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What is the relationship between dietary calcium intake and CVD risk factors in a college-age population?

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Abstract

Risk factors for cardiovascular disease (CVD) including dyslipidemia and hypertension can develop in adolescence and increase risk of CVD in adulthood. Improved blood pressure and lipid profiles are associated with higher dietary calcium intake in older adults, but limited data exists in young adults. **Purpose:** Determine the relationship between dietary calcium intake and CVD risk factors in a college-age population. **Methods:** IRB approval was obtained. Fasting blood samples were collected from 149 college students ages 18-24. Serum total cholesterol (TC), LDL, HDL, and triacylglycerol (TG) concentrations were measured using a LDX Cholestech machine, blood glucose using a Precision Xtra glucometer, and blood pressure (systolic [SBP] and diastolic [DBP]) using an Omron automated sphygmomanometer. Dietary calcium intake was assessed using the Brief Calcium Assessment Tool (BCAT) (1). Correlation between CVD risk factors and dietary calcium was determined. Unpaired t-tests determined differences between sexes. **Results:** Average daily dietary calcium intake was 804 mg (RDA for 18 year olds: 1300mg, 19-50 year olds: 1000mg). Mean calcium intake was 186 mg lower in females than males (p=0.001). Acceptable TC, LDL, and TG concentrations occurred in 85%, 92%, and 75% of total participants respectively based on guidelines for 20-24 year olds (2). HDL concentrations were normal 75% of participants and SBP and DBP were normal in 84% and 87% of subjects, respectively. Mean HDL was lower in males than in females (p=0.001). Mean SBP was higher in males than females (p=0.000). TGs were positively correlated with dietary calcium intake (r=0.221, p=0.010). **Conclusions:** Average dietary calcium intake in college students is below recommendations and over half (56%) consumed less than 1000mg and 29% consumed less than 400mg. The majority of participants fell within normal ranges for lab values. Education about meeting dietary calcium recommendations may be warranted in a college-age population. The positive correlation between dietary calcium and TGs was unexpected and may be attributed to the calcium sources and the relatively small sample size.

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2. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents. (2011). Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents: Summary Report. *Pediatrics,* 128(5), S213-s256. Doi: 10.1542/peds.2009-2107c.

Introduction

Cardiovascular disease (CVD) is the number one cause of death in adults in the US with one person dying of a heart-related event every 60 seconds (1, e30). Risk factors for CVD are developing as early as adolescence and can carry into adulthood increasing risk of developing CVD (2, p1036). Excess body weight is the most prevalent risk factor for 12-19 year olds and in 2009-2010 it is estimated 34% of adolescents in the US were overweight or obese, (2, p1036). Additional risk factors include prehypertension/hypertension, elevated total cholesterol (TC), borderline high/high low density lipoprotein (LDL), low high density lipoprotein (HDL), elevated triacylglycerol (TG) and elevated fasting blood glucose (BG). As weight increases, risk of additional risk factors increases as well. At least one CVD risk factor is present in 37% of healthy weight adolescents, 49% of overweight adolescents, and 61% of obese adolescents (age 12-19 years) based on NHANES 1999-2008 data (2, p1039). Little data exists assessing prevalence of heart health markers in college-age populations because most studies examine larger age groupings only partially encompassing college-students.

Diet is a major modifiable factor to alter risk of CVD and mortality and is widely studied. Consumption of low-fat dairy foods and fluid dairy products have an inverse relationship with risk of having elevated blood pressure in a meta-analysis study (3, p6-7). Total daily calcium intake greater than 1,425mg is associated with a 33% decrease in risk of coronary heart disease mortality in post-menopausal US women (4, p155-158). Similarly, the highest tertile of dietary calcium intake (mean=1,953mg) is associated with a significant, lower rate of CVD mortality compared to the lowest tertile of calcium intake (mean=990mg) in a cohort study of Swedish men age 45-79 years (5, p804). Calcium and CVD risk markers have limited research in a young adult population.

