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Association of Calcium Intake, Dairy Product Consumption with Overweight Status in Young Adults (1995–1996): The Bogalusa Heart Study

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Abstract

Objective—To examine the association between calcium intake and dairy product consumption with overweight and obesity in young adults.

Methods—The sample used in this study consisted of 1306 young adults, ages 19–38 years, who participated in the 1995–1996 young adult survey. Analysis was performed with analysis of covariance (ANCOVA) for ethnicity-gender groups separately.

Results—No significant association was found between dairy product consumption, calcium intake and overweight, defined by body mass index or waist circumference. However, there was a significant inverse association between calcium intake, low-fat dairy product consumption and waist-to-hip ratio in white males.

Conclusion—Increasing intake of calcium and low-fat dairy products may be associated with lower abdominal adiposity, particularly in young adult white males.

Keywords

dietary intake; calcium; adult nutrition; overweight

INTRODUCTION

Obesity threatens to become the most prevalent public health problem in the U.S. Approximately 55% of American adults are overweight or obese, representing 97 million American adults 20 years of age and older (Third National Health and Nutrition Examination Survey (NHANES III), 1988–1994) [1]. Of these American adults, 22% are obese. The (NHANES) data further indicate that the prevalence of obesity among adults increased from 23% (1998–1994) to 31% (1999–2000) [2]. If this trend continues, 39% of Americans will be obese in 2008 [2].

The prevalence of overweight and obesity are even higher in minority groups [1,3]. The black population has a higher prevalence of obesity compared to their white counterparts [3,4].

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Thirty-one percent of black males were defined as overweight, 30% of white males, 48% of black females, and 29% of white females were defined as overweight (From NHANES III, 1998–1994) [1].

High calcium intake has been shown to be inversely related to obesity-related metabolic disorders in humans, such as hypertension [1,2,5,6] and diabetes and insulin resistance [3–9]. Emerging evidence from animal and in vitro studies [8,9] and more recently from human studies [8–11] have shown a negative association between calcium intake [10–12], dairy product consumption [10–12] and body weight [10,11] and the risk of becoming obese [8,9]. An inverse association has been reported between calcium intake and body fat, particularly in children [12–14] and women [8–11]. In a study of adipose cells in transgenic mice, high calcium, medium and high dairy diets at equivalent levels of energy intake reduced lipogenesis, stimulated lipolysis and reduced the accumulation of body fat [8,9].

Although previous research has shown evidence on the inverse association between high intakes of calcium, and dairy products, on overweight, more studies are needed to confirm these associations in other ethnically diverse populations. The Bogalusa Heart Study [3,15] a long-term epidemiology study, provides the unique opportunity to study a well-defined biracial (whites and blacks) population of the total community and to further investigate the associations between calcium intake, dairy product consumption, and overweight.

METHODS

Population

The Bogalusa Heart Study is an epidemiological investigation of cardiovascular risk factor variables and environmental determinants in a bi-racial (white-black) population that began in 1973 [3,15]. The study sampled consisted of 1306 young adults who participated in a 1995–1996 young adult cross-sectional survey. Age ranged from 20–38 years of age (mean = 29.7 years) (Table 1). The subjects consisted of 505 males (38.7%) and 801 females (61.3%); and 952 whites (72.9%) and 354 blacks (27.1%).

Obesity Measures

The Bogalusa Heart Study data included height and weight measurements, and waist and hip circumference measurements on the sample subjects. Height was measured twice to the nearest 0.10 centimeters (cm) on an automatic height board and averaged. Weight was measured twice to the nearest 0.10 kilogram (kg) on a balance beam metric scale and averaged. Waist and hip circumference measurements were each recorded three times to the nearest cm and averaged and were taken either over an examination gown or street clothing [3].

These data were used to calculate several different measurements of obesity. Body mass index (BMI) was calculated by dividing the average weight measurement (in kg) by the square of the average height (in cm) divided by 100 (weight/height^2 (kg/m^2). The waist-to-hip (WHR) ratio was calculated by dividing the average waist circumference (WC) (in cm) by the average hip circumference (in cm). Overweight and obese were identified by a BMI ≥ 25, and obese were identified by WC (> 88 cm for female; > 102 cm for male) and WHR (> 0.8 for female; > 0.9 for male) using CDC guidelines [7].

Physical Activity Measures

Study participants were asked to provide a subjective rating of their physical activity level outside of work using the following 5-item Likert question adapted from the Lipid Research Clinic's questionnaire [16].

