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Eating Patterns and Lipid Levels in Older Adolescent Girls

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Abstract

Background and Aims—Few studies have evaluated the effects of food-based eating patterns on adolescent lipid levels. This study examines whether usual adolescent eating patterns (ages 9–17 years) predict lipid levels at 18–20 years of age.

Methods and Results—This study uses previously collected data from the longitudinal NHLBI Growth and Health Study in which 2,379 girls were enrolled at ages 9–10 years and followed for ten years. Food-based eating patterns were derived from multiple 3-day diet records. After adjusting for age, race, socioeconomic status, height, physical activity, and television viewing, girls with higher intakes of dairy, fruit and non-starchy vegetables had about a 40–50% reduced risk an LDL-C 170 mg/dL and non-HDL-C 145 mg/dL. Diets characterized by higher intakes of dairy and whole grains had similar benefits on TC and LDL-C. Girls consuming more fruits and non-starchy vegetables as well as more whole grains were much less likely to have high-risk lipid levels. Lean meat, poultry and fish when consumed in the context of other healthy eating patterns had no adverse effects on lipid levels in late adolescence. In fact when consumed with higher amounts of fruit and non-starchy vegetables, lean meat, poultry and fish had beneficial effects on HDL. Finally, dietary patterns that included more whole grains tended to be associated with lower TG levels.

Conclusion—Healthy childhood eating patterns characterized by higher intakes of a variety of fruits, vegetables, whole grains, dairy, lean meat, poultry and fish are important modifiable predictors of lipid levels in late adolescence.

Keywords

Diet; lipids; adolescence

Introduction

Children with higher total cholesterol (TC) or low-density lipoprotein cholesterol (LDL-C) levels are more likely to have elevated lipid levels as adults. The American Academy of

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Pediatrics (AAP) recently issued updated guidelines for lipid screening and treatment with the goal of controlling sub-optimal lipid levels at earlier ages.¹ Analysis of 1999–2006 NHANES data indicated that 20.6% of youth ages 12–19 years had abnormal levels for at least one lipoprotein type,² with the prevalence being particularly high among overweight and obese adolescents.

Diet is an important potentially modifiable risk factor for lipid abnormalities. The USDA's Dietary Guidelines for Americans recommend increased consumption of fruit, vegetables, fish, poultry, lean meats, whole grains and low-fat dairy for children over the age of 2 years.³ While some studies have examined the impact of eating patterns such as vegetarian or Western diet patterns on cardiovascular risk,^{4,5} there are few food-based studies specific to youth.^{6, 7}

The current analyses were designed to study the effects of usual adolescent food intake patterns on lipid levels in late adolescent girls.

Methods

The current analyses were approved by the Boston University Institutional Review Board and used data from the National Heart, Lung and Blood Institute's Growth and Health Study (NGHS), a 10-year longitudinal study of bi-racial differences in the development of obesity and other cardiometabolic outcomes in girls initially 9–10 years of age. The NGHS enrolled 2,379 white and black girls from three clinical centers: the University of Cincinnati Children's Hospital Medical Center, the University of California at Berkeley, and Westat Inc./Group Health Association in Rockville, MD. For these analyses, we excluded girls who: (a) were missing lipid data at end of adolescence, (b) provided fewer than three sets of dietary records between ages 9 and 17 years, including at the beginning and end of the exposure period and (c) were missing data on potential confounders of interest (e.g., SES, height, physical activity, television/ video watching). This yielded a sample of 1500 girls (46.5% white, 53.5% black). At baseline, median body mass index (BMI) was 17.7 kg/m², with 28.8% of girls being overweight and 13.4 % obese using 85th and 95th BMI-for-age percentiles from the CDC growth charts.⁸

Dietary Data

Diet was assessed using three-day diet records (two weekdays and one weekend day) during eight of the 10 study years (exam years 1–5, 7, 8, and 10). Girls were instructed by a trained nutritionist to use standard household measures to estimate portion sizes; whenever necessary, they got information from a parent on recipes, brands and other food details. Standardized in-person debriefing was completed and data were entered into the Nutrition Data System (NDS) of the University of Minnesota.⁹ Nutrient intakes were derived from NDS using the nutrient database appropriate to the year of data collection. Investigators at Boston University derived USDA Food Pyramid servings by linking NDS food codes generated from the entered data with those in the USDA's "Pyramid Serving Database for USDA Survey Food Codes, Version 2".¹⁰ The final data set contained each subject's intake (measured during eight exam years in the study) in the five major USDA food groups (i.e., fruit, vegetables, dairy, meat/other proteins, grains) and all related subgroups. To enhance the precision of estimated intake, we combined all sets of dietary data collected between 9 and 17 years of age. Pearson correlation coefficients comparing food intakes from one year to the next throughout adolescence ranged from about 0.40 to 0.56.