The benefits of adequate calcium intake for bone health have been known for many years, however, daily calcium intake in the US population remains below current recommendations (6, p14). Mean calcium intake in 12-19 year old men and women is 1260mg and 948mg, respectively (7). Mean dietary calcium intake is 1210mg for men and 947mg for women in 20-39 year olds (7). Age groupings from 12-19 and 20-39 cover a large range and fail to properly describe the college-age population, typically 18-25 years old.

The current study was carried out to evaluate whether calcium intake was adequate in a college-age population and to what extent select CVD risk factors were present in the population. In addition, the study was investigating the existence of a correlation between dietary calcium intake and blood pressure, blood lipid profiles, and blood glucose in a college-age population.

Methods

The Institutional Review Board approved use of the data, which is routinely collected in introductory nutrition courses, for the cross-sectional study investigating whether dietary calcium intake is correlated to cardiovascular risk factors in a college-age population.

Data used in the study was collected from select introductory nutrition course sections over a period of three semesters from fall 2014 - fall 2015. Students signed an informed consent form on the first day of the laboratory course (Appendix A). Participants, totaling 149, were included if they were over the age of 18 and able to provide all lab value and calcium intake data.

Calcium intake was assessed using a food frequency questionnaire entitled Brief Calcium Assessment Tool (BCAT) (Appendix B). The BCAT was used with permission of the author and is valid and reliable for use in adolescent populations (8, p114). The questionnaire allowed students to assess their own calcium intake with immediate feedback. The questionnaire included fifteen foods commonly providing calcium in the diet and took only five minutes to complete. Dairy products including milk, yogurt, ice cream, and cheese and a limited selection of non-dairy items like tofu were included in the questionnaire. Students reported how often they eat each food and the food was assigned a point value. Students summed the values and the total fell into a range that equated to a calcium intake. For example, a score >58 reflected an estimated dietary calcium intake of 1300mg.

Lab values were collected in the laboratory component of the nutrition courses. Students were told to fast for a minimum of four hours before blood lipid and blood glucose measurements were taken. Lipid profiles including TC, LDL, HDL and TG were measured using a Cholestech machine and finger sticks (40 microliters) were used to collect blood samples. Fasting blood glucose was measured using an Abbott Precision Xtra glucometer. Student teaching assistants and course instructors performed all lipid profile and BG tests. Students measured their own blood pressures (BP) twice using an Omron automatic sphygmomanometer and reported the average. Students also reported height and weight with their laboratory data.

Mean, standard deviation, and range were determined for all collected data. Percent of participants in each category of risk (acceptable, borderline, and high risk) was calculated using established guidelines for the age group (Table 1). Unpaired t-tests determined if there was a difference between males' and females' data. A significance level of $p<0.05$ was used. Correlation between reported dietary calcium intake and lab values was determined using a Pearson product-moment correlation coefficient. Data was analyzed using SPSS (IBM Version 23).

Table 1. Categories of risk for adolescent and young adult populations

Ranges:	acceptable	borderline	high
TC (mg/dL)	<190	190-224	>225
LDL (mg/dL)	<120	120-159	>160
HDL (mg/dL)	>45	40-44	<40
TG (mg/dL)	<115	115-149	>150
BG (mg/dL)	<99	99-126	>126
SBP (mmHg)	<120	120-139	>140
DBP (mmHg)	<80	80-89	>90

TC, LDL, HDL, TG cut-offs (9, pS237)
Blood pressure and BG cut-offs (10, p560)

Results

Males made up 42% (n=62) and females comprised 58% (n=87) of 149 participants. BMI ranged from 18.02 to 36.58. The average BMI of participants (24.2 ± 3.2) fell into normal weight ranges (Table 2). Average BMI of females (23.6 ± 3.5) was also within the normal range, while the average BMI for males (25.1 ± 2.7) falls into the overweight range for BMI.

