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The Association of Dairy Food Intake and Physical Activity on Serum Lipid Levels in Adolescent Females

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Abstract

Background: Abnormal lipid levels in adolescents are gaining attention since it can translate into adverse levels in adults and is linked to cardiovascular disease risk.

Purpose: To determine if a cohort of adolescent girls who consumed the recommended dairy intake for one year have higher serum lipids than adolescent girls who have consumed low dairy intake. Additionally, to examine if specific behavioral variables (diet and exercise) had an effect on serum lipid levels.

Methods: A cross-sectional analysis of 124 adolescent girls was done using t-tests to compare the differences in serum cholesterol, triglycerides, HDL, and LDL levels between the control and dairy groups. Multiple linear regression was used to investigate predictors of serum lipid values.

Results: There were not statistically significant differences in total serum cholesterol, triglycerides, HDL, or LDL values between the dairy group and the controls.

Within the overall regression model, physical activity was a significant predictor of serum lipid levels.

Conclusion: In this cohort milk drinking was not associated with higher serum lipid levels in adolescent girls. Findings support the importance of current recommendations that adolescent girls should consume at least four servings of dairy per day and exercise at least 60 minutes or more each day.

Keywords: *Adolescents; Dairy; Lipid Levels; Physical activity.*

Introduction

Cardiovascular Disease (CVD) is the leading cause of death in North America, and it is well-accepted that the disease process starts during childhood and adolescence [1-3]. Abnormal lipid concentrations in adolescence have been shown to be correlated with adverse lipids into adulthood [4]. According to a report released by the Centers for Disease Control and Prevention (CDC) in January 2010, over 20% of adolescents in the United States (US), and more than 40% of obese teens have abnormal lipid levels. Li found that elevations of low density lipoprotein (LDL) and body mass index (BMI) in adolescents are predictive of carotid intima media thickness, which is strongly associated with coronary arthrosclerosis and cardiovascular risk [5]. The progression of atherosclerosis is related to the presence and intensity of cardiovascular risk factors [6, 7]. One significant risk factor for the development of atherosclerosis is high lipids levels. Cholesterol is a lipid (fat) found in blood that the body needs to function properly, however, if lipid levels are abnormal, it places individuals at risk for development of atherosclerosis and CVD [8, 9].

There are many causes of abnormal cholesterol levels. Genetics or family history play a role but for most individuals, it is the result of modifiable unhealthy lifestyles, such as consuming diets high in saturated fat or cholesterol, being overweight, and/or having a lack of physical activity [6, 8, 10]. There is growing concern that in order to detect risk factors for CVD such as dyslipidemia (abnormal blood lipid levels), identification should begin in childhood to prevent potential long-term complications. In fact, use of family history of CVD or cholesterol disorders as the primary factor for screening for children misses anywhere from 30% to 60% of children with dyslipidemias [1]. This concern led to the release of new guidelines in November 2011 by an expert panel sponsored by the National Heart, Lung, and Blood Institute, National Institutes of Health and endorsed by the American Academy of Pediatrics [1]. These guidelines recommend that every child between the ages of 9-11 years be screened for hyperlipidemia and then have it repeated between ages of 17-21. The guidelines are consistent with the objectives of Healthy People 2020 that emphasize the importance of the nutritional health of adolescents and highlight key components related to this focus such as fat intake, obesity, and intake of calcium rich foods [11].

Dairy Intake and Lipids

Dairy foods contain saturated fats and cholesterol which can increase plasma lipid levels and ultimately contribute to CVD [12, 13]. It has been suggested that the consumption of dairy foods is associated with high risk of CVD, although results from studies have been conflicting [13-15]. These concerns have led health authorities and governmental agencies to modify their recommendations and encourage a reduction or elimination of high-fat dairy foods in healthy diets [16-19]. On the other hand, there is a fear that altering

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fat intake by eliminating dairy can have significant consequences to overall diet quality because dairy foods have been shown to improve some CVD risk factors in the population in general [2, 13, 15]. Specific to adolescent girls, significant modifications in consumption of dairy products can be detrimental to their overall health because of the nutrient concentration found in most dairy products [13, 20-22]. For example, calcium and vitamin D are essential for development of healthy bones. Dairy foods are the best food source of calcium, and milk is one of the few foods fortified with vitamin D [20]. Thus, the role of dairy in the health of adolescent girls presents a conundrum: dairy foods provide many nutrients essential to the health of growing girls, while they also contain saturated fats and cholesterol that are known to increase risk of CVD.