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"Compared to other people your age and sex, how would you rate your physical activity outside of work during the past year?"

1 Physically Inactive	2	3 Moderately Active	4	5 Very Active

Previous research has shown that the questionnaire had high test-retest reliability (r = 0.85), and was significantly associated with a four week physical activity history [16].

Dietary Methodology

Intakes of calcium were obtained from data collected from a Youth and Adolescent Questionnaire (YAQ) which has proved both valid [17] and reliable [18]. The YAQ is a self-administered, semi quantitative food frequency questionnaire that contains 131 foods, each with response categories for frequency of consumption in terms of food items [17,18]. Daily portion sizes were calculated for each of the food items. The selected food frequency for each food was then converted to daily intake: for example: "one serving per week" was converted to 0.14 serving per day.

The serving equivalent of dairy foods in mixed dishes was determined by a researcher at Harvard Medical School. Mixed dishes included cheeseburgers, pizza, tacos and burritos, lasagna and baked ziti, macaroni and cheese, cream (milk) soups or chowder, frozen yogurt, ice cream, milkshakes or frappes, pudding, and nachos with cheese. One cup of milk contains 296 mg of calcium and was used to calculate the servings of dairy products from mixed dishes according to the formula:

$$\begin{aligned}&\text{Servings dairy food from mixed dishes}\\&=((\text{calcium content})/296)\\&\times(\text{daily frequency of consumption})\end{aligned}$$

For example, the amount of calcium in two slices of pizza is 235. If a person consumed 2 slices of pizza per day, their dairy servings would be 0.79 (235/296 of dairy).

Food items were classified as high fat or low fat, utilizing responses to the questions on the type of milk (whole, 2% milk, 1% milk, or skim/nonfat milk) and type of yogurt and cheese (low fat or regular) usually consumed. However, the dairy products from mixed dishes were not specified and so all were classified into the high fat dairy group. Foods normally consumed in amounts more than 30 g were considered low fat if they had less than 3 g fat per 100 g and less than 30% of calories from fat; and foods normally consumed in amounts lower than 30 g were considered low fat if they had less than 3 g fat per 50 g and less than 30% of its calories from fat (FDA, 2002). The dairy ingredients for each food item were then extracted and entered into the Pyramid Servings Database (PSDB) (National Cancer Institute, n.d.). The mean dairy servings from the PSDB were utilized to calculate the number of dairy servings from each food item. The food items were later categorized into six groups:

- **low fat milk** (unflavored milk + chocolate milk),
- **high fat milk** (unflavored milk + chocolate milk),
- **low fat dairy** (cheese [slice] + cottage cheese + cream cheese + whipped cream + yogurt),

- **high fat dairy** (cheese [slice] + cottage cheese + cream cheese + frozen yogurt + pudding + cream- or milk-based soups + ice cream + milk shake + whipped cream + yogurt),
- **high fat cheese dishes** (cheeseburger + lasagna/baked ziti + macaroni and cheese + nachos + pizza + tacos/burritos),
- **total milk and dairy** (cheese [slice] + cheeseburger + chocolate milk + cottage cheese + cream cheese + cream- or milk-based soups + frozen yogurt + ice cream + lasagna/baked ziti + macaroni and cheese + milkshake/frappe + nachos + pizza + pudding + tacos/burritos + unflavored milk + whipped cream + yogurt).

Statistical Analysis

The data analyses for this study were conducted using Statistical Package for Social Sciences (SPSS) for Windows (version 11.0.1). The difference in mean daily calcium intake, daily servings of milk and dairy products, daily servings of low fat milk, daily servings of high fat milk, daily servings of low fat dairy products, daily servings of high fat dairy products, and daily servings of dishes with cheese by race and gender, BMI, WC, and WHR were analyzed using analysis of variance (ANOVA). Mean dietary intakes of dairy products and calcium by weight status defined by WHR were presented in Model 1. Model 2 was adjusted for energy intake; Model 3 was adjusted for energy intake and age, and further adjusted for physical activity in Model 4. The effect of dairy product consumption on overweight was analyzed using General Linear Model and Logistic Regression.