Lab values from each participant were placed into risk categories (acceptable, borderline, and high risk). The majority of participants fell within normal ranges, but each category had some participants with risk (Figures 1-7). Average HDL was lower in males (50.0 ± 15.2 mg/dL) than females (58.4 ± 13.6 mg/dL) (unpaired t-test, p=0.001) (Figure 8). SBP was higher in males (114.7 ± 10.3 mmHg) than females (100.7 ± 12.1 mmHg) (unpaired t-test, p=0.000). No other significant differences between males' and females' lab values existed (Table 4).

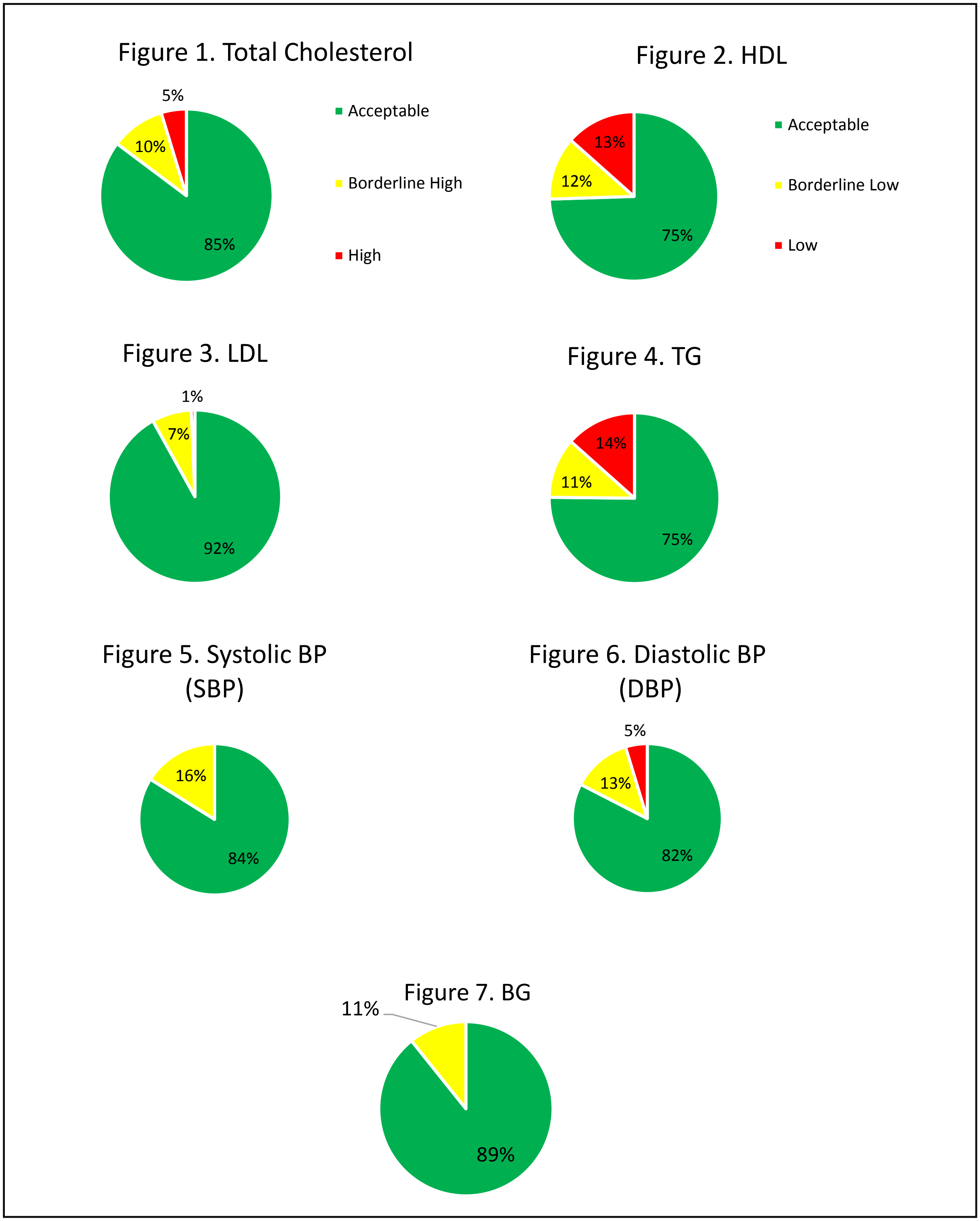
Average dietary calcium intake ranged from 58mg to 1300mg with a mean intake of 804.4 ± 335.0mg. The mean dietary calcium intake as calculated from the BCAT was greater in males (912.9 ± 327.7mg) than females (727.1 ± 320.0mg) (unpaired t-test, p=0.001).