Serum Lipids

Blood specimens were collected after an overnight fast at examination visits 1, 3, 5, 7 and 10. Of the 1500 girls included in these analyses, only 37 failed to fast for at least 10 hours, leading to exclusion of their data for LDL-C and TG. For these analyses, data from exam 10 (when girls were 18–20 years of age) were used. Lipid analyses were carried out at the Johns Hopkins Department of Lipid Research. The Cholesterol CHOD-PAP method was used to determine total and HDL-C cholesterol (Boehringer-Mannheim Diagnostics); triglycerides (TG) were ascertained enzymatically (Abbott A-Gent TGs Reagent Set). LDL-C was calculated using the following modified Friedewald equation for children: $LDL-C = TC - HDL-C - (TG/6.5)$.¹¹ Non-HDL-C, which is increasingly recognized as an important predictor of atherogenic cardiovascular disease, was estimated as the difference between TC and HDL-C.¹²

Assessment of Potential Confounders

Potential confounding variables explored included age, race (self-described as black or white), height, BMI, energy and dietary fat intakes, physical activity, and television/video watching. Eating patterns are frequently associated with other lifestyle characteristics and behaviors (e.g., SES, physical activity). Since these factors may also be independently associated with lipid levels, they may confound the relation between diet and lipids. In our final analyses, however, we included only factors that led to actual confounding of at least one diet-lipid relationship as measured by a 5% change in estimated effects. For example, age at menarche was a statistically significant predictor of lipid levels in many of the repeated measures models but not a confounder of the diet-lipid relationship in any; therefore, it was dropped from the final models.

Data on income and education were used to classify SES as low (income <\$20,000 and high school or income <\$10,000), high (income \$40,000 and >high school) or moderate (everything else). Physical activity was assessed at visits 1, 3, 5 and 7–10 using the validated Habitual Activity Questionnaire¹³ (HAQ). The HAQ score was calculated by multiplying an estimate of the metabolic equivalent (MET) for each recorded activity by weekly frequency of participation and the portion of the year it was performed. Time spent watching television/videos was assessed by asking the usual number hours watched in a typical week.

Statistical Analysis

We first examined the effects of usual dietary intake in each of the five major USDA food groups and then combined intakes in selected food groups /subgroups to examine the effects of a priori-defined eating patterns. Cutpoints for high versus low intakes in various food groups were selected after considering the USDA Dietary Guidelines as well as the distributions of intake among the girls in this study. Actual intakes were much lower than recommended intakes so feasibility concerns took precedence in the selection of the final cutpoints. High vs. low dairy, fruit and non-starchy vegetables, and lean meat, poultry and fish intakes were 2 vs. <2 servings/day; high vs. low whole grain intake was 0.75 vs. <0.75 servings/day.

Non-fasting TC, HDL-C, and non-HDL-C, were available for 1500 girls at 18–20 years of age; fasting values for LDL-C, the LDL-C:HDL-C ratio and TG values were available for 1463 girls. Analysis of covariance modeling was used to estimate adjusted mean lipid levels associated dietary intake levels. We also dichotomized lipid levels at the end of follow up (18–20 years) using previously-identified or recommended cutpoints to classify girls as being at higher risk or not. Specifically, a TC level 170 mg/dL and an LDL-C level 110 mg/dL were considered “high risk” based on the NCEP classification of “borderline high” levels for children and adolescents.¹⁴ Our cutpoint of < 50 mg/dL for HDL-C in this all-

female population was selected from the International Diabetes Federation guidelines for late adolescent girls.¹⁵ The cutpoint for the LDL-C:HDL-C ratio (≥ 2.2) was derived by dividing the cutpoint for high LDL-C by the cutpoint for low HDL-C. For non-HDL-C, we defined higher risk as ≥ 145 mg/dL since this level is associated with higher risk of metabolic syndrome amongst adolescents.¹⁶ Similarly, a cutpoint of ≥ 110 mg/dL for TG has also been associated with metabolic syndrome in adolescents.¹⁷ Multiple logistic regression analyses were used to estimate the adjusted relative risk (RR) of being in one of the “higher risk” lipid groups. All analyses were performed using Statistical Analysis Systems software package version 9.1 (SAS Institute, Cary, NC, USA).

Results

Table 1 shows the girls’ adjusted mean lipid levels at 18–20 years of age associated with categories of usual intake (at 9–17 years of age) in each major food groups. Total, LDL-C, and non-HDL-C cholesterol levels tended to decline with increasing consumption of dairy and fruit (with similar but non-statistically significant effects shown for vegetables). No beneficial or adverse effect was found for total grains or meats. Consumption of at least one serving of fruit daily was associated with a statistically significant decrease in LDL-C:HDL-C ratio; this effect was due to its effect on LDL-C rather than HDL-C.

In Table 2, selected food combinations and subgroups are examined. A diet high in total fruit and non-starchy vegetables had a greater beneficial effect on lipid outcomes than did fruit and total vegetables. Neither whole grains nor lean meat, poultry and fish was independently associated with serum lipids. The consumption of small amounts of nuts, seeds and legumes benefited LDL-C, non-HDL-C and the LDL-C:HDL-C ratio. However, intake was very low so this subgroup was dropped from subsequent analyses due to limited analytical power.

Beginning with Table 3, several a priori-defined healthy eating patterns were examined. The four individual food groups/subgroups selected were fruit and non-starchy vegetables, dairy, whole grains, and lean meat, poultry and fish. All possible 2-way combinations of these food groups were explored with each girl being classified according to her usual diet (at 9–17 years of age) as having high or low intakes. The three eating patterns in Table 3 most consistently associated with favorable levels of total, LDL-C, and non-HDL-C a better LDL-C:HDL-C ratio included the following: (1) dairy/ fruit and non-starchy vegetables, (2) dairy/ whole grains, and (3) fruit and non-starchy vegetables/ whole grains. Dietary patterns that included higher intakes of lean meat, poultry, and fish tended to be associated with lower TG levels at the end of follow up.