RESULTS

Population

The descriptive statistics of the study population is presented in Table 1. The mean age of the population used in this study was 29.7 years. The level of physical activity was significantly higher ($p < 0.05$) among white males and black males than the white females. BMI was significantly higher ($p < 0.05$) among black females compared to white females. In contrast, WHR was significantly lower in females than in males, regardless of ethnicity. WC was significantly higher in white males compared to females ($p < 0.05$). Black females had a significantly higher mean hip circumference than white females and males ($p < 0.05$). The mean energy intake of the study population was significantly higher ($p < 0.05$) among white males than white females and blacks. Overall intake of dairy products was higher among blacks than whites ($p < 0.05$). Blacks had significantly higher ($p < 0.05$) intakes of high fat dairy products, and whites had higher intakes of low fat dairy products ($p < 0.05$). Overall, females had statistically significant lower intakes of dairy products than males ($p < 0.05$).

Dairy Products and Calcium Intake by Waist Hip Ratio (WHR)

Mean dietary intakes of dairy products and calcium by weight status defined by WHR are presented in Table 2. Mean intakes of low fat dairy products and calcium were significantly higher in normal weight white males than in overweight white males, even after adjusting for all the covariates. This association was not found in the other ethnic-gender groups. Consumption of high fat dairy was significantly higher in overweight white males compared to normal weight white males after adjusting for energy intake, age, and physical activity.

Dairy Products and Calcium Intake by Waist Circumference (WC)

Mean dietary intakes of dairy products and calcium by weight status defined by WC are presented in Table 3. No significant differences were found in the intake of total dairy, low fat dairy, calcium and overweight in the four ethnic-gender groups. Overweight white males

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showed significantly higher ($p < 0.01$) intakes of high fat dairy products than normal weight white males after adjusting for energy intake and age, but significance disappeared after controlling for physical activity.

Dairy Products and Calcium Intake by BMI

Mean dietary intakes of dairy products and calcium by weight status defined by BMI are presented in Table 4. After adjusting for energy intake, age, and physical activity, there was no significant association between dairy product consumption, calcium intake and overweight defined by BMI in all four race-gender groups.

DISCUSSION

There is an emerging body of research suggesting that calcium intake [10,11,19] and dairy product consumption [12,20] are inversely related to body weight [10,11,19] and to risk of becoming obese [21]. Furthermore, some research groups have reported an inverse association between calcium consumption and body fat in women [22–24], and specifically in white women [23] men [23], and children [12,25]. A plausible physiological basis for the association between calcium intake, dairy product consumption and overweight has been proposed by Zemel et al [21,26–28]. Briefly, a high calcium intake results in lower blood parathyroid hormone and 1,25-dihydroxy vitamin D concentrations resulting in an increase in lipolysis [21]. In contrast, a low calcium intake causes a rise in parathyroid hormone and 1,25-dihydroxyvitamin D, which results in an increase in [Ca^{2+}] promoting lipogenesis [21,26]. Most associations were found with BMI and overall fat mass, but there were some associations found with abdominal adiposity. This study was conducted to examine the association between intake of calcium and dairy products and overweight status in a biracial sample of young adults. Our results are generally consistent with those reported previously in humans [11,21]. However, there are differences between our findings and previously reported studies. In this study, we found that low-fat dairy and calcium intake were significantly higher in normal weight white males compared to their overweight counterparts when using WHR to define overweight status. This was observed despite adjustments for a number of confounding variables. However, the correlation between calcium intake and adiposity did not exist when we defined overweight using WC or BMI. This is in contrast to other studies, which report calcium-adiposity associations mainly in women [11,21,29], and to a lesser extent in men [21]. In the Heritage Family Study [23] and the Quebec Family Study [22], the strongest inverse association between calcium intake and abdominal adiposity was found in black men and white women. In white men, a negative association was found only for percent fat and not for total abdominal fat, abdominal visceral and abdominal subcutaneous [23]. However, in this study, we found a negative association between intake of calcium and low-fat dairy products and overweight in white males only when WHR was used to define overweight status and not when BMI or WC was used.

There is a lack of consensus on the best anthropometric indicator of abdominal obesity [24, 30–42]. WHR has been referred to as an indicator of fat distribution [24] and has been reported to be a better predictor than WC and BMI of coronary heart disease risk factors [31–33,35–39,42] and increased risk of non-insulin dependent diabetes [31,34,42]. Men tend to have larger WC and higher WHR than women, indicating a greater degree of central fat distribution [41, 43]. Data from this study showed that white males had a significantly higher WHR than the other race-gender groups. This higher WHR was reflected in a higher WC suggesting increased abdominal fat, majority of which is visceral fat. Men who were least active were more likely to have a larger waist and smaller hips than expected from their BMI [41]. It is likely that the association between physical inactivity and high WHR indicates both skeletal muscle atrophy and increased abdominal fat deposition [41].