Dairy Intake and Lipids in Adolescents

Studies investigating the impact of dairy foods on adolescents are limited. Only two studies were found that specifically investigated the effect of dairy intake on lipid levels in healthy adolescents and neither one was in the US. One study completed in Sweden was to describe the intake of dietary fatty acids and saturated fatty acids on serum cholesterol in healthy adolescent boys and girls [23]. In the sample of 50 subjects, statistically significant inverse relationships were found between the dietary content of saturated fatty acids and the corresponding fatty acids on serum cholesterol. This led the investigators to conclude that a high intake of dairy fat should be part of a healthy food pattern.

Crowe, Murray, Green, and Gray [24] conducted a cross sectional, population-based survey of nearly 2800 people that included adults and adolescents from New Zealand. They found an association between dietary fat intake and serum cholesterol levels, particularly with increasing age. Further, they discovered that saturated and polyunsaturated fat intakes, as measured by serum fatty acids, are predicators of total serum cholesterol concentrations. The authors concluded that to reduce serum cholesterol, a population approach should continue to focus on decreasing the intakes of saturated fat, especially dairy fat.

Numerous investigators have examined the relationship between a high dairy diet and the risk of metabolic syndrome, which includes high blood pressure, hyperglycemia, high triglycerides, and low levels of high density lipoprotein (HDL). A study of 785 adolescents from Tehran found no significant relationship between the intake of dairy products and components of the metabolic syndrome [25]. Research conducted with adolescents in Portugal evaluated dairy intake (consisting of milk, cheese, and yogurt) on the risk of developing metabolic syndrome. Specifically, total cholesterol, total triglycerides, and HDL were measured in approximately 500 young adults. No association was found between these values and total dairy intake, although milk intake was associated with a lower risk of metabolic syndrome [26]. Conversely, Perichart-Perera et al. [27] found that school age children in Mexico who consumed a high dairy diet had higher diastolic blood pressure.

Lappe [20] and other investigators [28, 29] have shown that increased dairy intake reduces the risk of being overweight and/or slows weight gain in adolescents. If a higher dairy intake, with no negative effect on lipid levels, will slow weight gain or contribute to maintaining a healthy weight, it is possible an adequate dairy intake in adolescence can help decrease the risk of developing CVD. Although further research is needed, adolescent girls can then be encouraged to have sufficient dairy intake given the potential health benefits that can occur without concern for weight gain contributing to CVD risk.

The purpose of the proposed study was to determine if there was a significant difference in serum lipid levels between post-menarcheal adolescent girls who consumed four or more servings of dairy per day (high dairy group) for one year and similar girls who consumed two or less servings of dairy per day (low dairy group) for one year. Additionally, to examine if specific behavioral variables (diet and exercise) had an effect on serum lipid levels.

Research Design and Methods

This study used a cross-sectional design to evaluate the end-of-study serum lipid levels in 13- 15-year-old post-menarcheal girls who participated in an ongoing clinical trial, the Dairy and Weight (D&W) study. The primary objective of the D&W study was to determine if increasing intake of dairy foods to currently recommended levels in adolescent females will decrease the risk of overweight.

To qualify for the D&W study, the subjects were healthy 13- and 14-year-old girls who were above the 50th and less than the 98th percentile for BMI, at least one and one-half years post-menarcheal and reported eating two or less dairy servings per day. Both the D&W and the current project were approved by the Creighton University Institutional Review Board. Subject assent and parental consent were obtained.

After a two-week run in period to determine their tolerance to dairy, girls in the D&W study were randomized into either the dairy (treatment) or control group. The girls enrolled in the treatment group were instructed to consume at least four servings of low fat milk or yogurt, or a combination of both every day for one year. A registered dietician provided one-on-one counseling to each participant and a parent on enrollment and every visit thereafter. The dietician assessed treatment adherence with a monthly calendar and three-day diet diaries and counseled the girls in the treatment group on an individual basis if they were not maintaining at least four servings of dairy per day. The control group continued with their previous diet, which was averaging less than two servings of milk or yogurt a day.

Assessment of dietary intake was done using the Nutrition Data System for Research (NDSR) software, which is the current gold standard for assessing dietary intake. This food and nutrient database is supported and updated by the Nutrition Coordinating Center (NCC) at the University of Minnesota. The NCC is a non-profit service organization that has been deemed a National Research Resource by the National Institutes of Health (www.ncc.umn.edu). The NDSR includes prompts for comprehensive food descriptions, specific additives for food preparation and precise amount descriptions. The multi-pass dietary recall was used to measure intake of dairy food and calcium, as well as cholesterol, total fat, saturated fat, and percent of calories from fat and saturated fat. Three-day dietary recalls were obtained every three months during the D&W study– one on a weekend day and two on weekdays over the course of one year.