Tables 4 and 5 show the adjusted RR of having an abnormal lipid level associated with these same dietary patterns. Consuming ≥ 2 servings of dairy per day plus ≥ 2 servings of fruit and non-starchy vegetables led to a non-statistically significant 26% reduction in risk of a TC ≥ 170 mg/dL and more than a 40% statistically significant reduction in risk of a non-HDL-C ≥ 145 mg/dL (Table 4). Consuming more whole grains plus more dairy or fruit and non-starchy vegetables (vs. lower intakes) led to about a 30% reduction in risk of a high TC level. For HDL-C, the eating pattern that led to the most stable risk reduction was high fruit and non-starchy vegetable intake combined with high intake of lean meat, poultry and fish. Some dairy-based eating patterns showed similar risk reductions but with wider confidence intervals (that included the null value).

Table 5 shows that higher dairy intakes combined with higher fruit and non-starchy vegetables led to about a 50% lower risk of a high LDL-C, a 41% reduction in risk of having a LDL-C:HDL-C ratio of ≥ 2.2 , and about a 30% (non-statistically significant) reduction in

risk of high TG (> 110 mg/dL). Combined intakes of whole grains with fruit and non-starchy vegetables also led to substantial reductions in risk for these outcomes. Consuming ≥ 2 one-ounce servings of lean meat, poultry and fish with ≥ 2 servings of fruit and non-starchy vegetables daily also yielded about a 40% reduction in risk of a high LDL-C:HDL-C ratio.

To assess whether the associations between eating patterns and lipid levels might be explained by level of body fat, lastly we added BMI (from the time of the lipid assessment) to the multiple logistic regression models in Tables 4–5 (data not shown). There was very little, if any, effects attenuation by including BMI in the models. (Most RR estimates changed by less than 5% and the maximum change was 6.8 %.) Therefore, it appears that the dietary effects on lipid levels in these analyses are independent of BMI.

Discussion

In this study, we examined the effects of individual food groups and selected subgroups on blood lipids in the context of pre-defined dietary patterns among 1500 adolescent girls. Diet patterns reflecting any combination of the following food groups led to substantially lower risks of having elevated levels of TC, LDL-C, non-HDL-C or TG in late adolescence: fruit and non-starchy vegetables (≥ 2 servings/day), dairy (≥ 2 servings/day) and whole grains (≥ 0.75 servings/day). Combined consumption of lean meat, poultry and fish as well as dairy and fruit and non-starchy vegetables benefited HDL-C and fasting TG. (Many, although not all, of these findings were statistically significant at $p < 0.05$.) Since some food groups benefited LDL-C (and non-HDL-C) and others HDL-C, all of the above food groups when consumed as a part of a healthy pattern contributed to a lower LDL-C to HDL-C ratio. We found no meaningful confounding by other dietary factors including intake in other food groups, energy intake, and percent of calories from fat. Similarly, there were no meaningful changes in the effect estimates associated with controlling for BMI.

The paucity of similar studies amongst children and adolescents limits the comparison of these results to studies conducted in adults. The original DASH trial showed that the combined intakes of low-fat dairy plus fruits and vegetables led to a lowering of both total and LDL-C concentrations, but HDL-C declined as well.¹⁸ In our analyses, we included all dairy (not just low-fat dairy) resulting in much higher overall fat and saturated fat intakes (35% of total energy from fat and 13% of calories from saturated fat for NGHS subjects compared with 27% overall fat and 10% saturated in the original DASH trial). We found no reduction in HDL-C associated with higher intakes of dairy plus fruits and non-starchy vegetables or dairy plus total fruit and vegetables (not shown). These results are consistent with earlier studies showing a positive association between dietary fat intake and HDL-C.¹⁹

Observational studies of diet and cardiovascular risk frequently use factor analysis methods to derive eating patterns such as the “Western” style diet.^{5,20} Few studies have explored the independent effects of individual food groups or explicitly-defined eating patterns on lipid levels. For example, fruit and vegetable intake has been often studied as a part of a vegetarian diet⁴ but there are limited studies of its independent effects on serum lipids. Family Heart Study data showed an inverse association between fruit and vegetable intake and LDL-C²¹ while in NHANES III only fruit intake was inversely associated with TC or LDL-C.²²

A 2009 review concluded that current evidence suggests different dairy-derived foods such as milk, butter, hard and soft cheeses and fermented dairy products have variable and oftentimes equivocal effects on serum lipids.¹⁹ Our study results for total dairy are consistent with other studies showing an inverse association between calcium intake (from food sources) and TC and LDL-C as well as the TC:HDL-C ratio.²³

Higher intakes of whole grains have been associated with lower TC and LDL-C as well as reduction of overall cardiovascular risk.²⁴ At least one such trial also found increases in HDL-C levels.²⁵ In our study of adolescent girls, whole grains especially when consumed with more fruit and non-starchy vegetables had beneficial effects on serum lipids.

Diets high in fatty red meat have been linked with increases in total and LDL-C.²⁶ Lean red meat has had cholesterol-lowering effects in some studies, suggesting that it is the fat content not the red meat itself that is hypercholesterolemic.²⁷ In some trials including a long-term multicenter trial in hypercholesterolemic adults, lean red meat, chicken and fish had comparable effects on LDL-C.²⁸ In the current study, lean meat, poultry and fish when consumed in the context of a healthy diet pattern had no adverse effects on lipid profiles.