Zemel et al [44] found that both high calcium and high dairy diets resulted in striking changes in the distribution of body fat loss, particularly from the abdominal region, during energy restriction, suggesting increased mobilization and loss of visceral fat. There is some suggestion that increasing dietary calcium not only accelerates weight and fat loss, but also appears to shift the distribution of fat loss, with more fat loss from the abdominal region. Although the mechanism of this effect is not clear, a possible explanation has been proposed [44]. Production rates of cortisol have been related to obesity [45]. 1,25 Dihydroxyvitamin D_3 produces an increase in human adipocyte intracellular levels of Ca^{2+}, which results in increased production of cortisol in adipose tissue. This occurrence may explain the preferential loss of adipose tissue [46]. Hence it has been suggested that a high calcium or high-dairy diet leads to suppression of 1,25 Dihydroxyvitamin D_3 and a consequent reduction in intracellular calcium levels, resulting in reduced adipocyte cortisol production and a preferential loss of visceral fat in obese adults. Zemel has demonstrated that increasing intracellular Ca^{2+} using 1,25-dihydroxyvitamin D_3, resulted in a marked increase of human adipocyte cortisol production [47]. According to Zemel et al., “one may reasonably expect that suppression of adipocyte intracellular Ca^{2+} levels on high-calcium diets may result in reduced adipose tissue cortisol production, which may, thereby, explain the preferential loss of visceral adipose tissue” [21]. Clearly, more studies are needed to examine the relationship between body fat distribution and intake of calcium and dairy products.

The strengths of the current study are the large biracial sample, the variety of adiposity measures obtained, and the quality control of the data collected. However, there are some limitations in the data. The Bogalusa Heart Study was not originally designed to examine the effects of calcium and dairy product intake on body composition. More randomized, controlled intervention trials are needed to confirm the effects of calcium and dairy product intake on adiposity. Another limitation is self-reported dietary intake [48]. Although the YAQ used in the present study has a reasonable reproducibility and validity [49], it may not be the best method to characterize intake of calcium and dairy products. A recent study showed that a food frequency questionnaire underestimated calcium intake compared to the 24-hour dietary recall [50].

Dietary information from a self-reported food frequency questionnaire has substantial error, including error in the estimation of portion sizes among individuals and the total number of foods actually consumed [51]. The investigators used the YAQ instead of the adult version of the food frequency questionnaire [49], based on a review of 24-hour dietary recalls collected in a previous (1989–91) cross-sectional survey that was also conducted in Bogalusa, Louisiana on adults of a similar age range. After reviewing the 24-hour dietary recalls, we found that a lot of snack foods were reported. A major difference between the YAQ and the adult food frequency questionnaire is that the YAQ contains more snack foods. From our previous studies using the YAQ, this young adult population showed similar total energy intake and percentage of energy from fat with the 1995 Continuing Survey of Food Intakes by Individuals (CSFII) measured by 2-day dietary recall [52,53].

Dairy product consumption may have been over-estimated in our study, due to the approach used to calculate the number of dairy servings from the mixed dishes and desserts. All of the mixed dishes where the dairy servings were estimated contained cheese as the predominant source of calcium (e.g., lasagna, macaroni and cheese, pizza, cheeseburger). The dairy servings in desserts were predominantly from milk (e.g., pudding, ice cream, frozen yogurt). Thirty-nine percent of dairy servings were from the cheese-containing dishes (30%) and desserts containing dairy (9%). One could argue that the estimation of the number of servings of dairy from mixed dishes and desserts in addition to other sources may be a better estimate of overall dairy product consumption compared to studies that have defined dairy product consumption as only the individual foods themselves (e.g., milk, cheese, yogurt). However, if the percentage of dairy servings from mixed dishes and desserts were not estimated, a very large percentage of the daily dairy servings consumed would have not been accounted for, resulting in an under-estimation of dairy intake. It is also important to note that a limitation of using a food frequency is that the instrument does not contain all possible foods that may be consumed, specific to dairy, the YAQ assesses intake of cheese, milk, yogurt and some mixed dishes containing dairy. The YAQ does not include all possible mixed dishes that contain dairy as an ingredient or calcium-fortified foods. The analyses were rerun deleting the number of dairy servings from mixed dishes and similar results were obtained.

