ABSTRACT
Dairy calcium may help prevent excess weight gain and obesity when consumed in adequate amounts (three or more servings per day) and combined with energy balance. This prospective cohort study was conducted to evaluate dairy intake and examine the association between low-fat dairy intake and body weight and composition changes in college students. Seventy-six college students (65 women and 11 men; mean age ± standard error [SE] = 19.2 ± 0.2 years) completed 7-day food records, body height (cm), weight (kg), and waist circumference (cm) measurements twice (September 2004 and April 2005). Percentage of truncal fat and percentage of total body fat were measured by dual-energy x-ray absorptiometry. One-way multivariate analysis of covariance was conducted. Overall (mean ± SE) total dairy (1.4 ± 0.1 servings/day), low-fat dairy (0.5 ± 0.1 servings/day), and calcium (815 ± 41 mg/day) intakes were low. Subjects who consumed a higher amount of low-fat dairy products (mean ± SE = 0.8 ± 0.1 servings/day) had better diet quality, gained less body weight, and had reductions in waist circumference, percentage truncal fat, and percentage total body fat compared to those with lower intake (mean ± SE = 0.1 ± 0.0 servings/day). Low-fat dairy intake may be associated with better diet quality and weight management in college students. Nutrition interventions in young adults should promote low-fat dairy intake as part of an overall healthful lifestyle.

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Low-Fat Dairy Intake and Body Weight and Composition Changes in College Students

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METHODOLOGY

The study protocol was approved by the Institutional Review Board at Virginia Tech. Participants 18 years of age or older provided informed consent; parental consent and participant assent were obtained for students younger than 18 years of age prior to participation.

Participants and Recruitment
One-hundred ninety-two participants were recruited from a freshmen-level introductory nutrition course in the Fall 2004 semester for this prospective cohort study.
all data were collected twice (September 2004 and April 2005). All students enrolled in the class (n=362) were eligible to participate. Seventy-six participants completed data collection at both time points and were included in final data analyses. Twenty bonus points were assigned to participants in Fall 2004 and $30 gift certificates were provided in Spring 2005 as compensation for participation. Alternate methods to earn bonus points were offered to students who chose not to participate.

Testing Protocol
Data collection at both time periods was conducted by the same four technicians. Technicians were trained to measure height, body weight, and waist circumference by a faculty member with American College of Sports Medicine certification. Training was conducted according to American College of Sports Medicine guidelines for Exercise Testing and Prescription (25).

Anthropometric Measurements
Fasting (overnight) body weight (kg), height (cm), and waist circumference (cm) measurements were conducted with participants wearing lightweight clothing and no shoes. Weight and height were measured using a balance beam scale with a stadiometer (Seca, Hanover, MD). Waist circumference was measured three times to the nearest 0.5 cm at the umbilicus and measurements were averaged.

Body Composition Measures
Total body dual-energy x-ray absorptiometry (QDR 4500A, Hologic, Bedford, MA) scans were conducted and analyzed by a licensed radiologic technologist, limited to measure percent truncal fat and percent total body fat. Quality control and test-retest reliability data for this densitometer have been reported elsewhere (26,27).

Food and Activity Record
Participants completed 7-day food and activity records. Detailed written instructions were provided to participants in completing the food and physical activity log, including examples for correct recording of popular food items with serving sizes. Participants were asked to record all physical activity, including walking to class, with time spent in each activity. Diet and physical activity record sheets were reviewed for completeness and e-mail requests were sent to participants to request missing information, such as meals, beverages, and portion sizes. Nutrient analysis was conducted using Nutritionist Pro (version 2.1.13, 2003, First DataBank, San Bruno, CA). Servings per day for dairy products, whole grains, and fruits and vegetables were calculated from the 7-day food records based on MyPyramid (28). Dairy products included milk, cheese, yogurt, ice cream, pudding, and dairy-based smoothies. Regular dairy products were defined as products made with milk fat >1%. Low-fat dairy products were defined as products made with ≤1% milk fat. Total dairy intake was calculated as the sum of regular and low-fat dairy products. Servings of dairy from mixed meals were determined by the calcium content equivalent to 1 cup of milk or ~300 mg calcium (29).