Dietary calcium intake was positively correlated to TG (Pearson product moment correlation coefficient, p=0.010, r=0.221) (Table 5). No other risk factors were correlated with calculated dietary calcium intake.

Table 2. Characteristics of participants

Variables	Mean (n=149)	Male (n=62)	Female (n=87)
Age (yrs)	20.3 ± 1.4	21.0 ± 0.9	19.9 ± 1.6
Height (inches)	68.0 ± 4.4	71.3 ± 2.8	65.6 ± 3.7
Weight (lbs)	159.1 ± 29.4	181.8 ± 23.1	143.0 ± 21.8
BMI	24.2 ± 3.2	25.1 ± 2.7	23.6 ± 3.5

Data are presented as mean ± SD
BMI categories: <18.5 underweight, 18.5-24.9 normal weight, 25.0-29.9 overweight, >30.0 obese



Figures 1-7. Percentage of participants falling in the acceptable, borderline risk, and high risk categories for each lab value studied

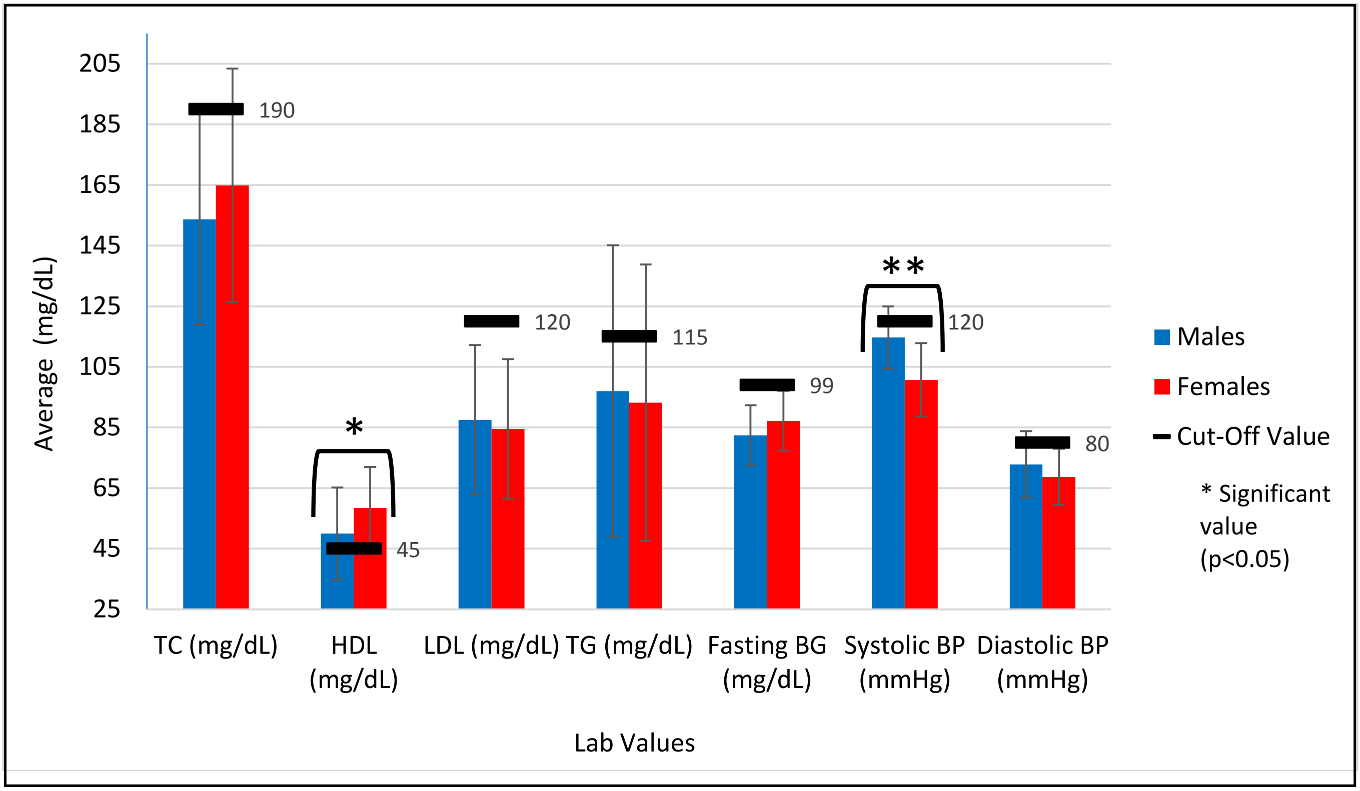


Figure 8. Males' and females' mean lab values compared to cut-off for acceptable values
* Denotes significant difference between sexes ($p<0.001$)
**Denotes significant difference between sexes ($p=0.000$)

Table 3. CVD risk factor mean values and ranges and dietary calcium intake compared to acceptable ranges

Variables	Mean (n=149)	Range in current study	Acceptable Range
