoid any food with greater than 15% of daily calcium value per serving, and they were taught to avoid naturally occurring nondairy calcium sources. Participants in both groups received daily vitamin D supplements (400 IU) to prevent insufficient dietary intake.

Energy intake requirements were estimated using the Food and Nutrition Board’s equation for determining energy needs in overweight and obese adult women [27]. Adjustment of total energy expenditure (TEE) for physical activity levels (PAL) were accomplished by multiplying the TEE by the appropriate PAL coefficient determined by assessing usual activity level (sedentary = 1.0 or low active = 1.16). This energy estimate was added to the energy intake determined by the baseline dietary recall information. The 2 estimates were averaged, resulting in the energy required for weight maintenance. The energy prescription was determined by subtracting 250 kcal to promote a 0.25-kg weight loss per week. During the course of the 16-week trial, if weight loss was not progressing as planned, the study RD immediately assessed diet adherence and subsequently decided if additional food exchanges needed to be subtracted from the diet plan to create a greater energy intake deficit.

Diet Assessment

Participants reported their dietary intake during a phone interview by staff trained in the use of nutrition research.
software. The Nutrition Data System for Research (NDS version 2008, Minneapolis, MN) nutrition software system was used to collect and assess dietary intake. This system uses the multiple-pass method to help improve the validity of dietary data [28,29]. The multiple-pass method is a standardized recall strategy that refers to the number of times a participant’s food intake is reviewed during the interview in efforts to improve accuracy. Two random weekday 24-hour dietary recalls occurred within a 7-day period at baseline, midpoint, and at the end of the study.

Statistical Analysis
Sample size was determined using the difference in loss of fat mass reported by Zemel et al. [12] (high-calcium group = 4.43 ± 0.47 kg, low-calcium group = 2.75 ± 0.73 kg). A final sample size of 26 (13 per group) was estimated to provide significant power (80%) to detect a 1.68-kg difference in fat loss between groups. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software for Windows (version 15.0, SPSS Inc, Chicago, IL, 2007). Differences between groups in baseline characteristics were determined with the Student t test. Differences in body composition, weight, anthropometrics, diet, and strength over time and by group were determined by repeated-measures analyses of variance (RMANOVA). Since energy intake affects fat loss, post hoc analysis was done, entering change in energy intake as a covariate in the RMANOVA of fat loss between groups. A post hoc analysis was also conducted with race (black versus nonblack) as a covariate when assessing changes in BMD. Data are reported as means and standard deviations.

RESULTS
Thirty-five participants met all eligibility requirements and were invited to the laboratory for baseline measures. After randomization, 6 participants withdrew from the study because to pregnancy (n = 1, HIGH) and personal reasons (n = 2, LOW; n = 3, HIGH). A total of 29 participants completed the 16-week intervention. Baseline characteristics were not different between dropouts and those who completed the study. There were no significant differences in baseline age, weight, height, or BMI between groups (Table 1).

Body Composition
Changes in weight and body composition by group are outlined in Table 2. Mean weight loss over the 16-week protocol was 2.7 ± 4.5 kg (LOW) and 1.1 ± 2.5 kg (HIGH), which was significant over time but not between groups. While both groups significantly decreased their fat mass over time (LOW = 3.8 ± 4.1 kg versus HIGH = 1.8 ± 2.1 kg), there were no observed group differences. When change in energy intake

Table 1. Baseline Characteristics of Participants by Group

<table>
<thead>
<tr>
<th></th>
<th>Low Calcium (n = 15)</th>
<th>High Calcium (n = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y), mean (SD)</td>
<td>37.1 (5.4)</td>
<td>36.4 (4.3)</td>
</tr>
<tr>
<td>Weight (kg), mean (SD)</td>
<td>76.7 (7.3)</td>
<td>76.9 (6.9)</td>
</tr>
<tr>
<td>Height (cm), mean (SD)</td>
<td>163.4 (5.9)</td>
<td>162.2 (5.6)</td>
</tr>
<tr>
<td>Body mass index (kg/m²), mean (SD)</td>
<td>28.9 (2.3)</td>
<td>29.3 (1.9)</td>
</tr>
<tr>
<td>Race (n)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>White</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Asian</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Latina</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2. Mean (SD) Body Composition Measurements at Baseline and Endpoint by Group

