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Research Article

Calcium and Dairy Intake: Longitudinal Trends during the Transition to Young Adulthood and Correlates of Calcium Intake

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ABSTRACT

Objective: To describe changes in calcium and dairy intake during the transition from middle adolescence to young adulthood and to identify baseline correlates of calcium intake in young adulthood.

Design: Population-based, 5-year follow-up study (Project EAT: Eating Among Teens).

Setting: Baseline surveys were completed in Minneapolis/St. Paul, MN schools and by mail at follow-up.

Participants: Males and females (N = 1521) attending high school at baseline (mean age = 15.9 years) and with a mean age of 20.5 years at follow-up.

Main Outcome Measures: Calcium intake.

Analysis: Mixed and linear regression methods were used to respectively examine trends and correlates of intake.

Results: During the transition to young adulthood, mean daily calcium intakes of females and males decreased by an average of 153 mg and 194 mg respectively. Mealtime milk availability, health/nutrition attitudes, taste preference for milk, healthful weight control behaviors, and peer support for healthful eating at baseline were associated with better follow-up calcium intake. Time spent watching television and lactose intolerance were associated with lower intake at follow-up.

Conclusions and Implications: Nutrition interventions are needed to counter longitudinal decreases in calcium intake. Interventions targeted to adolescents should address the availability of milk at meals and other identified supports for healthful eating.

Key Words: calcium intake, dairy intake, young adulthood, adolescence, longitudinal study (*J Nutr Educ Behav*. 2009;41:254-260.)

INTRODUCTION

Calcium and dairy products play major roles in the maintenance of health and the prevention of chronic disease.[1] Peak bone mass is not achieved until the third decade of life; therefore, adequate intake of calcium and other essential nutrients found in dairy products (eg, protein, vitamin D) are important during young adulthood to support health and prevent osteoporosis.[2,3] National survey data indicate only about half (53%) of young men and a mere 21% of young women (19 to 30 years) in the United States consume the recommended amount of calcium.[4] Furthermore, 39% of men and 43% of women (20 to 29 years) consume less than even 1 daily serving of dairy products.[5]

Designing effective interventions to improve calcium consumption will require knowledge of longitudinal trends in dietary intake during the transition from adolescence to adulthood and a strong understanding of what factors during adolescence may have an influence on intake as young people progress to adulthood. Little prior research could be found

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describing changes in diet during this period, and only a small number of mostly cross-sectional studies have identified correlates of calcium intake (eg, male gender, on-campus residence, food preparation involvement) during early young adulthood.[6-9]

The current study aimed to describe longitudinal changes in intakes of calcium and dairy products during the transition to young adulthood in a large ethnically and socioeconomically diverse sample of young people in Minnesota. In addition, this study aimed to identify baseline correlates of follow-up calcium intake from within the personal, behavioral, and socioenvironmental domains described by Social Cognitive Theory (SCT).[10]

METHODS

Sample and Study Design

Data for the current study were drawn from Project EAT (Eating Among Teens), a prospective, population-based study designed to examine determinants of dietary intake and weight status. The sample consisted of 1521 young adults (45% male) who completed study assessments at baseline and follow-up. The mean age of participants was 15.9 years (SD = 0.8 years) at baseline and 20.5 years (SD = 0.8 years) at follow-up.

For Project EAT-I (1998-1999), 3074 Minnesota students completed the Project EAT survey, the Youth and Adolescent Food Frequency Questionnaire (YAQ), and anthropometric measures in high school classrooms. Five years later, Project EAT-II (2003-2004) aimed to resurvey by mail all original participants for whom contact information was available (n = 2513) to examine changes in their eating patterns and weight status as they progressed from high school to young adulthood. Surveys and a letter explaining that return of completed surveys implied written consent were sent by mail to the addresses provided by participants during Project EAT-I. Follow-up survey data were collected from 68% of those contacted (n = 1710), representing 56% of the original high school cohort. All study protocols were approved by the University of Minnesota's Institutional Review Board Human Subjects Committee.