TC (mg/dL)	160.3 ± 37.3	100.0 - 387.0	<190
HDL (mg/dL)	54.9 ± 14.8	24.0 - 99.0	<120
LDL (mg/dL)	85.7 ± 23.7	22.0 - 161.0	>45
TG (mg/dL)	94.7 ± 46.5	45.0 - 276.0	<115
Fasting BG (mg/dL)	85.2 ± 10.2	64.0 – 113.0	<99
Systolic BP (mmHg)	106.5 ± 13.3	70.0 – 138.0	<120
Diastolic BP (mmHg)	70.4 ± 10.2	48.0 – 114.0	<80
Ca Intake (mg)	804.4 ± 335.0	58.0 – 1300.0	1300 (9-18 yr olds) 1000 (19-50 yr olds)

Data are presented as mean ± SD
TC, LDL, HDL, TG range (9, pS237)
Blood pressure and BG range (10, p560)

Table 4. Differences in lab values and dietary calcium intake between sexes

Variables	Male (n=62)	Female (n=87)	P Value
TC (mg/dL)	153.7 ± 34.9	164.9 ± 38.5	0.066
HDL (mg/dL)	50.0 ± 15.2	58.4 ± 13.6	0.001*
LDL (mg/dL)	87.5 ± 24.7	84.5 ± 23.0	0.443
TG (mg/dL)	97.0 ± 48.1	93.2 ± 45.6	0.637
Fasting BG (mg/dL)	82.4 ± 9.9	87.2 ± 9.9	0.005
Systolic BP (mmHg)	114.7 ± 10.3	100.7 ± 12.1	0.000*
Diastolic BP (mmHg)	72.8 ± 11.0	68.7 ± 9.3	0.017
Ca Intake (mg)	912.9 ± 327.7	727.1 ± 320.0	0.001*

Significant values (p< 0.05) denoted by *

Table 5. Correlation between dietary calcium intake and CVD markers in a college-age population controlling for sex, age, ethnicity, and BMI