<table>
<thead>
<tr>
<th></th>
<th>Low Calcium (n = 15)</th>
<th>High Calcium (n = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)¹</td>
<td>76.7 (7.3)</td>
<td>74.1 (6.9)</td>
</tr>
<tr>
<td>Body fat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat mass (kg)²</td>
<td>32.5 (5.2)</td>
<td>28.7 (5.3)</td>
</tr>
<tr>
<td>Fat mass index (fat kg/m²)²</td>
<td>12.2 (2.0)</td>
<td>10.8 (2.0)</td>
</tr>
<tr>
<td>Trunk fat (g)²</td>
<td>17.0 (3.6)</td>
<td>14.9 (3.7)</td>
</tr>
<tr>
<td>Fat-free mass (kg)²</td>
<td>44.2 (3.7)</td>
<td>45.4 (3.8)</td>
</tr>
<tr>
<td>Waist circumference (cm)²</td>
<td>87.9 (6.0)</td>
<td>83.9 (6.6)</td>
</tr>
<tr>
<td>Sagittal diameter (cm)²</td>
<td>26.6 (2.2)</td>
<td>25.4 (2.2)</td>
</tr>
<tr>
<td>Bone mineral density (BMD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total body BMD (g/cm²)</td>
<td>1.25 (0.06)</td>
<td>1.25 (0.06)</td>
</tr>
<tr>
<td>Lumbar spine BMD (g/cm²)³</td>
<td>1.31 (0.14)</td>
<td>1.29 (0.12)</td>
</tr>
<tr>
<td>Total hip BMD (g/cm²)</td>
<td>1.05 (0.10)</td>
<td>1.05 (0.10)</td>
</tr>
</tbody>
</table>

¹ Significantly decreased over time, p ≤ 0.05 (repeated-measures analyses of variance [RMANOVA]).
² Significantly changed over time, p ≤ 0.005 (RMANOVA).
³ Significantly different by group, p ≤ 0.01 (RMANOVA).
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Table 3. Dietary Intake at Baseline, Midpoint, and Endpoint by Group

<table>
<thead>
<tr>
<th></th>
<th>Low Calcium (n = 15)</th>
<th>High Calcium (n = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Midpoint</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>1882 (324)</td>
<td>1458 (425)</td>
</tr>
<tr>
<td>Kilocalories per kilogram</td>
<td>24.6 (4.5)</td>
<td>19.6 (6.6)</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>73.6 (19.4)</td>
<td>60.8 (12.6)</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>13.6 (3.7)</td>
<td>17.7 (3.9)</td>
</tr>
<tr>
<td>Protein per kilogram</td>
<td>1 (0.3)</td>
<td>0.8 (0.2)</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>72.7 (24.8)</td>
<td>41.4 (18.3)</td>
</tr>
<tr>
<td>Total carbohydrate (g)</td>
<td>237 (41.5)</td>
<td>197 (27.7)</td>
</tr>
<tr>
<td>Caffeine (mg)</td>
<td>133 (192)</td>
<td>114 (229)</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>19.4 (7.4)</td>
<td>22.3 (5.4)</td>
</tr>
<tr>
<td>Vitamin D (mg)</td>
<td>2.8 (3.0)</td>
<td>2.7 (2.6)</td>
</tr>
<tr>
<td>Alcohol (g)</td>
<td>2 (5.6)</td>
<td>0.01 (0.0)</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>554 (136)</td>
<td>463 (150)</td>
</tr>
</tbody>
</table>

1 Significantly different over time, \( p \leq 0.001 \) (repeated-measures analyses of variance [RMANOVA]).
2 Significantly different between groups, \( p \leq 0.05 \) (RMANOVA).
3 Significantly different over time and between groups, \( p \leq 0.001 \) (RMANOVA).

was included as a covariate, there was still no significant difference in fat loss between groups.

Trunk fat decreased significantly over time, with no differences between groups (LOW = 2.1 ± 2.5 kg versus HIGH = 1.2 ± 1.4 kg). Waist circumference decreased significantly over time, without group differences. Participants in the LOW group lost 3.97 ± 5.3 cm in waist circumference compared with participants in the HIGH group, who lost 2.1 ± 2.3 cm. Women with a waist circumference greater than 88 cm at baseline (n = 11), which is considered at risk for the development of chronic disease per ACSM guidelines [23], lost 5.3 cm in waist circumference compared with 1.7 cm in women with lower baseline measures (n = 18; \( p = 0.02 \)). Mean sagittal diameter reduction was significant over time (LOW = 1.2 ± 1.4 cm versus HIGH = 1.1 ± 0.8 cm) but not between groups.

Women in the HIGH group gained 0.8% in their lumbar spine BMD, which was significantly different from the loss of 1.5% in the LOW group (\( p = 0.02 \)). There were no differences in total body or hip BMD over time or between groups. In post hoc analysis, after controlling for race, there was still a significant difference between groups (\( p = 0.002 \)) in lumbar spine but not in total body or hip BMD. Only 2 women (13%) in the LOW group increased their lumbar spine BMD, compared with 9 (64%) in the HIGH group.

Dietary Changes

The dietary intake of groups over the course of the study is outlined in Table 3. Energy intake, protein intake per kilogram body weight, and calcium intake were not significantly different at baseline. The HIGH group achieved their goal calcium intake, as evidenced by a mean intake (average of midpoint and endpoint) of 1312 mg, whereas the LOW group reported a mean intake of 454 mg. Energy intake significantly decreased over time in both groups (\( p \leq 0.05 \)). The mean energy intake reduction from baseline was 382 kcal (LOW) and 214 kcal (HIGH; \( p = 0.14 \)). The mean study protein intake was 67 g (LOW) and 78 g (HIGH; \( p = 0.01 \)), with protein per kilogram body weight remaining constant (0.9 ± 0.1 g/kg LOW versus 1.0 ± 0.2 g/kg HIGH; \( p = 0.08 \)) throughout the study. Carbohydrate intake was significantly different between groups, with an average of all 3 time points of 205 g (LOW) and 219 g (HIGH). No time \( (p \geq 0.09) \) or group \( (p \geq 0.39) \) differences were observed in caffeine, alcohol, or fiber intake. Dietary vitamin D intake was not significant between groups \( (p = 0.06) \). Adherence with vitamin D supplementation was estimated at >90% based on self-reported weekly assessment.