CONCLUSION

In summary, the present study suggests that intake of calcium and low-fat dairy products is inversely associated with abdominal adiposity, particularly in white males. However, the results need to be interpreted with caution until large clinical trials confirm a causal association between the intake of calcium and dairy products and body weight regulation.

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Table 1

Descriptive Statistics

	Whites		Blacks		
	Male (N = 374)	**Female (N = 578)**	**Male (N = 131)**	**Female (N = 223)**	**Total**
			Mean (SD)		
Age	30.2 (5.0)^{a}	29.6 (5.0)^{ab}	29.7 (5.4)^{ab}	28.8 (5.3)^{b}	29.7 (5.1)
Level of Physical Activity	3.36 (1.02)^{a}	3.04 (1.05)^{b}	3.72 (1.26)^{c}	3.18 (1.19)^{ab}	3.2 (1.1)
BMI	27.7 (5.3)^{a}	26.0 (6.7)^{b}	27.9 (7.4)^{a}	30.3 (8.5)^{c}	27.4 (6.9)
Waist Circumference, cm	94.0 (14.1)^{a}	80.0 (14.5)^{b}	90.1 (17.2)^{ac}	89.3 (17.8)^{c}	86.6 (16.5)
Hip Circumference, cm	105.6 (9.3)^{a}	104.2 (13.3)^{a}	105.5 (14.0)^{a}	111.2 (15.1)^{b}	105.9 (12.9)
Waist/Hip Ratio	0.89 (0.08)^{a}	0.76 (0.06)^{b}	0.85 (0.07)^{c}	0.80 (0.07)^{d}	0.8 (0.1)
Energy, Kcal	2290 (873)^{a}	1976 (623)^{b}	2595 (1011)^{c}	2494 (1187)^{c}	2217 (886)
Dairy Product, # serving	2.02 (1.24)^{a}	1.73 (1.02)^{b}	2.03 (1.47)^{ab}	1.87 (1.50)^{ab}	1.87 (1.23)
Low-fat Dairy Product, # serving	0.68 (1.08)^{a}	0.74 (0.98)^{a}	0.35 (0.96)^{b}	0.32 (0.99)^{b}	0.61 (1.02)
High-fat Dairy Product, # serving	1.34 (1.09)^{a}	1.00 (0.85)^{b}	1.68 (1.37)^{c}	1.54 (1.36)^{ac}	1.26 (1.11)
Calcium, mg	854.0 (438.0)^{a}	730.2 (331.5)^{b}	894.3 (489.6)^{a}	829.8 (500.1)^{a}	799.1 (417.0)

[1] Mean (S.D.)

[2] Models adjusted for calories intake, age, and physical activity outside of work

[3] L-S Mean

[abcd] Multiple Comparison = significant mean differences at $p < 0.05$ level if with different superscripts

Table 2

The Dairy Products and Calcium Intake by Weight Status Defined by Waist Hip Ratio (WHR)