A number of mechanisms may explain the effects seen in this study. Diets rich in fruits and vegetables and some whole grains are high in soluble fiber which in its viscous form reduces LDL-C by affecting bile acid absorption, resulting in cholesterol being removed from the blood stream and converted by the liver into replacement bile acids.²⁹ The capacity of fiber to slow gastric emptying and glucose absorption may also minimize post-prandial insulin response and subsequent hepatic lipogenesis.³⁰ Additionally, the phytosterol content of plant-based diets is believed to inhibit cholesterol absorption.³¹ Whole grains also contain bioactive compounds such as trace micronutrients, lignans, and other phytochemicals that may benefit lipid metabolism.³² The calcium content of dairy foods may benefit lipid concentrations by binding with intestinal fatty acids and bile acids, thereby inhibiting lipid absorption.³³ Saturated fatty acids such as palmitic (c16:0), myristic (c14:0), and lauric (c12:0) acids have cholesterol-raising effects while both palmitic and myristic acid have been associated with a greater concentration of larger (less atherogenic) LDL-C particles.³⁴ In addition, dairy as well as lean red meat has high levels of oleic acid (c18:1), a monounsaturated fatty acid with cholesterol-lowering effects³⁵ and favorable effects on lipid particle size. While neither red meats nor poultry impact TG levels,²⁸ fish and fish oils rich in omega-3 fatty acids lower TG levels in a dose-dependent fashion by accelerating clearance of chylomicrons.³⁶

This study is subject to several limitations that are common to epidemiologic studies of dietary exposures. Dietary data are of necessity obtained by self-report and thus subject to error. Children and adolescents have difficulty accurately reporting what they eat as a result of difficulties estimating portion sizes and reporting details such as recipes, brands, and preparation methods. Under-reporting of dietary intake is also a common problem although this tends to be more of a problem for snacks than for other foods.³⁷ A further limitation of this study is the availability of only a single measure of lipids in the last three years of the study. Repeated measures of lipid levels may have facilitated more accurate identification of high-risk girls. An important strength of the current study is its prospective design and the availability of a large number of diet records collected during adolescence, thus enhancing the precision of estimated dietary intakes and increasing our ability to identify true effects of eating patterns on lipid levels. The calculation of food group intakes by linking NDS data from study subjects with USDA Food Pyramid data is also an important strength. Additionally, the sample size allowed us to evaluate the effects of healthier eating patterns, despite the fact that such patterns are not particularly common in adolescents.

Lipid profiles in late adolescence are important determinants of adult cardiovascular risk. Thus, the identification of modifiable predictors of lipoprotein levels in adolescence is particularly important. This study demonstrates that dietary patterns during childhood and adolescence have the potential to alter the lipid levels of older adolescent girls.

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Abbreviations

TC	Total cholesterol
HDL-C	High-density lipoprotein cholesterol
Non-HDL-C	Non-high-density lipoprotein cholesterol
LDL-C	Low-density lipoprotein cholesterol
TG	Triglycerides

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Table 1
Adjusted mean lipid levels in late adolescent girls according to individual food group intakes

Servings/Day (Ages 9–17)	(n)	Total Cholesterol (mg/dL)	HDL Cholesterol (mg/dL)	Non-HDL-C (mg/dL)	(n)	LDL Cholesterol (mg/dL)	LDL/HDL Ratio	Log of Serum Triglycerides
<i>Adjusted Mean (± s.e.)^a</i>								
Total Dairy								
<1.0	240	168.2 ± 2.1	55.2 ± 0.8	113.0 ± 2.1	237	100.9 ± 2.0	1.95 ± 0.05	4.28 ± 0.03
1.0–<2.5	1066	164.3 ± 1.0	53.2 ± 0.4	111.1 ± 1.0	1032	98.4 ± 0.9	1.94 ± 0.02	4.30 ± 0.01
2.5	194	160.3 ± 2.4	53.5 ± 0.9	106.8 ± 2.4	194	94.6 ± 2.2	1.88 ± 0.06	4.29 ± 0.03
<i>p for trend</i>		0.017	0.117	0.068		0.041	0.442	0.663
Total Fruit								
<1.0	657	166.5 ± 1.3	53.4 ± 0.5	113.1 ± 1.3	644	100.6 ± 1.2	1.99 ± 0.03	4.32 ± 0.02
1.0–<2.0	595	163.3 ± 1.3	53.8 ± 0.5	109.4 ± 1.3	578	96.9 ± 1.2	1.89 ± 0.03	4.28 ± 0.02
2.0	248	161.5 ± 2.1	53.4 ± 0.8	108.1 ± 2.1	241	95.5 ± 1.9	1.90 ± 0.05	4.28 ± 0.03
<i>p for trend</i>		0.026	0.848	0.020		0.012	0.048	0.186
Total Vegetables								
<1.5	347	165.5 ± 1.7	53.1 ± 0.6	112.5 ± 1.7	341	99.0 ± 1.6	1.98 ± 0.04	4.33 ± 0.02
1.5–<3.0	970	164.6 ± 1.0	53.8 ± 0.4	110.8 ± 1.0	943	98.5 ± 1.0	1.93 ± 0.03	4.29 ± 0.01
3.0	183	161.0 ± 2.4	53.4 ± 0.9	107.6 ± 2.4	179	95.6 ± 2.2	1.88 ± 0.06	4.27 ± 0.03
<i>p for trend</i>		0.168	0.583	0.110		0.280	0.171	0.083
Total Grains								
<5.0	297	164.5 ± 1.9	54.0 ± 0.7	110.5 ± 1.9	291	98.5 ± 1.7	1.94 ± 0.05	4.27 ± 0.02
5.0–<7.0	781	164.5 ± 1.2	53.1 ± 0.4	111.4 ± 1.1	757	98.7 ± 1.1	1.95 ± 0.03	4.29 ± 0.01
7.0	422	164.1 ± 1.6	54.1 ± 0.6	110.0 ± 1.6	415	97.4 ± 1.4	1.91 ± 0.04	4.32 ± 0.02
<i>p for trend</i>		0.826	0.793	0.749		0.560	0.517	0.146
Total Meat Group								
<3.0	321	165.0 ± 1.9	54.0 ± 0.7	111.1 ± 1.9	316	97.6 ± 1.7	1.91 ± 0.05	4.33 ± 0.02
3.0–<5.0	785	163.7 ± 1.1	53.2 ± 0.4	110.5 ± 1.1	758	98.2 ± 1.1	1.94 ± 0.03	4.29 ± 0.01
5.0	394	165.4 ± 1.7	54.0 ± 0.6	111.3 ± 1.7	389	99.0 ± 1.6	1.95 ± 0.04	4.28 ± 0.02
<i>p for trend</i>		0.853	0.879	0.897		0.567	0.525	0.114

^a Adjusted for age, race, SES, height, activity score, TV/video watching.