Variables	Dietary Calcium Intake	P value
TC (mg/dL)	-0.087	0.592
HDL (mg/dL)	-0.123	0.326
LDL (mg/dL)	0.019	0.963
TG (mg/dL)	0.221	0.010*
Fasting BG (mg/dL)	0.034	0.761
Systolic BP (mmHg)	-0.075	0.600
Diastolic BP (mmHg)	0.053	0.695

Data is presented as Pearson's correlation coefficient
Controlling for gender, age, ethnicity, and BMI
Significant values (p<0.05) denoted by *

Discussion

CVD is the number one cause of death in US adults and risk factors developing in adolescents can increase the possibility for CVD into adulthood (2, p1036). Identification of CVD risk factor prevalence and possible interventions allow for prevention to begin earlier in life. The purpose of the current study was to determine relationships between CVD risk factors and dietary calcium intake in a college-age population. The major finding of the current study was dietary calcium was not correlated to CVD risk factors with the exception of a positive correlation to TGs. Mean dietary calcium intake was below recommendations while lab values fell in the acceptable range for the majority of participants. Comparing between sexes, males had significantly greater calcium intake. Males also had lower HDL and higher SBP than females.

In previous research dietary intake of calcium was inversely associated with hypertension in a prospective study of women at or above the age of 45 years old (11, p1073). DBP was also significantly, negatively correlated with plant calcium intake in a group of hypertensive adults (12, p424). The mechanism by which calcium benefits blood pressure is not fully understood. Calcium may benefit the inhibition of vascular smooth muscle constriction through the binding to calcium receptors and calcium channels (13, p888). Ionized calcium may also play a role in the down-regulation of renin secretion (14, p99). Renin is an enzyme which helps in the regulation of blood pressure by acting on angiotensinogen. Blood pressure was not correlated to nutrient intake in normotensive adults who consumed 429.9mg of calcium (12, p424). Approximately 85% of participants in the current study had normal blood pressure, potentially explaining the lack of correlation in the current study. The effects of calcium may be greatest when participants have preexisting hypertension.

Daily supplemental calcium intake (1000mg/day) for one year significantly increased HDL by 7% and decreased LDL by 6% in a group of post-menopausal women in a 2002 study (15, p345). Daily calcium intake of 2,200 mg for ten days decreased total cholesterol by 6% and decreased LDL by 11% compared to a 410mg/day diet in a small randomized clinical trial (16, p1047). High amounts of calcium in the intestinal tract may decrease blood lipid levels by binding to fatty acids creating insoluble soaps (16, p1049). The binding of fatty acids to calcium decreases fatty acid absorption which may contribute to a negative correlation between calcium intake and lipid profiles in some studies (16, p1049). The studies demonstrating a correlation between calcium intake and blood lipids included daily calcium intakes greater than 1000mg. The mean calcium intake in the current study was under 1000mg/day and a correlation may not exist with lower intake levels. TC, HDL, LDL, and TG were not associated with dietary calcium intake in a group of 83 hypertensive adults aged 55-69 years old who consumed less than 500mg (12, p425). Calcium intake and triglycerides were significantly, positively correlated in a group of normotensive adults who consumed 360mg of calcium per day (12, p425). The current study agrees with the previous finding and may explain the correlation found in college-age normotensive individuals with a mean intake of 804mg. High intake of calcium from animal products which are in higher fat and particularly saturated fatty acids may mask any positive effect of calcium on lipids. The BCAT included eleven dairy products. Dairy products are good sources of calcium, but can be higher in saturated fatty acids. Calcium sources including milk and yogurt can also be sweetened with added sugar in addition to naturally occurring sugars. Excess added sugar intake can contribute to elevated TG values, counteracting any potential benefit of calcium intake.