Physical activity was assessed using the Modifiable Activity Questionnaire for Adolescents (MAQ-A). The MAQ-A provides an estimation of participants' total daily energy expenditure. It combines dimensions of intensity, duration and frequency of activity into a single measure, metabolic equivalents (METs). One-month and one-year test-retest reproducibility of the MAQ-A questionnaire were determined by Aaron et al. [30]. These researchers noted Spearman correlations for different physical activities. The correlations between the questionnaire and the average of the 7-day recalls ranged from 0.55 to 0.67 in males and 0.73 to 0.83 in females, significant at $p < 0.01$. The MAQ-A was completed at baseline and at 3, 6, 9, and 12 months. The girls were asked to record the activities in which they had

participated at least 10 times in the past 12 months in their leisure time and to identify the frequency, intensity, and duration for each activity. Metabolic equivalent task was calculated by multiplying METS for each activity with the total number of minutes per each time, the number of times per month and the number of months per year. That number was then divided by 60 and 52 to estimate the hours per week. An average MET- hour/week score was computed for each visit and the higher the MET-hr/week, the greater the activity. Examples of common activities for this age group and corresponding values in MET-times per week that were used in the calculations were: playing basketball one or two times per week for 39 weeks per year, 9.0 MET-times per week; swimming three or more times per week for 13 weeks per year, 4.5 MET-times per week and walking briskly three or more times per week for 39 weeks per year, 9.0 MET-times per week.

A one-time fasting lipid profile, consisting of total cholesterol, high-density lipoprotein (HDL), and triglyceride (TG) level was drawn to assess the cholesterol levels and low-density lipoprotein (LDL) was calculated using Friedewald's equation. All lab work was analyzed using the Beckman UniCell DX C 600i machine at Creighton Medical Laboratory at CUMC.

Statistical Analysis

This cross-sectional study included 124 girls (Dairy, N=61, and Control, N=63) from the D & W parent study who agreed to have blood drawn for a lipid profile at the final visit. The ethnic breakdown of this sub study was 78% (N=97) Caucasian; 14% (N=17) Black; 6% (N=7) Multi-racial and 2% (N=3) Asian. The girls for this study were enrolled between January 2012 and September 2013.

Data analyses were performed using the Statistical Package for Social Sciences, version 25.0 (SPSS Inc. – Chicago, IL, United States). Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Differences in the mean lipid levels between two groups, girls assigned to a high dairy intake and those assigned to a low dairy intake, were analyzed with SPSS software using independent group t-tests. Hierarchical multiple linear regression was used to investigate predictors of serum lipid values. Covariates included BMI, race, and levels of physical activity as measured by the MAQ.

Results

Five of the 124 girls (4%) had total cholesterol values over 200 which is considered high and 23 girls (18%) had values considered borderline high (170-199). Eight girls (6%) had triglycerides values considered high (over 130) and 20 (16%) had values considered borderline high (90-129).

Over the course of the one-year study, girls in the Dairy group averaged 3.9 (SD ±0.98) dairy servings per day, while girls in the Control group averaged 1.4 dairy servings per day (SD ±0.61). There were not statistically significant differences in total serum cholesterol, triglycerides, HDL, LDL or physical activity values between the dairy group and the controls. [Table 1] describes the continuous variables used in the analysis for both the groups as well as all the girls participating in the study.

Hierarchical multiple linear regression modeling was used to examine the contribution of dairy intake to serum lipid values. Average dairy servings, BMI and physical activity were entered as covariates. In the overall model with the total cholesterol as the outcome, total variance explained by the model was 5% and average dairy servings did not predict total cholesterol values F change (4, 107) = 4.1, p = 0.294. However, physical activity was a significant predictor of total cholesterol (β = -.193; p = 0.046). A hierarchical linear regression focusing on triglycerides as the outcome was not statistically significant, F change (4, 111) = 4.6; p = .099 (7% variability). However, the covariates within this model also showed physical activity (β= -.203; p=.034) as a statistically significant contributor.