Surveys and Measures

The development of the baseline Project EAT survey was guided by SCT, focus group discussions with adolescents,[11] an in-depth literature review, and pilot-testing. For the follow-up Project EAT survey, 55% of items were retained without modification, but some revisions were made to improve the relevance of items for young adults.[12,13] The independent personal, behavioral, and socioenvironmental variables were assessed on the baseline survey.[14,15]

Personal variables. Concern about health was based on 5 items that assessed how much adolescents cared about being healthy and eating healthful food (range: 5-20, Cronbach $\alpha = 0.69$).[14,15] Perceived barriers to healthful eating were based on 4 items assessing attitudes about the amount of time it takes to eat healthful food (range: 4-16, Cronbach $\alpha = 0.68$). Perceived benefits of healthful eating were based on 5 items assessing attitudes about the extent to which dietary intake can affect health, appearance, and performance (range: 5-20, Cronbach $\alpha = 0.80$).[16] Self-efficacy for healthful eating was based on 9 statements assessing how sure adolescents were they could eat healthful food in various situations (range: 9-54, Cronbach $\alpha = 0.87$).[17] Taste preference for milk (range: 1-4) was based on agreement with the statement "Milk tastes good to me." Body satisfaction was assessed using a modified version of the Body Shape Satisfaction Scale[18] (range: 10-50, Cronbach $\alpha = 0.92$). Weight concern was based on response to 4 statements, such as "I think a lot about being thinner" (range: 4-16, Cronbach $\alpha = 0.80$). Lactose intolerance (yes/no) was assessed with the question: "Are you lactose intolerant or allergic to dairy foods?"

Behavioral variables. Frequency of eating breakfast, lunch, and dinner (range: 0-7) were self-reported for the past week.[17] Frequency of eating snacks (range: 0-6) was assessed with the question: "How many times did you snack (eat in-between meals) yesterday?"[17] Fast-food frequency (range: 0-9) was assessed with the question: "In the past week, how often did you eat something from a fast-food restaurant (like McDonald's, Burger King, Hardee's, etc.)?" Food preparation (range: 0-7) and shopping involvement were assessed using questions that asked about how often adolescents helped with these tasks over the past week. Responses to the shopping item were dichotomized (none or ≥ 1 time). Sport involvement was assessed with a question about the number of sport teams played on during the past year[19]; responses were dichotomized (none or ≥ 1 team). Television viewing was assessed using 2 items that separately asked about hours watched on an average weekday and weekend day[20,21]; weekly hours of television viewing were computed (range: 0-35). Use of healthful and unhealthful weight control behaviors were self-reported for the past year. Adolescents indicated whether they had used (yes/no) any of 4 healthful methods (eg, ate more fruits and vegetables, exercise) or any of 9 unhealthful methods (eg, took diet pills, made myself vomit, smoked more cigarettes).[15]

Socioenvironmental variables. Parental support for healthful eating was based on 4 items assessing perceptions of how strongly one's mother and father care about and encourage eating healthful food (range: 4-16, Cronbach $\alpha = 0.64$). Peer support for healthful eating (range: 1-4) was based on agreement with the statement: "Many of my friends care about eating healthful food." Family meal frequency (range: 0-9) was assessed with the question: "During the past seven days, how many times did all, or most, of your family living in your house eat a meal together?"[22] Mealtime milk availability and home availability of soft drinks (range: 1-4) were each assessed by single items about the frequency of having "milk served at meals" and "soda pop available" at home. Food insecurity was assessed with the question: "How often during the last 12 months have you been hungry because your family could not afford food?" and responses were dichotomized to represent the presence or absence of food insecurity.

Sociodemographic characteristics. Characteristics of participants were assessed using the Project EAT surveys.