Table 2
Adjusted mean lipid levels in late adolescent girls according to food group sub-groups and combined intakes

Servings/Day (Ages 9-17)	(n)	Total Cholesterol (mg/dL)	HDL Cholesterol (mg/dL)	Non-HDL-C (mg/dL)	(n)	LDL Cholesterol (mg/dL)	LDL/HDL Ratio	Log of Serum Triglycerides
Fruit and Vegetables								
0-<2.0	161	164.3 ± 2.5	54.2 ± 0.9	110.1 ± 2.5	159	97.8 ± 2.3	1.93 ± 0.06	4.28 ± 0.03
2.0-<4.0	946	165.8 ± 1.0	53.6 ± 0.4	112.2 ± 1.0	923	99.5 ± 1.0	1.96 ± 0.03	4.30 ± 0.01
4.0	393	161.2 ± 1.6	53.3 ± 0.6	107.9 ± 1.6	381	95.5 ± 1.5	1.89 ± 0.04	4.28 ± 0.02
<i>p for trend</i>		0.095	0.447	0.162		0.151	0.356	0.606
Fruit & Non-Starchy Vegetables								
0-<1.5	344	167.0 ± 1.8	53.2 ± 0.7	113.8 ± 1.7	335	101.1 ± 1.6	2.02 ± 0.04	4.32 ± 0.02
1.5-<3.0	838	164.5 ± 1.1	53.7 ± 0.4	110.8 ± 1.1	820	98.2 ± 1.0	1.92 ± 0.03	4.30 ± 0.01
3.0	318	161.4 ± 1.9	53.8 ± 0.7	107.6 ± 1.8	308	95.4 ± 1.7	1.88 ± 0.05	4.25 ± 0.02
<i>p for trend</i>		0.035	0.479	0.017		0.018	0.025	0.050
Whole Grains								
<0.25	331	163.7 ± 1.8	53.0 ± 0.7	110.7 ± 1.8	321	98.3 ± 1.7	1.95 ± 0.04	4.32 ± 0.02
0.25-<0.75	805	165.7 ± 1.1	53.9 ± 0.4	111.9 ± 1.1	786	98.9 ± 1.0	1.95 ± 0.03	4.30 ± 0.01
0.75	364	162.1 ± 1.7	53.4 ± 0.6	108.6 ± 1.7	356	96.8 ± 1.6	1.90 ± 0.04	4.26 ± 0.02
<i>p for trend</i>		0.484	0.683	0.390		0.498	0.425	0.098
Lean Meat, Poultry, Fish								
<1.0	230	164.8 ± 2.1	53.4 ± 0.8	111.4 ± 2.1	228	98.7 ± 2.0	1.95 ± 0.05	4.34 ± 0.03
1.0-<3.0	1044	163.7 ± 1.0	53.4 ± 0.4	110.4 ± 1.0	1013	97.8 ± 0.9	1.94 ± 0.02	4.29 ± 0.01
3.0	226	167.0 ± 2.2	54.7 ± 0.8	112.3 ± 2.2	222	99.9 ± 2.0	1.93 ± 0.05	4.29 ± 0.03
<i>p for trend</i>		0.489	0.266	0.778		0.690	0.793	0.218
Nuts, Seeds, Legumes								
0<0.25	817	165.4 ± 1.1	53.0 ± 0.4	112.3 ± 1.1	800	99.6 ± 1.0	1.99 ± 0.03	4.30 ± 0.01
0.25-<0.50	475	164.1 ± 1.5	54.4 ± 0.5	109.7 ± 1.5	459	97.2 ± 1.4	1.88 ± 0.04	4.30 ± 0.02
0.50	208	161.4 ± 2.2	53.9 ± 0.8	107.5 ± 2.2	204	95.5 ± 2.1	1.86 ± 0.05	4.28 ± 0.03
<i>p for trend</i>		0.122	0.115	0.031		0.041	0.007	0.817

^a Adjusted for age, race, SES, height, activity score, TV/video watching.

Table 3

Adjusted mean lipid levels in late adolescent girls associated with usual eating patterns