	Whites						Blacks					
	Male			Female			Male			Female		
	Normal (N = 220)	**Overweight (N = 142)**	**P Value**	**Normal (N = 422)**	**Overweight (N = 132)**	**P Value**	**Normal (N = 96)**	**Overweight (N = 24)**	**P Value**	**Normal (N = 110)**	**Overweight (N = 78)**	**P Value**
Lowfat Dairy, # servings												
Model 1	0.82 (1.23)	0.48 (0.79)	0.003	0.76 (1.02)	0.71 (0.86)	0.62	0.38 (1.03)	0.23 (0.75)	0.49	0.26 (0.90)	0.41 (0.99)	0.28
Model 2	0.81 (0.07)	0.49 (0.09)	0.005	0.76 (0.05)	0.70 (0.08)	0.53	0.37 (0.10)	0.27 (0.19)	0.63	0.25 (0.09)	0.42 (0.11)	0.24
Model 3	0.82 (0.07)	0.47 (0.09)	0.003	0.76 (0.05)	0.70 (0.08)	0.53	0.36 (0.10)	0.31 (0.20)	0.83	0.26 (0.09)	0.41 (0.10)	0.26
Model 4	0.75 (0.09)	0.44 (0.11)	0.008	0.75 (0.06)	0.70 (0.09)	0.61	0.53 (0.13)	0.44 (0.21)	0.67	0.25 (0.10)	0.40 (0.11)	0.27
Highfat Dairy, # servings												
Model 1	1.28 (1.09)	1.41 (1.10)	0.26	1.00 (0.83)	1.04 (0.96)	0.58	1.77 (1.43)	1.67 (1.43)	0.77	1.53 (1.31)	1.54 (1.45)	0.97
Model 2	1.26 (0.06)	1.45 (0.08)	0.054	1.00 (0.04)	1.03 (0.07)	0.76	1.74 (0.12)	1.79 (0.25)	0.86	1.50 (0.11)	1.58 (0.13)	0.64
Model 3	1.24 (0.06)	1.67 (0.08)	0.02	1.00 (0.04)	1.03 (0.07)	0.74	1.74 (0.12)	1.78 (0.25)	0.88	1.50 (0.11)	1.58 (0.13)	0.66
Model 4	1.21 (0.08)	1.41 (0.09)	0.053	0.98 (0.04)	1.02 (0.07)	0.66	1.60 (0.17)	1.71 (0.26)	0.71	1.43 (0.12)	1.48 (0.14)	0.76
Total Dairy, # servings												
Model 1	2.10 (1.37)	1.89 (1.05)	0.12	1.76 (1.04)	1.75 (0.99)	0.99	2.15 (1.54)	1.90 (1.40)	0.47	1.79 (1.44)	1.95 (1.56)	0.47
Model 2	2.07 (0.06)	1.94 (0.07)	0.18	1.76 (0.04)	1.73 (0.07)	0.66	2.11 (0.11)	2.06 (0.23)	0.83	1.75 (0.12)	2.00 (0.14)	0.18
Model 3	2.06 (0.06)	1.94 (0.08)	0.21	1.76 (0.04)	1.73 (0.07)	0.67	2.10 (0.11)	2.09 (0.23)	0.98	1.76 (0.11)	1.99 (0.13)	0.20
Model 4	1.96 (0.08)	1.85 (0.09)	0.25	1.74 (0.05)	1.72 (0.07)	0.85	2.14 (0.16)	2.15 (0.25)	0.97	1.68 (0.12)	1.88 (0.15)	0.25
Calcium, mg												
Model 1	883.3 (490.8)	792.9 (336.5)	0.055	739.7 (339.8)	722.0 (314.5)	0.59	936.9 (521.9)	827.2 (416.6)	0.34	807.0 (488.1)	830.5 (486.0)	0.74
Model 2	870.8 (18.5)	812.3 (23.0)	0.049	743.1 (11.4)	711.3 (20.4)	0.17	921.6 (30.9)	888.3 (61.9)	0.63	791.5 (29.0)	852.5 (34.5)	0.18
Model 3	872.2 (18.7)	810.1 (23.4)	0.041	743.0 (11.4)	711.5 (20.4)	0.18	920.0 (31.1)	894.8 (63.2)	0.72	792.8 (28.6)	850.6 (34.0)	0.19
Model 4	847.8 (24.02)	791.7 (27.6)	0.07	736.7 (13.4)	711.3 (21.1)	0.28	924.7 (42.6)	904.6 (66.7)	0.78	776.0 (31.0)	829.8 (37.1)	0.23

Model 1: Unadjusted. Mean (S.D.)

Model 2: Adjusted for energy intake. Least-Square mean (STDERR)

Model 3: Adjusted for energy intake, age. Least-Square mean (STDERR)

Model 4: Adjusted for energy intake, age, physical activity level outside of work. Least-Square mean (STDERR)

Table 3

The Dairy Products and Calcium Intake by Weight Status Defined by Waist Circumference (WC)