Resting metabolic rate was calculated using the Mifflin St-Jeor formula (30) and multiplied by an activity factor to estimate total energy requirement. Activity factor was assigned according to level of physical activity, with physical activity expressed as metabolic equivalents (METs; hours per day). METs were calculated using the Compendium of Physical Activities (31). One to three METs (light activity; 1.3 activity factor), more than three to six METs (moderate activity; 1.5 activity factor), and more than six METs (vigor activity; 1.7 activity factor) were used in calculations (25). Percent intake of estimated total energy requirement was calculated by dividing the estimated daily energy intake by estimated total energy requirement.

Data Analyses
Data were analyzed using the Statistical Package for Social Sciences (SPSS, version 16.0 for Windows, 2006, SPSS, Inc, Chicago, IL). Statistical significance was set at P<0.05.

Change in body weight, waist circumference, percent truncal fat, and percent total body fat were calculated by subtracting the follow-up (April 2005) value from baseline value (September 2004). Participants were dichotomized based on a median split for total and low-fat dairy intake (upper vs lower). Multivariate analysis of covariance was conducted to determine the association of baseline total dairy and low-fat dairy intake with change in body weight, waist circumference, percent truncal fat, and percent total body fat. Because of their potential influence on body composition, race, sex, and percent intake of estimated energy requirement were included as covariates in analyses (32-34). Baseline total dairy intake, body mass index (BMI; calculated as kg/m²) and percent total body fat were also included as covariates in primary analyses for low-fat dairy intake. Additional analyses were conducted for low-fat dairy intake for which baseline total dairy was replaced by baseline total calcium as a covariate to examine the influence of calcium on body composition. Secondary analyses were conducted for low-fat dairy intake with whole-grain and fruit and vegetable intake as additional covariates.

RESULTS AND DISCUSSION
Description of the Study Population
Of the 76 subjects, 11 (14%) were males and 65 (86%) were females. Participants ages ranged from 17 to 27 years, with a mean±standard error (SE) age of 19.2±0.1 years. Seven percent of subjects were underweight (BMI <18.5), 68% were normal weight (BMI 18.5 to 24.9), 20% were overweight (BMI 25 to 29.9), and 5% were obese (BMI ≥30) (35). The percentage of subjects who completed vs did not complete the study did not differ by race, sex, or academic classification. Multivariate analysis of variance indicated no substantial group (completed vs not completed) differences at baseline for age, body weight, waist circumference, BMI, or percent total body fat.
Overall Dairy Intake
Mean (±SE) total dairy, low-fat dairy, and calcium intakes were 1.4±0.1 servings/day, 0.5±0.1 servings/day, and 815±41 mg/day, respectively, at baseline. Total dairy intake ranged from 0 to 4.2 servings/day. The majority of subjects (78%) consumed fewer than two servings per day of total dairy, with 17% consuming between two and three servings per day. Only three subjects (4%) consumed three or more per day of total dairy. Low-fat dairy intake ranged from 0 to 0.4 servings/day; 41% consumed three or more per day of total dairy. Low-fat dairy intake was also positively associated with percentage intake of estimated energy (r=0.350, P=0.002), total energy intake (r=0.398, P=0.000), and percentage of energy intake from fat (r=0.264, P=0.019). Although the associations were weak, regular dairy intake was negatively associated with whole-grain (r=−0.187, P=0.099), fruit (r=−0.151, P=0.183), and vegetable (r=−0.198, P=0.081) intake.

Total Dairy Intake and Body Composition Changes
Total dairy intake ranged from 0 to 1.31 servings/day (mean±SE=0.8±0.1 servings/day) in the “lower half” group and 1.32 to 4.2 servings/day (mean±SE=2.0±0.1 servings/day) in the “upper half” group. Total dairy intake was not associated with change in body weight, waist circumference, percent total body fat, or percent truncal fat. Dairy consumption, along with restricted energy intake, may be associated with reduced adiposity in obese individuals (23,24), as opposed to normal weight healthy individuals (37), but the majority of participants in the current study were of normal weight. In addition, a lack of association between total dairy consumption and body composition has been reported previously (22,37-40), and diet quality is a potential confounding factor (18). In the current study, participants in the upper half group for total dairy intake consumed higher total energy (2,158 kcal/day vs 1,928 kcal/day; P=0.046), percentage of energy from fat (32.5% vs 29.7%; P=0.048), and regular-fat dairy products (1.4±0.1 servings/day vs 0.4±0.1 servings/day; P=0.000), and less fruit (0.8±0.2 servings/day vs 1.1±0.2 servings/day; P=0.048) compared to participants in the lower half group. Regular-fat dairy intake was weakly associated with consumption of fruit (r=−0.133, P=0.05).