Race/ethnicity and socioeconomic status (SES) were assessed at baseline by self-report.[23] The prime determinant of SES was the higher educational level of either parent.[23] Classification tree methodology[24] was used to generate 5 SES categories. At follow-up, participants also reported their post-secondary student status (ie, not in college, part-time student, full-time community college student, or full-time 4-year college student), and current living situation (ie, own/rent residence, with parents, on campus, other), as defined by where they had lived for the majority of the past year.

Dietary intake. The YAQ was used to assess intakes of calcium, dairy products, soft drinks, and total energy at baseline and at follow-up. Usual calcium intakes (mg) at baseline and follow-up were determined for the sample by Channing Laboratory in May of 2006 using a specially designed food composition database.[25] The food composition database used by Channing Laboratory is based on the United States Department of Agriculture's (USDA's) Nutrient Database for Standard Reference (Release 16),[26] with additional information from *McCance and Widdowson's The Composition of Foods*,[27,28] journals, and manufacturers. The validity of the YAQ for calcium intake was previously evaluated in adolescents by comparing intakes determined from the average of three 24-hour recalls to intakes determined from the average of 2 YAQs administered over 1 year; the correlation coefficient for energy-adjusted intake of calcium was found to be modest in males ($r = 0.60$) and females ($r = 0.51$).[29] In addition, mean and median estimates for absolute calcium (mg) intake based on dietary recalls were found to be similar to estimates based on responses to the YAQ.[29]

The unit of measure for intake of dairy and intake of soft drinks, an independent variable, was daily servings, reflecting frequency of consumption only, as serving sizes were not queried or defined for all food and beverage items on the YAQ. Milk intake was estimated by summing reported consumption of milk and chocolate-flavored milk. Cheese intake was estimated by summing reported consumption of cottage and ricotta cheese, sliced cheese, cream cheese, and 7 additional items made with cheese (eg, pizza). Dairy dessert intake was estimated by summing reported consumption of ice cream, milkshakes and frappes, pudding, and yogurt (frozen and not frozen). Total dairy intake was estimated by summing reported consumption of the 18 food items and beverages included within the categories of milk, cheese, and dairy desserts. Soft drink intake was estimated by summing reported consumption of soda, punch, lemonades, and fruit drinks. Previous studies have reported on the reliability of the YAQ, including milk and soda intake.[29,30]

Statistical Analyses

For the examination of longitudinal change in intakes of calcium and dairy products, mixed linear regression models were used to estimate and test differences between mean intakes in 1999 and 2004. Models included a main effect term for year and a random effect term for individuals to account for the tracking of behavior within individuals.

Separate multiple linear regression models were used to examine each potential baseline correlate (personal, behavioral, and socioenvironmental variables) of follow-up calcium intake; no adjustment was made for multiple comparisons, as the results emphasize patterns. Regressions were adjusted for sociodemographic characteristics (Model 1) and additionally for baseline calcium intake (Model 2). Model 1 was used to examine the total association of potential correlates with calcium intake at follow-up. Model 2 was used to examine associations between correlates and *change* in calcium intake over the 5-year study period.

For Models 1 and 2, all variables were standardized (unless they were dichotomous) to allow for relative comparisons of strength between the observed associations. Prior to being standardized, calcium intake was also energy-adjusted using the regression approach,[31] as correlates of dietary intake above and beyond any relationship with total energy consumption were of interest. The computed residuals of intake approximated a normal distribution.

Of the 1710 young adults who provided follow-up survey data, participants were excluded from analysis if they did not complete the Project EAT-II survey (n = 10) or the YAQ at either time point (n = 88). In addition, participants were excluded if they reported a biologically implausible level of energy intake (defined a priori as <400 kcal/day or >7000 kcal/day) at either time point (n = 91). These exclusions resulted in a final sample for analysis of 1521 participants.