Mean dietary calcium intake in the current population (804mg) is slightly lower than national averages. Mean dietary calcium intake in US 12-19 year olds is 1260mg and 948mg for males and females, respectively and decrease to 1210mg for males and 947mg for females in 20-39 year olds (7). Mean dietary calcium was 186mg lower in female participants in the current study than males which is consistent with national averages. The mean calcium intake of college students in the current study was 80% of the recommendation for 19-50 year olds (1000mg), but only 62% of the 9-18 year old recommendation (1300mg). More importantly, 29% of participants consumed 400mg or less of calcium per day, meeting only 30-40% of the recommended intake. Bone mass increases up to age 30 with adequate calcium intake as calcium is deposited in bone and increases bone density. Participants ranged from 18-25 years old and are thus still in an important bone density building phase where calcium intake should be emphasized to reach optimal bone health.

The most prevalent CVD risk factors were low HDL concentration and elevated TG concentration (25% of participants for each). Similar results occurred in US college first-years with 20% and 17.5% prevalence, respectively (17, p316). US 18-19 year olds were more likely to have low HDL (10.4%) and elevated TG (16.4%) than young people age 12-13 years (4.7% and 9.5%, respectively) (18, p30). All mean serum lipid values were within acceptable ranges for the current study. Prevalence of abnormal lipids ranged from 8-25% of participants. Abnormal lipid levels were present in 20.3% of youths aged 12-19 years that participated in NHANES surveys from 1999-2006 which is comparable to prevalence in the current study (18, p29). Mean HDL concentration was lower in males than females in the current study which agrees with CDC reports that a greater proportion of child and adolescent males have low HDL-C (11.0%) compared with females (4.0%) (18, p29). LDL was high in 8% of participants in the current study. NHANES 1999-2006 participants age 12-17 had a 5.2% prevalence of high LDL using the same cut-offs as the current study (19, p1110). Nationally 31% of US adults have high LDL which is notably higher than in the current study (20, pe32). The difference between the national average for adults and the current study may result from the relatively healthy weight status of the current study's population. Only 37% were overweight and 0.3% were obese as determined by BMI compared to national averages of 69% of US adults (21). Only 11% of participants had borderline high BG and none had high BG which is notably lower than the 23% prevalence of prediabetes/diabetes in 12-19 year old NHANES 1999-2008 participants (2, p1038). No participants had high SBP and only 16% had borderline high SBP. High DBP occurred in 5% of participants and 13% had borderline high DBP. Prehypertension or hypertension was present in 14% of 12-19 year olds based on NHANES 1999-2008 (2, p1035). Nationally 29.1% of US adults over age 18 have hypertension according to NHANES 2011-2012 (22, p1). The current study's result is comparable to NHANES data of 12-19 year olds and is much lower than national data on US adults. The difference may be a result of the wide range of ages included in the US adult data which comprises anyone over age 18 instead of targeting only those under age 25.

A limitation of the current study was the self-reporting of height and weight by participants. While the BCAT tool is valid and reliable for adolescent populations for assessing dietary calcium intake, the BCAT included only 15 foods and did not ask about calcium supplement use. Students may have been consuming some calcium in food sources like broccoli which was not included on the BCAT. Students may have also been taking a calcium supplement which could have impacted lipid profiles and blood pressure independent of the dietary calcium intake collected. The source of calcium intake was also not separated based on animal or plant sources in the current study as it was in others. Total dietary intake records were not collected and as a result total calorie intake and the proportion of calcium to calorie intake could not be determined. Dietary calcium intake compared to total calorie intake could reveal if students need greater calorie intake overall which would in turn increase dietary calcium intake. Conversely, total calorie intake may be adequate, in which case, interventions to increase dietary calcium intake should focus on food selection. The sample size was relatively small which limited the range of BMI values and limited the statistical power of tests used. For example, correlation between BMI and TGs lacked statistical power because only 55 participants were classified as overweight while five were classified as obese. Ethnicity is an additional risk factor for CVD and was not assessed in the current study. The school used in the current study has limited ethnic diversity with over 80% of students identifying as "white" and thus lessens the impact of ethnicity on results (23). Collecting data on ethnicity has the potential to help further identify trends in risk factors and subsequently target interventions.