Baseline Characteristics and Dietary Measures in Low-Fat Dairy Groups
Low-fat dairy intake ranged from 0 to 0.4 servings/day (mean±SE=0.1±0.0 servings/day) in the lower half group and from 0.5 to 2.6 servings/day (mean±SE=0.8±0.1 servings/day) in the upper half group. No significant group differences were observed for baseline body weight, waist circumference, BMI, percent truncal fat, percent total body fat, and METs (Table 1). Although intake of low-fat dairy products was below current recommendations, it is possible that participants who consumed higher amounts of low-fat dairy products were more health conscious, exhibiting more healthful overall dietary patterns (41). Total dairy, whole-grain, vegetable, and calcium intake were weakly associated with consumption of fruit (r=0.133, P=0.05). Mean (±SE) total dairy, low-fat dairy, and calcium intakes were 1.4±0.1 servings/day, 0.5±0.1 servings/day, and 815±41 mg/day, respectively, at baseline. Total dairy intake ranged from 0 to 4.2 servings/day. The majority of subjects (78%) consumed fewer than two servings per day of total dairy, with 17% consuming between two and three servings per day. Only three subjects (4%) consumed three or more per day of total dairy. Low-fat dairy intake ranged from 0 to 0.4 servings/day; 41% consumed three or more per day of total dairy. Low-fat dairy intake was also positively associated with percentage intake of estimated energy (r=0.350, P=0.002), total energy intake (r=0.398, P=0.000), and percentage of energy intake from fat (r=0.264, P=0.019). Although the associations were weak, regular dairy intake was negatively associated with whole-grain (r=−0.187, P=0.099), fruit (r=−0.151, P=0.183), and vegetable (r=−0.198, P=0.081) intake.
and vegetables, \( r = 0.155, P = 0.177 \), and perhaps because of the frequency with which participants consumed milk with cereal \( r = 0.400, P = 0.000 \). Low-fat dairy intake was negatively associated with percentage of energy from fat \( r = -0.314; P = 0.005 \).

### Low-Fat Dairy Intake and Body Composition Changes

The primary multivariate analysis of covariance examined the association between low-fat dairy intake (upper half and lower half groups), while controlling for baseline total dairy intake, percentage estimated energy intake, race, sex, and baseline BMI and percent total body fat. Higher intake of low-fat dairy products was associated with lower gain in body weight and reductions in waist circumference, percent truncal fat, and percent total body fat (Table 2). Previous studies have shown low-fat dairy intake to be associated with lower waist-to-hip ratio in healthy normal-weight young adults compared to their overweight counterparts \( r = 0.046 \) associated with low-fat dairy intake.

Dietary components of positive dietary patterns may be a result of the relatively small sample size.

### Calcium and Body Composition Changes

The initial analyses examined the effect of low-fat dairy intake while controlling for total dairy intake. It is possible that calcium and not total dairy intake could explain the association between low-fat dairy and changes in body weight, waist circumference, percent truncal fat, and percent total body fat \( r = 0.05 \). To this end, an additional analysis replacing the total dairy intake covariate with total calcium intake was conducted. Calcium intake did not influence any of the dependent variables, including body weight, waist circumference, percent truncal fat, or percent total body fat, with only slight variations in effects associated with low-fat dairy intake. These findings are incongruent with a study by Davies and colleagues \( r = 0.05 \), which suggests that higher dairy calcium intake in young adults \( 18 \) to \( 28 \) years \( r = 0.05 \) promotes healthier BMI \( r = 0.05 \). Davies and colleagues \( r = 0.05 \) reported that each milligram increase in the ratio of calcium to protein \( r = 0.05 \) was associated with a 0.19 decrease in BMI. In the current study, no changes in body composition were associated with total calcium intake; this is consistent with some observational \( r = 0.05 \) and intervention \( r = 0.05 \) studies.