All analyses were weighted to adjust for differential response rates to Projects EAT-I and EAT-II using the response propensity method.[32] Project EAT-II participants were more likely to be female, white, and of higher SES than Project EAT-I participants. The weighted racial/ethnic and SES proportions of the study sample are as follows: 59% white, 17% Asian, 14% African American, and 10% mixed or other race, whereas SES was low (16%), low-middle (19%), middle (25%), upper-middle (26%), and high (13%). After weighting and adjusting for sociodemographic characteristics, there were no significant differences between baseline calcium or dairy intakes of responders and nonresponders for Project EAT-II. A 95% confidence level was used to interpret the statistical significance of probability tests. Analyses were conducted using the Statistical Analysis System (SAS, version 8.2, SAS Institute, Cary, NC, 2001).

RESULTS

Longitudinal Trends in Intake of Calcium and Dairy

During the transition from middle adolescence (baseline) to young adulthood (follow-up), mean daily intakes of calcium and dairy products decreased in terms of absolute intake (Table 1) and intake density (ie, intake per 1000 kcal; data not shown). Females and males respectively reduced their daily calcium intakes by an average of 153 ± 19 mg and 194 ± 23 mg. Although 38% of females and 39% of males increased their intake of calcium over 5 years, the majority of the sample reduced their intake of calcium over 5 years. During middle adolescence, more than 72% of females and 55% of males had calcium intakes

Table 1. Longitudinal Trends in Calcium and Dairy Product Intake among Female and Male Participants in Project EAT (Eating Among Teens)

	Mean Daily Intake[a] ± Standard Error			
	Baseline[b] (middle adolescence)	Follow-up[c] (young adulthood)	Change over 5 Years	*P*[d]
Females (n = 843)				
Calcium (mg)	1014 ± 17	860 ± 17	−153 ± 19	< .001
Dairy (servings)	3.08 ± 0.06	2.57 ± 0.06	−0.51 ± 0.06	< .001
Milk[e] (servings)	1.54 ± 0.04	1.06 ± 0.04	−0.48 ± 0.04	< .001
% Flavored milk	12.76 ± 0.74	7.97 ± 0.76	−4.79 ± 0.93	< .001
Cheese (servings)	1.16 ± 0.03	1.13 ± 0.03	−0.03 ± 0.03	.19
Dairy desserts (servings)	0.37 ± 0.01	0.37 ± 0.01	<0.01 ± 0.01	.66
Males (n = 678)				
Calcium (mg)	1247 ± 22	1052 ± 22	−194 ± 23	< .001
Dairy (servings)	3.86 ± 0.07	3.29 ± 0.07	−0.57 ± 0.07	< .001
Milk[e] (servings)	2.12 ± 0.05	1.40 ± 0.05	−0.72 ± 0.05	< .001
% Flavored milk	15.99 ± 0.83	8.24 ± 0.85	−7.76 ± 1.05	< .001
Cheese (servings)	1.32 ± 0.03	1.52 ± 0.03	0.19 ± 0.04	< .001
Dairy desserts (servings)	0.41 ± 0.02	0.36 ± 0.02	−0.05 ± 0.02	.001

[a]Analyses are weighted to counter differential response rates in 1999 and 2004; [b]Mean age = 15.9 y; [c]Mean age = 20.5 y; [d]*P* value for longitudinal trend (change in intake from baseline to follow-up); [e]Servings of white and chocolate-flavored milk (% Flavored milk = servings of chocolate-flavored milk/total servings of white and chocolate-flavored milk).

lower than the Adequate Intake level (AI = 1300 mg/day).[33] Similarly, during young adulthood, 68% of females and 53% of males had calcium intakes lower than the AI level (1000 mg/day).[33] Between baseline and follow-up, daily mean total intakes of dairy products were reduced by approximately 0.5 servings in both genders. Both females and males reduced their milk intake, although males increased their cheese intake.