Discussion

This cross-sectional study in adolescent girls found no difference between the high dairy and low dairy intake groups in serum lipid levels. Dairy intake is an important source of calcium, protein and other nutrients for adolescent girls who are rapidly accruing bone to achieve an optimal peak bone mass. This study's findings suggest that the current calcium recommendations to optimize peak bone mineral accrual should be a priority in the overall health of adolescents [1].

Several studies have noted the benefits of an increased calcium intake, either by diet or supplementation, as positively influencing cholesterol metabolism and improving lipid concentrations in adults [14, 31, 32]. Prior research specific to adolescents also demonstrates that when this age group obtained a minimum of 3-4 servings of dairy per day, neither total cholesterol nor triglyceride levels were elevated [33, 34]. This cross-sectional study shows that adolescent girls can maintain the current dietary recommendations for dairy intake without the fear of increasing lipids on a short-term basis. The literature suggests that when children and adolescents have negative/undesirable "metabolic profiles" there is a considerable chance that risk will lead to chronic diseases into adulthood [35]. However, this research surrounding children and adolescent dietary intake and serum lipid levels has mixed findings [33, 34, 36, 37].

This study showed that physical activity was associated with lower triglycerides and total cholesterol. Studies investigating the effects of physical activity on cholesterol values in children and young adults have produced mixed results. Some evidence demonstrates that increased levels of physical activity are associated with lower total and LDL cholesterol levels and higher HDL cholesterol in children [38]. However, other researchers report no significant improvement in cholesterol values after interventions of sustained, aerobic physical activity [39]. These researchers contend however, that lack of significant findings may be related to small sample sizes and short duration of the intervention. Although participants in our study were not instructed to increase their physical activity levels, findings demonstrate that physical activity can have beneficial effects on some cholesterol values. This is important since abnormal lipid values during childhood may serve as predictors to the development of heart disease as an adult [2].

Strengths and Limitations

Study strengths include the close monitoring of the participants to the protocol and the multiple, detailed dietary recalls validated by a registered dietician and analyzed using a highly recommended NDS-R system. Serum 25(OH)D was analyzed with the Liaison which has quality checks with DEQAS.

There were several limitations of this study. Due to the cross-sectional design of the sub-study, there were no baseline serum lipid levels and since the subjects were enrolled in a study in which they were asked to increase their milk and yogurt intake, subjects may not be representative of adolescent girls. The sample in general was a limited population of female adolescents living in a defined geographical area and who had a BMI between the 50th and 98th percentile. Self-reported dietary intake can lead to possible recall errors and finally,

Table 1: Means and standard deviations of cholesterol and dairy variables compared to normal parameters and recommendations by groups .

	Normal parameters or recommendation	Control Group	Intervention Group	All Girls
Total Cholesterol	170-199 mg/dL	154.84 (±25.07)	151.11(±28.17)	153.01(±26.60)
Triglycerides	90-129 mg/dL	65.57 (±36.85)	67.93 (±37.41)	66.73 (±36.99)
HDL	40-45 mg/dL	53.87 (±13.03)	51.61 (±11.26)	52.76 (±12.20)
LDL	110-129 mg/dL	87.83 (±20.76)	85.92 (±22.70)	86.89 (±21.66)
Average Dairy Servings	4 servings/day	1.36 (±.61)	3.85 (±.97)	2.57 (±1.48)
Physical Activity Levels	Range 6.3-61.1 of MET-hour/week for this sample	32.1 (±12.2)	30.1 (±10.4)	31.1 (±11.4)

HDL – High Density Lipoprotein; **LDL** – Low Density Lipoprotein; **MET** – Metabolic Equivalent Task

the study may have been underpowered for finding statistically significant differences.

Conclusion

The purpose of this study was to determine if 13-15-year-old girls who have consumed the recommended dairy intake for one year have higher serum lipids than adolescent girls who have consumed low dairy intake. Findings from this study contribute to the advancement of evidence-based knowledge by concluding there was no difference in serum lipids between these groups and in fact, physical activity may impact those levels more than dietary intake. This supports the importance and safety of current recommendations that adolescent girls should consume at least four servings of dairy per day and exercise at least 60 minutes or more each day.

Declaration Statements

Funding

This study was funded by a Institutional Grant, The President's Faculty Research Fund at Creighton University in Omaha, Nebraska

Ethics and approval and consent to participate

This project was approved by the Creighton University Institutional Review Board. Subject assent and parental consent were obtained for all participants.

Consent for publication

Statements regarding permission to publish this information were included in both the assent and consent forms.

Competing interests

There are no competing interest regarding the publication of this study for any of the authors.

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