Servings/Day ^a (Ages 9-17)	(n)	Total Cholesterol (mg/dL)	p-value	HDL Cholesterol (mg/dL)	p-value	Non-HDL-C (mg/dL)	p-value	LDL Cholesterol (mg/dL)	p-value	LDL/HDL Ratio	p-value	Log of Serum Triglycerides (mg/dL)	p-value
Dairy / Fruit & N-S Vegetables													
Adjusted mean ($\pm$ s.e.) ^b													
Low / Low	515	167.6 $\pm$ 1.5	ref	53.4 $\pm$ 0.5	ref	114.3 $\pm$ 1.4	ref	498	101.6 $\pm$ 1.3	ref	2.01 $\pm$ 0.04	ref	4.31 $\pm$ 0.02
Low / High	567	163.1 $\pm$ 1.4	0.022	53.9 $\pm$ 0.5	0.478	109.2 $\pm$ 1.4	0.010	554	96.7 $\pm$ 1.3	0.008	1.88 $\pm$ 0.03	0.011	4.27 $\pm$ 0.02
High / Low	151	165.9 $\pm$ 2.6	0.571	52.6 $\pm$ 1.0	0.529	113.3 $\pm$ 2.6	0.737	148	100.6 $\pm$ 2.4	0.711	2.04 $\pm$ 0.06	0.724	4.31 $\pm$ 0.03
High / High	267	160.2 $\pm$ 2.1	0.005	53.9 $\pm$ 0.8	0.567	106.2 $\pm$ 2.1	0.002	263	94.0 $\pm$ 1.9	0.002	1.86 $\pm$ 0.05	0.017	4.30 $\pm$ 0.03
Dairy / Whole Grains													
Low / Low	891	165.5 $\pm$ 1.1	ref	53.8 $\pm$ 0.4	ref	111.7 $\pm$ 1.1	ref	866	98.9 $\pm$ 1.0	ref	1.94 $\pm$ 0.03	ref	4.30 $\pm$ 0.01
Low / High	191	164.0 $\pm$ 2.3	0.571	52.8 $\pm$ 0.9	0.314	111.2 $\pm$ 2.3	0.846	186	99.4 $\pm$ 2.2	0.828	1.96 $\pm$ 0.06	0.739	4.27 $\pm$ 0.03
High / Low	245	164.3 $\pm$ 2.1	0.617	53.0 $\pm$ 0.8	0.377	111.2 $\pm$ 2.1	0.862	241	98.4 $\pm$ 1.9	0.834	1.99 $\pm$ 0.05	0.419	4.33 $\pm$ 0.03
High / High	173	159.5 $\pm$ 2.6	0.037	54.0 $\pm$ 0.9	0.880	105.5 $\pm$ 2.5	0.031	170	93.7 $\pm$ 2.3	0.046	1.83 $\pm$ 0.06	0.133	4.26 $\pm$ 0.03
Dairy / Lean Meat, Poultry & Fish													
Low / Low	576	164.1 $\pm$ 1.3	ref	53.8 $\pm$ 0.5	ref	110.3 $\pm$ 1.3	ref	560	97.7 $\pm$ 1.2	ref	1.92 $\pm$ 0.03	ref	4.31 $\pm$ 0.02
Low / High	506	166.5 $\pm$ 1.5	0.240	53.5 $\pm$ 0.6	0.701	113.0 $\pm$ 1.5	0.183	492	100.5 $\pm$ 1.4	0.138	1.97 $\pm$ 0.04	0.239	4.27 $\pm$ 0.02
High / Low	268	162.5 $\pm$ 2.1	0.515	52.4 $\pm$ 0.8	0.120	110.2 $\pm$ 2.0	0.941	265	97.2 $\pm$ 1.9	0.805	1.97 $\pm$ 0.05	0.352	4.34 $\pm$ 0.03
High / High	150	161.8 $\pm$ 2.7	0.446	55.3 $\pm$ 1.0	0.160	106.5 $\pm$ 2.6	0.195	146	94.9 $\pm$ 2.5	0.300	1.83 $\pm$ 0.07	0.264	4.25 $\pm$ 0.03
Fruit & N-S Veg / Whole Grains													
Low / Low	550	167.5 $\pm$ 1.4	ref	53.4 $\pm$ 0.5	ref	114.0 $\pm$ 1.4	ref	534	101.2 $\pm$ 1.3	ref	2.01 $\pm$ 0.03	ref	4.32 $\pm$ 0.02
Low / High	116	166.2 $\pm$ 3.0	0.696	52.0 $\pm$ 1.1	0.257	114.1 $\pm$ 3.0	0.975	112	102.3 $\pm$ 2.8	0.715	2.03 $\pm$ 0.07	0.856	4.26 $\pm$ 0.04
High / Low	586	163.1 $\pm$ 1.3	0.025	53.8 $\pm$ 0.5	0.588	109.3 $\pm$ 1.3	0.014	573	96.6 $\pm$ 1.2	0.011	1.89 $\pm$ 0.03	0.011	4.29 $\pm$ 0.02
High / High	248	159.8 $\pm$ 2.1	0.003	54.1 $\pm$ 0.8	0.499	105.8 $\pm$ 2.1	0.001	244	94.0 $\pm$ 1.9	0.003	1.83 $\pm$ 0.05	0.005	4.27 $\pm$ 0.03
Fruit & N-S Veg / Lean Meat, Poultry, Fish													
Low / Low	414	166.3 $\pm$ 1.6	ref	52.4 $\pm$ 0.6	ref	113.8 $\pm$ 1.6	ref	401	101.0 $\pm$ 1.5	ref	2.03 $\pm$ 0.04	ref	4.33 $\pm$ 0.02
Low / High	252	168.8 $\pm$ 2.0	0.330	54.4 $\pm$ 0.8	0.039	114.4 $\pm$ 2.0	0.834	245	102.0 $\pm$ 1.9	0.689	1.99 $\pm$ 0.05	0.547	4.28 $\pm$ 0.03
High / Low	430	161.2 $\pm$ 1.6	0.028	54.2 $\pm$ 0.6	0.038	107.0 $\pm$ 1.6	0.003	424	94.4 $\pm$ 1.5	0.002	1.84 $\pm$ 0.04	0.001	4.31 $\pm$ 0.02
High / High	404	163.2 $\pm$ 1.6	0.184	53.6 $\pm$ 0.6	0.174	109.6 $\pm$ 1.6	0.064	393	97.4 $\pm$ 1.5	0.087	1.91 $\pm$ 0.04	0.033	4.25 $\pm$ 0.02
Whole Grains / Lean Meat, Poultry, Fish													
Low / Low	614	164.7 $\pm$ 1.3	ref	53.3 $\pm$ 0.5	ref	111.3 $\pm$ 1.3	ref	597	98.3 $\pm$ 1.2	ref	1.95 $\pm$ 0.03	ref	4.34 $\pm$ 0.02