Baseline Correlates of Follow-up Calcium Intake

Table 2 presents the results from multiple linear regression models that were used to separately examine each potential correlate at baseline while adjusting for sociodemographic characteristics (Model 1) and for baseline calcium intake (Model 2). Among females and males, baseline availability of milk at meals was the only factor associated with calcium intake at follow-up (Model 1) and with longitudinal increases in intake (Model 2). With every standard deviation increase in mealtime milk availability, energy-adjusted intake of calcium increased by 0.17 standardized units (57 mg) among females and 0.11 standardized units (38 mg) among males (Model 2).

Among females, concern about health and self-efficacy for healthful eating were also associated with both higher calcium intake at follow-up and with longitudinal increases in intake. In contrast, time spent watching television was associated with lower calcium intake at follow-up and with longitudinal decreases in intake. Several additional factors were associated with calcium intake at follow-up, but not with changes in calcium intake. Having a positive taste preference for milk and family meal frequency were associated with higher calcium intake. Perceived barriers to healthful eating, snack frequency, fast food frequency, and soft drink intake were associated with lower calcium intake.

Among males, positive taste preference for milk, using healthful weight control behaviors, and peer support for healthful eating were associated with higher calcium intake at follow-up and with longitudinal increases in intake. Lactose intolerance was the only factor found to be associated with both lower calcium intake at follow-up and with longitudinal decreases in intake. Concern about health and breakfast frequency were associated with higher calcium intake at follow-up, but not with increases in calcium intake. As observed among females, in males, perceived barriers to healthful eating and fast-food frequency were also associated with lower calcium intake at follow-up, but not with decreases in calcium intake.

Perceived benefits of healthful eating, body satisfaction, lunch frequency, dinner frequency, food preparation involvement, sport involvement, unhealthful weight control behaviors, parental support for healthful eating, and home availability of soft drinks were not related to calcium intake among females or males (data not shown).

Multivariable Models of Follow-up Calcium Intake

To estimate the total variance in calcium intake at follow-up explained by all the covariates examined here, a final model was run including sociodemographic characteristics, calcium intake at baseline, and all of the personal, behavioral, and socioenvironmental variables simultaneously. The total variance explained in calcium

Table 2. Associations of Baseline Personal, Behavioral, and Socioenvironmental Variables with Calcium Intake at Follow-up Among Females (n = 843) and Males (n = 678)

	Females		Males	
	Model 1[ab]	Model 2[ac]	Model 1[ab]	Model 2[ac]
Social Cognitive Theory Factors	β	β	β	β
Personal Factors				
Concern about health	0.16***	0.10**	0.07*	0.04
Perceived barriers to healthful eating	−0.12***	−0.06	−0.07*	−0.03
Self-efficacy for healthful eating	0.12***	0.08*	0.06	0.04
Taste preference for milk	0.19***	0.07	0.21***	0.12**
Weight concerns	0.052	0.07*	0.03	0.04
Lactose intolerance	−0.18	−0.08	−0.68***	−0.64***
Behavioral Factors				
Breakfast frequency	0.06	−0.02	0.09**	0.03
Snack frequency	−0.09**	−0.06	−0.07	−0.04
Fast-food frequency	−0.11**	−0.05	−0.08*	−0.03
Soft-drink intake	−0.12***	−0.06	−0.07	−0.02
Shopping involvement	−0.12	−0.13*	0.03	−0.01
Television viewing	−0.11**	−0.10**	−0.06	−0.03
Healthful weight control behaviors	0.14	0.09	0.15*	0.15*
Socioenvironmental Factors				
Peer support for healthful eating	0.05	0.02	0.08*	0.08*
Family meal frequency	0.07*	0.04	0.06	0.03
Mealtime milk availability	0.27***	0.17***	0.21***	0.11**
Food insecurity	−0.23	−0.25*	−0.09	−0.05

*$P \leq .05$; **$P \leq .01$; ***$P \leq .001$; [a]β coefficients are standardized and are interpreted as the expected amount of standard deviation (SD) change in energy-adjusted calcium (mg) intake associated with a 1 SD change in the predictor variable; [b]Model 1: Associations between each individual factor and intake were tested separately, weighted for nonresponse and adjusted for race/ethnicity, student status, socioeconomic status, living situation, and energy intake at follow-up; [c]Model 2: Associations between each individual factor and intake were tested separately, weighted for nonresponse and adjusted for the covariates in Model 1 plus baseline calcium intake (mg) and energy intake.

intake was 30% among females and 28% among males. Dietary intake during adolescence and sociodemographic characteristics explained the majority of variance in calcium intake at follow-up among young adult females (25%) and males (24%).