	Whites						Blacks					
	Male			Female			Male			Female		
	Normal (N = 265)	Overweight (N = 97)	P Value	Normal (N = 415)	Overweight (N = 139)	P Value	Normal (N = 91)	Overweight (N = 29)	P Value	Normal (N = 109)	Overweight (N = 79)	P Value
Lowfat Dairy, # servings												
Model 1	0.74 (1.18)	0.52 (0.80)	0.09	0.74 (0.99)	0.79 (0.98)	0.61	0.39 (1.05)	0.25 (0.74)	0.5	0.27 (0.94)	0.39 (0.94)	0.38
Model 2	0.73 (0.06)	0.55 (0.11)	0.15	0.74 (0.05)	0.77 (0.08)	0.81	0.40 (0.10)	0.21 (0.18)	0.35	0.27 (0.09)	0.39 (0.11)	0.42
Model 3	0.74 (0.06)	0.54 (0.11)	0.13	0.74 (0.05)	0.76 (0.08)	0.81	0.39 (0.10)	0.24 (0.18)	0.46	0.28 (0.09)	0.37 (0.10)	0.51
Model 4	0.67 (0.09)	0.52 (0.12)	0.25	0.73 (0.06)	0.76 (0.09)	0.8	0.57 (0.13)	0.38 (0.19)	0.38	0.27 (0.10)	0.37 (0.11)	0.47
Highfat Dairy, # servings												
Model 1	1.30 (1.07)	1.41 (1.16)	0.39	1.00 (0.84)	1.02 (0.95)	0.87	1.73 (1.52)	1.78 (1.07)	0.87	1.47 (1.20)	1.63 (1.57)	0.43
Model 2	1.28 (0.06)	1.48 (0.09)	0.06	1.02 (0.04)	0.98 (0.06)	0.59	1.77 (0.13)	1.68 (0.23)	0.75	1.49 (0.11)	1.59 (0.13)	0.59
Model 3	1.27 (0.06)	1.49 (0.09)	0.04	1.02 (0.04)	0.98 (0.06)	0.62	1.77 (0.13)	1.68 (0.23)	0.73	1.50 (0.11)	1.58 (0.13)	0.65
Model 4	1.24 (0.07)	1.43 (0.11)	0.09	1.00 (0.04)	0.98 (0.07)	0.86	1.66 (0.17)	1.57 (0.24)	0.75	1.43 (0.12)	1.49 (0.14)	0.73
Total Dairy, # servings												
Model 1	2.05 (1.31)	1.93 (1.09)	0.45	1.74 (1.01)	1.80 (1.07)	0.53	2.12 (1.64)	2.03 (1.02)	0.78	1.73 (1.35)	2.02 (1.65)	0.2
Model 2	2.01 (0.05)	2.03 (0.09)	0.83	1.76 (0.04)	1.74 (0.07)	0.83	2.16 (0.12)	1.89 (0.21)	0.26	1.77 (0.12)	1.97 (0.14)	0.26
Model 3	2.01 (0.05)	2.04 (0.09)	0.77	1.76 (0.04)	1.74 (0.07)	0.86	2.16 (0.12)	1.91 (0.21)	0.32	1.78 (0.11)	1.95 (0.13)	0.34
Model 4	1.91 (0.07)	1.95 (0.10)	0.7	1.73 (0.05)	1.74 (0.07)	0.89	2.22 (0.16)	1.95 (0.23)	0.28	1.69 (0.12)	1.85 (0.15)	0.37
Calcium, mg												
Model 1	866.5 (467.5)	796.9 (344.3)	0.18	733.0 (333.7)	743.0 (334.9)	0.76	925.1 (543.3)	882.8 (353.3)	0.69	781.5 (472.3)	865.4 (503.4)	0.24
Model 2	852.7 (16.9)	834.6 (28.0)	0.58	740.9 (11.5)	719.3 (19.9)	0.35	942.3 (31.4)	829.1 (55.7)	0.08	796.2 (29.2)	845.1 (34.3)	0.28
Model 3	852.8 (17.0)	834.2 (28.2)	0.57	740.9 (11.5)	719.5 (19.9)	0.35	941.4 (31.6)	832.0 (56.3)	0.09	799.3 (28.8)	840.9 (33.9)	0.35
Model 4	827.7 (22.5)	818.3 (32.3)	0.78	733.9 (13.5)	720.4 (20.7)	0.56	955.7 (43.0)	835.8 (60.8)	0.08	780.8 (31.5)	821.0 (36.7)	0.37

Model 1: Unadjusted. Mean (S.D.)

Model 2: Adjusted for energy intake. Least-Square mean (STDERR)

Model 3: Adjusted for energy intake, age. Least-Square mean (STDERR)

Model 4: Adjusted for energy intake, age, physical activity level outside of work. Least-Square mean (STDERR)

Table 4

The Dairy Products and Calcium Intake by Weight Status Defined by BMI (>=25)