Servings/Day ^a (Ages 9–17)	Total Cholesterol (mg/dL)	HDL Cholesterol (mg/dL)	Non-HDL-C (mg/dL)	LDL Cholesterol (mg/dL)	LDL/HDL Ratio	Log of Serum Triglycerides (mg/dL)								
Low / High	522	165.8 ± 1.5	0.567	54.0 ± 0.5	0.359	111.8 ± 1.4	0.815	510	99.4 ± 1.3	0.561	1.95 ± 0.04	0.894	4.27 ± 0.02	0.006
High / Low	230	161.0 ± 2.2	0.141	53.2 ± 0.8	0.908	107.7 ± 2.1	0.149	228	95.9 ± 2.0	0.305	1.89 ± 0.05	0.293	4.28 ± 0.03	0.059
High / High	134	163.7 ± 2.8	0.741	53.6 ± 1.0	0.818	110.1 ± 2.8	0.675	128	98.2 ± 2.6	0.979	1.92 ± 0.07	0.696	4.25 ± 0.04	0.030

^aHigh vs. low dairy intake = 2 vs. <2 servings/day; High vs low fruit and non-starchy vegetable intake = 2 vs. <2 servings/day; High vs. low whole grain intake = 0.75 vs. <0.75 servings/day; High vs. low lean meat, poultry and fish intake = 2 vs. <2 servings/day.

^bAdjusted for age, race, SES, height, activity score and TV/video watching

Table 4

Effect of eating patterns on higher risk total, HDL, and non-HDL cholesterol levels in late adolescent girls

Servings/Day ^a (Ages 9–17)	TC 170				HDL < 50				Non-HDL-C 145			
	Subjects (n)	Cases (n)	RR ^b	95% CI	Cases (n)	RR ^b	95% CI	Cases (n)	RR ^b	95% CI	95% CI	
Dairy / Fruit N-S Veg												
Low / Low	515	216	1.00	-	215	1.00	-	78	1.00	-	-	
Low / High	567	221	0.87	(0.68, 1.12)	211	0.85	(0.66, 1.09)	71	0.76	(0.53, 1.09)	(0.53, 1.09)	
High / Low	151	59	0.88	(0.60, 1.29)	74	1.12	(0.77, 1.63)	25	1.03	(0.62, 1.71)	(0.62, 1.71)	
High / High	267	96	0.74	(0.53, 1.03)	105	0.76	(0.54, 1.05)	29	0.58	(0.35, 0.95)	(0.35, 0.95)	
Dairy / Whole Grains												
Low / Low	891	363	1.00	-	342	1.00	-	123	1.00	-	-	
Low / High	191	74	0.96	(0.69, 1.32)	84	1.18	(0.86, 1.64)	26	0.96	(0.61, 1.53)	(0.61, 1.53)	
High / Low	245	99	0.97	(0.71, 1.31)	108	1.04	(0.77, 1.41)	37	1.02	(0.67, 1.55)	(0.67, 1.55)	
High / High	173	56	0.68	(0.47, 0.98)	71	0.93	(0.65, 1.33)	17	0.60	(0.34, 1.05)	(0.34, 1.05)	
Dairy / Lean Meat, Poultry, Fish												
Low / Low	576	214	1.00	-	235	1.00	-	73	1.00	-	-	
Low / High	506	223	1.35	(1.05, 1.73)	191	0.98	(0.76, 1.27)	76	1.31	(0.91, 1.87)	(0.91, 1.87)	
High / Low	268	92	0.86	(0.63, 1.18)	126	1.11	(0.82, 1.51)	37	1.04	(0.67, 1.62)	(0.67, 1.62)	
High / High	150	63	1.14	(0.79, 1.66)	53	0.72	(0.49, 1.06)	17	0.79	(0.45, 1.40)	(0.45, 1.40)	
Fruit N-S Veg / Whole Grains												
Low / Low	550	228	1.00	-	234	1.00	-	88	1.00	-	-	
Low / High	116	47	0.99	(0.66, 1.50)	55	1.13	(0.75, 1.70)	15	0.76	(0.42, 1.37)	(0.42, 1.37)	
High / Low	586	234	0.92	(0.72, 1.17)	216	0.80	(0.63, 1.03)	72	0.70	(0.49, 0.98)	(0.49, 0.98)	
High / High	248	83	0.70	(0.50, 0.98)	100	0.85	(0.61, 1.17)	28	0.59	(0.37, 0.96)	(0.37, 0.96)	
Fruit N-S Veg / Lean Meat, Poultry, Fish												
Low / Low	414	156	1.00	-	192	1.00	-	62	1.00	-	-	
Low / High	252	119	1.45	(1.05, 2.00)	97	0.78	(0.57, 1.08)	41	1.12	(0.72, 1.73)	(0.72, 1.73)	
High / Low	430	150	0.86	(0.64, 1.15)	169	0.73	(0.54, 0.97)	48	0.65	(0.43, 0.99)	(0.43, 0.99)	
High / High	404	167	1.13	(0.85, 1.51)	147	0.73	(0.55, 0.98)	52	0.81	(0.54, 1.23)	(0.54, 1.23)	
Whole Grains / Lean Meat, Poultry, Fish												
Low / Low	614	233	1.00	-	261	1.00	-	85	1.00	-	-	