DISCUSSION

This study found longitudinal decreases in daily intakes of calcium, total dairy servings, and milk servings during the transition from adolescence to young adulthood. In early young adulthood, two-thirds of females and more than half of males had calcium intakes that were lower than recommended. The findings of this study and others suggest there is a need for interventions to address dietary calcium intake prior to and during the transition from adolescence to adulthood.[4,34-36] The observed decreases in milk intake suggest that interventions designed to promote improvements in calcium intake should emphasize messages and strategies that encourage milk consumption.

Correlates of calcium intake during early young adulthood were also examined. Among females and males, common baseline correlates of follow-up intake represented the personal (eg, taste preference for milk), behavioral (eg, fast-food frequency), and socioenvironmental (eg, availability of milk at meals) domains of SCT. These findings suggest that nutrition interventions that address each of the 3 domains may be most effective in efforts to improve calcium intake. As mealtime milk availability was found to be the only baseline correlate of calcium intake at follow-up and longitudinal increases in intake among both genders, it may be particularly important to promote the practice of making milk available at meals. Differences in the observed correlates of calcium intake across gender further suggest it may be beneficial to design targeted intervention messages.

Before drawing conclusions from the results of this study, a number of strengths and weaknesses should be carefully considered. Strengths of this study include its prospective design and a sample that was both large and diverse. The prospective design allowed the authors to examine changes in dietary intake during the transition from adolescence to young adulthood and influences on dietary intake with the advantage of temporal order. Young adults in the study were diverse in terms of race/ethnicity, family SES, and post-secondary student status.

Limitations include the potential for secular trends in the general population, measurement errors, and attrition to have influenced the results. It

is possible that secular consumption trends in the general population may have impacted estimates of longitudinal change in intakes of calcium and dairy products. However, national food supply data indicate that between the years 1999 and 2004, there was little change in per capita availability of calcium.[37] Furthermore, per capita availability of dairy products increased.[38] Therefore, the longitudinal trends observed in this study were likely related to developmental factors. As dietary intake was assessed by a food frequency questionnaire, estimates of calcium and dairy product intake likely include measurement error. It is possible that the YAQ missed some important dietary sources of calcium (eg, fortified juices, calcium supplements), and servings were not defined for all calcium-rich food items. Attrition from 1999 to 2004 may have reduced the representativeness of the sample, but sampling weights correcting for nonresponse were used in all analyses to help address this limitation.[32]

IMPLICATIONS FOR RESEARCH AND PRACTICE

Additional research will be needed to add to the correlates of intake identified in this study and to determine which factors are the strongest and most proximal influences on calcium intake during early young adulthood. Similar to other research studies that have investigated correlates of dairy or calcium intake, this study was able to explain only a small proportion of the total variance in calcium intake among young women (31%) and men (29%) at follow-up.[34,39,40] More total variance might be explained by considering a wider range of potential correlates and by using more measures that are specific to the intake of calcium-rich food.

The findings of this study indicate that future interventions designed to promote improvements in calcium intake should encourage the families of adolescents to serve milk at meals. In addition, interventions targeted to female adolescents should build concern for healthful eating, develop confidence in skills for healthful eating, and reduce exposure to television advertisements. Interventions targeted to male adolescents should emphasize opportunities to taste calcium-rich food, the promotion of healthful weight management behaviors, and supporting peers to engage in healthful eating behaviors.

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