Strength Change

Total workload (load × repetitions) significantly increased over time in both groups \( (p \leq 0.0001) \) without group differences. Measures of strength (1-RM) were similar between groups at baseline. Strength increases in both groups were significant in the bench press, squat, dead lift, and dumbbell row exercises \( (p \leq 0.001) \) with no group differences (data not shown). Exercise adherence in the LOW group was 93.2% versus 91.4% in the HIGH group.

DISCUSSION

High dairy calcium intake did not enhance fat loss when added to a structured resistance exercise and modest energy reduction program but did increase lumbar BMD in overweight women. The fat loss finding is similar to others who increased calcium intake but did not implement an exercise program. Shapses et al. [19] found no effect on fat loss with calcium supplementation during energy restriction, and Gunther et al.
Calcium-responsive effects in the development of metabolic syndrome are also evident in studies with low calcium intake. For instance, Zemel et al. [12] found no benefit in increasing dairy intake without energy restriction in premenopausal women. Their exercise group reported a nonsignificant 2.2% increase in spinal BMD compared with no observed changes in the control. Even though both groups in the current study were resistance training, only 2 women (13%) in the LOW group increased their BMD, compared with 9 (64%) in the HIGH group.

When examining BMD change across groups, the variations in calcium and energy restriction are also noteworthy. Other trials [19,30] allowed for a 200–400 mg/d difference between control and intervention groups in comparison to 600–700 mg/d in this study. Furthermore, the presence of a mild energy intake restriction in the current study may have contributed to the loss of BMD in the LOW group, an effect that was potentially negated by the group receiving high dairy calcium treatment. This preservation effect is supported by Shapses et al. [19], who studied obese premenopausal women during moderate weight loss and reported that a daily calcium supplement produced a small increase in lumbar BMD by 1.7%. The findings in this study suggest that suboptimal dairy calcium coupled with small energy restrictions may potentiate greater bone losses when calcium intake is less than 600 mg/d. The results also suggest the importance of increasing dairy calcium intake in the presence of a similar energy restriction and exercise program employed in this study. This strategy may improve BMD in women reporting low calcium intakes, even at this stage of life.

Strengths of this study include participant commitment, as evidenced by high exercise adherence (≥90%), high total work (load × repetitions) during supervised training sessions, and significant body composition changes by exercising 25–30 minutes 3 times per week while making small dietary changes. To our knowledge, there are no studies that match both the demographic (diverse racial group of women) and intervention characteristics (energy restriction, dairy supplementation, and resistance training) of this current trial.

A limitation of this trial is the possibility of underreporting dietary intake, as suggested by the low reported energy intake compared with weight loss outcomes. Dietary underreporting has been observed in women more than men, and there appears to be an inverse relationship in the magnitude of underreporting and BMI in women [33]. In addition, a study comparing telephone-administered multiple-pass dietary recall methods with doubly labeled water [34] found a 16% rate of underreporting among women with similar characteristics of participants in this trial. Another limitation of this study is sample size; for this trial, we conducted an a priori calculation of sample size. Based on the variability in fat loss reported by Zemel et al. [12] (−4.43 ± 0.47 kg vs −2.75 ± 0.73 kg), 26 participants were determined as our sample size goal to detect a difference of 1.68 kg in fat loss between groups at 80% power with a significance of p < 0.05. The large variability in weight losses between groups is potential confounding factor.
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loss observed in our women resulted in lower power to determine significant differences.

CONCLUSION

Fat loss and strength gains over time were primarily related to the resistance exercise stimulus and energy reduction and were not enhanced by increasing dairy calcium intake. While there may be other benefits to increasing calcium intake (e.g., BMD), high dairy calcium diets do not appear to enhance fat mass reduction when combined with 16 weeks of resistance training in this population of women. Since excess weight and truncal fat are associated with the risk for developing metabolic syndrome [35], this type of program may be a factor in preventing or delaying its onset. This is evident by the significant trunk fat reductions experienced in this trial despite relatively small dietary changes and resistance exercise lasting only 25 minutes, 3 times per week. In addition, dietary calcium of $\geq 1200$ mg per day was sufficient to support the anabolic effects of resistance training resulting in an increase in lumbar BMD, while $<500$ mg per day was not adequate as it resulted in a loss in lumbar BMD. Results from this study are promising because bone accretion is not thought to be possible at this age of life, particularly during weight loss. Therefore, the convenient and time-efficient nature of this diet and exercise program may be relevant in improving the health of women at risk for bone loss, weight gain, and metabolic syndrome.

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