Servings/Day ^a	Subjects (n)	TC		HDL < 50		Non-HDL-C	
		Cases (n)	RR ^b	95% CI	Cases (n)	RR ^b	95% CI
Low / High	522	229	1.28	(1.00, 1.63)	189	0.86	(0.67, 1.10)
High / Low	230	73	0.77	(0.55, 1.07)	100	1.01	(0.74, 1.38)
High / High	134	57	1.20	(0.82, 1.77)	55	0.95	(0.65, 1.40)

^aHigh vs. low dairy intake = 2 vs. <2 servings/day; High vs low fruit and non-starchy vegetable intake = 2 vs. <2 servings/day; High vs. low whole grain intake = intake = 0.75 vs. <0.75 servings/day; High vs. low lean meat, poultry and fish intake = 2 vs. <2 servings/day.

^bAdjusted for age, race, SES, height, activity score and TV/video watching

Table 5

Effect of eating patterns on higher risk LDL, LDL:HDL ratio, and triglyceride levels in late adolescent girls

Servings/Day ^a (Ages 9-17)	Subjects (n)	Cases (n)	LDL 110		LDL:HDL 2.2			Triglycerides 110		
			RR ^b	95% CI	(n)	RR ^b	95% CI	(n)	RR ^b	95% CI
Dairy / Fruit N-S Veg										
Low / Low	498	177	1.00	-	175	1.00	-	87	1.00	-
Low / High	554	164	0.73	(0.56, 0.95)	147	0.65	(0.50, 0.85)	79	0.74	(0.52, 1.05)
High / Low	148	53	1.00	(0.67, 1.48)	54	0.97	(0.65, 1.44)	33	0.88	(0.55, 1.41)
High / High	263	61	0.51	(0.36, 0.74)	70	0.59	(0.41, 0.84)	55	0.71	(0.47, 1.07)
Dairy / Whole Grains										
Low / Low	866	279	1.00	-	264	1.00	-	136	1.00	-
Low / High	186	62	1.09	(0.77, 1.53)	58	1.05	(0.74, 1.48)	30	0.84	(0.54, 1.32)
High / Low	241	75	0.95	(0.69, 1.32)	76	0.97	(0.70, 1.34)	56	1.01	(0.69, 1.47)
High / High	170	39	0.62	(0.41, 0.93)	48	0.82	(0.56, 1.22)	32	0.69	(0.44, 1.09)
Dairy / Lean Meat, Poultry, Fish										
Low / Low	560	163	1.00	-	177	1.00	-	100	1.00	-
Low / High	492	178	1.40	(1.07, 1.83)	145	0.93	(0.71, 1.23)	66	0.96	(0.67, 1.38)
High / Low	265	70	0.86	(0.61, 1.21)	83	0.94	(0.67, 1.30)	64	1.02	(0.71, 1.49)
High / High	146	44	0.99	(0.66, 1.49)	41	0.78	(0.52, 1.18)	24	0.67	(0.41, 1.11)
Fruit N-S Veg / Whole Grains										
Low / Low	534	191	1.00	-	188	1.00	-	101	1.00	-
Low / High	112	39	0.99	(0.64, 1.52)	41	1.07	(0.69, 1.63)	19	0.72	(0.42, 1.26)
High / Low	573	163	0.69	(0.53, 0.89)	152	0.65	(0.50, 0.84)	91	0.75	(0.54, 1.04)
High / High	244	62	0.59	(0.42, 0.85)	65	0.63	(0.44, 0.90)	43	0.62	(0.40, 0.95)
Fruit N-S Veg / Lean Meat, Poultry, Fish										
Low / Low	401	133	1.00	-	149	1.00	-	83	1.00	-
Low / High	245	97	1.30	(0.93, 1.82)	80	0.82	(0.59, 1.16)	37	0.82	(0.53, 1.27)
High / Low	424	100	0.59	(0.43, 0.82)	111	0.57	(0.42, 0.78)	81	0.73	(0.51, 1.05)
High / High	393	125	0.90	(0.66, 1.22)	106	0.61	(0.45, 0.84)	53	0.67	(0.45, 1.00)
Whole Grains / Lean Meat, Poultry, Fish										
Low / Low	597	178	1.00	-	194	1.00	-	123	1.00	-

Servings/Day ^a (Ages 9–17)	LDL 110		LDL:HDL 2.2		Triglycerides 110					
	Subjects (n)	Cases (n)	RR ^b	95% CI	(n)	RR ^b	95% CI	(n)	RR ^b	95% CI
Low / High	510	176	1.23	(0.95, 1.60)	146	0.85	(0.65, 1.11)	69	0.81	(0.58, 1.14)
High / Low	228	55	0.76	(0.54, 1.09)	66	0.86	(0.61, 1.20)	41	0.71	(0.47, 1.07)
High / High	128	46	1.31	(0.87, 1.96)	40	0.94	(0.62, 1.43)	21	0.69	(0.41, 1.17)

^aHigh vs. low dairy intake = 2 vs. <2 servings/day; High vs low fruit and non-starchy vegetable intake = 2 vs. <2 servings/day; High vs. low whole grain intake = 0.75 vs. <0.75 servings/day; High vs. low lean meat, poultry and fish intake = 2 vs. <2 servings/day.

^bAdjusted for age, race, SES, height, activity score and TV/video watching