This study is unique in that variables measured (waist circumference, percent truncal fat, percent total body fat) provide specific estimates of body composition changes. Percentage total body fat and percentage truncal fat were measured by dual-energy x-ray absorptiometry, which is a reliable and valid method of determining body fat \( r = 0.05 \). Limitations of the current study include high attrition rate and self-reported dietary intake, which may not re-

### Table 2. Estimated marginal means for change in weight, waist, percent truncal fat, and percent total body fat for college-age participants in the “lower half” and the “upper half” groups for low-fat dairy intake

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lower half (n=37)</th>
<th>Upper half (n=39)</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight change (kg)( ^{a} )</td>
<td>1.44±0.43</td>
<td>0.06±0.42</td>
<td>0.031*</td>
</tr>
<tr>
<td>Waist change (cm)( ^{a} )</td>
<td>0.95±0.81</td>
<td>-1.47±0.79</td>
<td>0.046*</td>
</tr>
<tr>
<td>% Total body fat change( ^{a} )</td>
<td>0.83±0.40</td>
<td>-0.47±0.39</td>
<td>0.030*</td>
</tr>
<tr>
<td>Weight change (kg)( ^{b} )</td>
<td>1.17±0.42</td>
<td>0.32±0.40</td>
<td>0.181</td>
</tr>
<tr>
<td>Waist change (cm)( ^{b} )</td>
<td>0.72±0.85</td>
<td>-1.25±0.83</td>
<td>0.129</td>
</tr>
<tr>
<td>% Total body fat change( ^{b} )</td>
<td>0.68±0.36</td>
<td>-0.48±0.35</td>
<td>0.030*</td>
</tr>
<tr>
<td>Weight change (kg)( ^{c} )</td>
<td>1.41±0.42</td>
<td>0.09±0.41</td>
<td>0.034*</td>
</tr>
<tr>
<td>Waist change (cm)( ^{c} )</td>
<td>1.10±0.81</td>
<td>-1.62±0.78</td>
<td>0.023*</td>
</tr>
<tr>
<td>% Total body fat change( ^{c} )</td>
<td>0.80±0.39</td>
<td>-0.44±0.38</td>
<td>0.033*</td>
</tr>
</tbody>
</table>

\( * \) Multivariate analysis of covariance (MANCOVA) with baseline percent estimated energy intake, race, sex, body mass index, percent total body fat, and total dairy intake as covariates; \( P = 0.05 \); means expressed as estimated marginal mean±standard error (SE).

\( ^{a} \) MANCOVA with baseline percent estimated energy intake, race, sex, body mass index, percent total body fat, total dairy intake, whole grains, fruits, and vegetables as covariates; \( P = 0.05 \); means expressed as estimated marginal mean±SE.

\( ^{b} \) MANCOVA with baseline percent estimated energy intake, race, sex, body mass index, percent total body fat, and total calcium intake as covariates; \( P = 0.05 \); means expressed as estimated marginal mean±SE.

\( * \) Significant at \( P < 0.05 \).
flect actual intake (50,51). In addition, results may not be
generalizable to young adults not enrolled in college.

CONCLUSIONS

Results of the current study suggest that college-aged
students who consume higher amounts of low-fat dairy
products are more likely to maintain a lower body weight
and percent total body fat. Low-fat dairy intake may be
associated with better overall diet quality and a more
healthful lifestyle, contributing to weight maintenance. A
combination of healthful food choices, including low-fat
dairy products, whole grains, vegetables, and fruits may
promote small differences in body-composition param-
ters for weight maintenance in the college years. Because
young adulthood is a transition phase characterized by
doory and lifestyle patterns (3-12), interventions
should focus on improving these patterns. Furthermore,
increasing low-fat dairy intake to the recommended level
of three servings per day as a part of healthful lifestyle
may be beneficial in improving overall nutrient quality of
the diet (52,53) in a population with low dairy intake.

STATEMENT OF POTENTIAL CONFLICT OF INTEREST:
No potential conflict of interest was reported by the
authors.

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