Dietary calcium and a relationship to CVD risk has primarily been studied in older adults. The current study focuses specifically on a college-age population to investigate the relationship in younger adults. The college-age population is often split into larger age parameters of adolescents (10-19 year olds) or adults (19-50 year olds). College students are a smaller portion of each age grouping and have lifestyle habits which differ greatly from other groups. Young adulthood is a time of transition between adolescents and adulthood with an increasing number of independent decisions (17, p313). Many college students are living away from parents for the first time and beginning to establish eating and health habits for themselves. Identifying CVD risk factors and adequate calcium intake during young adulthood provides an ideal time to establish lifelong healthy lifestyle patterns for prevention of CVD and other chronic conditions later in life.

Conclusion

Average dietary calcium intake in the college-age population studied was below national recommendations. Education about meeting dietary calcium recommendations may be warranted in a college-age population. The majority of participants fell within acceptable ranges for lab values. Interventions for those in the borderline and high risk categories need further research to be targeted as the study was not able to determine a correlation between factors such as BMI and presence of CVD risk factors. Future research is needed with a larger population that allows for greater distribution of BMI categories and ethnic diversity. Further research in a young adult population is needed to determine a relationship between dietary calcium intake and CVD risk factors, particularly TG, to target prevention measures. Students with risk factors could participate in interventions to increase dietary calcium intake and lab values should be monitored for changes which may better suggest a relationship between calcium intake and CVD risk factors in a college-age population.

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Appendix A

Informed Consent Form

Date: ___________ Course: NUTR 125/NUTR 110 Lab Day & Time: ___________

I,____ please print name ______, agree to participate in the experiments for NUTR 125/NUTR 110 (Concepts of Nutrition Science or Understanding Nutrition) Laboratory.

a) Finger sticks to collect blood samples for blood glucose and cholesterol measurements. (Code numbers will be used to report lab data in order to preserve confidentiality.)
   b) Lab data and class assignments, including your diet records, may be used for research purposes. Your data will be kept confidential. In the event we publish using data collected from this course, all results will be pooled and therefore, identifiers will be removed.
   c) The study has two possible risks. First, psychological discomfort or anxiety may be felt when analyzing your diet. This risk is minimized by the fact that only instructors/TAs will have access to your diet records. You will be not graded on the components of your diet. You will only be graded on your ability to analyze your diet. Additionally, if you believe you will experience psychological discomfort, a substitute diet analysis project can be determined between you and your instructor in order to minimize psychological discomfort.
   d) Second, you may experience slight pain with collection of blood samples. Risk is minimized by collecting the minimum amount of blood needed to run the health screening tests (blood glucose and cholesterol measurements). You may choose to not participate in the blood collection portion of the lab. However, you will be responsible for attending the lab session and writing the lab report using data collected from other students in the class.
   e) In the event of injury, first aid will be administered by the instructor if needed and security will be called in order to treat the injury appropriately.
   f) The benefits of participation are that you will be able to obtain health screening numbers such as your fasting blood glucose levels, cholesterol levels and identify any diet related behaviors that could be changed in order to promote more of a healthy lifestyle as well as those behaviors to continue (that are already promoting a healthy lifestyle).

I also agree to follow all lab directions and safety policies, including:

1) no eating, drinking or gum in lab
2) washing my hands before working with food or when instructed to do so
3) wearing pants and closed-toed shoes
4) following biohazard precautions

Signature: ____________________________________

Code Number (last 4 digits of your student ID#): _______________________

(**NOTE**: you will use this code number for the entire semester)

*If you have a health condition or personal concerns that may affect your participation, please talk to the laboratory instructor.

Appendix B – Brief Calcium Assessment Tool

- Attached electronically

Appendix C - Raw data – email as separate files

- Attached electronically