	Whites						**Blacks**					
	Male			**Female**			**Male**			**Female**		
	Normal (N = 104)	**Overweight (N = 258)**	**P Value**	**Normal (N = 206)**	**Overweight (N = 102)**	**P Value**	**Normal (N = 51)**	**Overweight (N = 69)**	**P Value**	**Normal (N = 56)**	**Overweight (N = 132)**	**P Value**
Lowfat Dairy, # servings												
Model 1	0.65 (1.22)	0.70 (1.04)	0.72	0.78 (1.07)	0.71 (0.87)	0.45	0.46 (1.27)	0.27 (0.70)	0.28	0.31 (1.18)	0.32 (0.82)	0.92
Model 2	0.57 (0.10)	0.73 (0.07)	0.21	0.78 (0.05)	0.71 (0.06)	0.39	0.47 (0.13)	0.27 (0.11)	0.25	0.29 (0.13)	0.33 (0.08)	0.79
Model 3	0.58 (0.10)	0.73 (0.07)	0.23	0.78 (0.05)	0.71 (0.06)	0.38	0.46 (0.13)	0.27 (0.11)	0.28	0.29 (0.12)	0.33 (0.08)	0.8
Model 4	0.50 (0.12)	0.68 (0.09)	0.15	0.77 (0.06)	0.71 (0.07)	0.5	0.70 (0.17)	0.43 (0.13)	0.15	0.27 (0.13)	0.32 (0.09)	0.76
Highfat Dairy, # servings												
Model 1	1.56 (1.25)	1.24 (1.01)	0.01	1.01 (0.84)	1.01 (0.89)	0.99	1.76 (1.44)	1.73 (1.42)	0.91	1.56 (1.35)	1.52 (1.38)	0.84
Model 2	1.40 (0.09)	1.30 (0.06)	0.36	1.02 (0.04)	1.00 (0.05)	0.79	1.77 (0.17)	1.73 (0.15)	0.83	1.45 (0.16)	1.57 (0.10)	0.54
Model 3	1.39 (0.09)	1.31 (0.06)	0.43	1.01 (0.04)	1.00 (0.05)	0.93	1.78 (0.17)	1.73 (0.15)	0.83	1.45 (0.16)	1.57 (0.10)	0.55
Model 4	1.37 (0.10)	1.26 (0.08)	0.29	0.99 (0.05)	1.00 (0.05)	0.91	1.69 (0.23)	1.60 (0.17)	0.74	1.38 (0.16)	1.48 (0.11)	0.58
Total Dairy, # servings												
Model 1	2.21 (1.41)	1.94 (1.18)	0.06	1.78 (1.07)	1.72 (0.97)	0.46	2.23 (1.69)	2.00 (1.37)	0.42	1.88 (1.61)	1.84 (1.44)	0.9
Model 2	1.97 (0.09)	2.03 (0.06)	0.57	1.79 (0.05)	1.70 (0.05)	0.21	2.24 (0.16)	1.99 (0.13)	0.23	1.75 (0.16)	1.90 (0.11)	0.44
Model 3	1.97 (0.09)	2.03 (0.06)	0.53	1.79 (0.05)	1.71 (0.05)	0.27	2.24 (0.16)	2.00 (0.13)	0.25	1.75 (0.16)	1.90 (0.10)	0.44
Model 4	1.87 (0.10)	1.94 (0.07)	0.53	1.76 (0.05)	1.71 (0.06)	0.49	2.38 (0.20)	2.03 (0.16)	0.11	1.65 (0.17)	1.80 (0.12)	0.44
Calcium, mg												
Model 1	931.4 (497.6)	814.1 (408.6)	0.02	747.7 (347.9)	719.3 (314.1)	0.32	959.4 (580.8)	882.1 (438.2)	0.41	859.8 (562.1)	798.5 (451.0)	0.43
Model 2	841.8 (27.3)	850.3 (17.2)	0.79	751.7 (13.2)	714.0 (15.2)	0.06	964.7 (42.0)	878.1 (36.1)	0.12	802.5 (41.0)	822.8 (26.6)	0.68
Model 3	841.9 (27.4)	850.2 (17.3)	0.8	751.3 (13.2)	714.6 (15.2)	0.07	963.8 (42.2)	878.8 (36.2)	0.13	803.2 (40.3)	822.5 (26.2)	0.69
Model 4	816.8 (30.9)	828.8 (22.8)	0.72	742.4 (15.0)	715.0 (16.4)	0.18	997.9 (55.9)	884.6 (42.0)	0.06	783.8 (42.6)	803.1 (29.3)	0.69

Model 1: Unadjusted. Mean (S.D.)

Model 2: Adjusted for energy intake. Least-Square mean (STDERR)

Model 3: Adjusted for energy intake, age. Least-Square mean (STDERR)

Model 4: Adjusted for energy intake, age, physical activity level outside of work. Least-Square mean (STDERR)