HHS Public Access
Author manuscript
Circulation. Author manuscript; available in PMC 2015 December 03.

Published in final edited form as:
Circulation. 2011 April 5; 123(13): 1410–1417. doi:10.1161/CIRCULATIONAHA.110.955922.

Association of DASH Diet With Cardiovascular Risk Factors in Youth With Diabetes Mellitus The SEARCH for Diabetes in Youth Study

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Abstract

Background—We have shown that adherence to the Dietary Approaches to Stop Hypertension (DASH) diet is related to blood pressure in youth with type 1 and type 2 diabetes mellitus. We explored the impact of the DASH diet on other cardiovascular disease risk factors.

Methods and Results—Between 2001 and 2005, data on total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, triglycerides, low-density lipoprotein particle density, apolipoprotein B, body mass index, waist circumference, and adipocytokines were ascertained in 2130 youth aged 10 to 22 years with physician-diagnosed diabetes mellitus. Dietary intake was assessed by food frequency questionnaire, categorized into the DASH food groups, and assigned an adherence score. Among youth with type 1 diabetes mellitus, higher adherence to the DASH diet was significantly and inversely associated with low-density lipoprotein/high-density lipoprotein ratio and A_{1c} in multivariable-adjusted models. Youth in the highest adherence tertile had an estimated 0.07 lower low-density lipoprotein/high-density lipoprotein ratio and 0.2 lower A_{1c} levels than those in the lowest tertile adjusted for confounders. No significant associations were observed with triglycerides, low-density lipoprotein particle density, adipocytokines, apolipoprotein B, body mass index *Z* score, or waist circumference. Among youth with type 2 diabetes mellitus, associations were observed with low-density lipoprotein particle density and body mass index *Z* score.

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Disclosures: None.

Conclusions—The DASH dietary pattern may be beneficial in the prevention and management of cardiovascular disease risk in youth with diabetes mellitus.

Keywords

diabetes mellitus; lipids; lipoproteins; nutrition; youth

Youth with diabetes mellitus are at high risk of cardiovascular disease (CVD) because of accelerated atherosclerosis that can lead to coronary artery disease in young adulthood.[1] Comorbidities are very common; 14% of youth with type 1 diabetes mellitus (T1DM) and 92% of youth with type 2 diabetes mellitus (T2DM) have ≥2 CVD risk factors.[2] Hypertension affects ≈30% of youth with diabetes mellitus aged > 10 years, and lipid abnormalities are present in 19% of youth with T1DM and 33% of youth with T2DM.[3] The American Heart Association recommends intense cardiovascular risk reduction in high-risk pediatric patients to improve long-term outcomes.[4] Although aggressive medical treatment is the cornerstone of diabetes therapy and management of associated risk factors, management of dietary behavior is also an important part of medical nutritional therapy in persons with diabetes mellitus.[5]

The National Heart, Lung, and Blood Institute–funded Dietary Approaches to Stop Hypertension (DASH) trial demonstrated the efficacy of a whole-diet approach on hypertension prevention and blood pressure reduction,[6] and observational studies have confirmed that adherence to a DASH-style diet benefits cardiovascular health.[7–12] We have shown previously that the DASH diet is associated with lower prevalence of hypertension in youth with T1DM.[13] However, little is known about its impact on other CVD risk factors.[6,14,15] The purpose of our study was to investigate the association of adherence to a DASH-like eating plan with blood lipid levels, lipoproteins, adipocytokines, and measures of adiposity and glycemic control in a large sample of youth with T1DM and T2DM.

Methods

The SEARCH for Diabetes in Youth Study is an ongoing multicenter study of physician-diagnosed diabetes mellitus in youth aged <20 years at diagnosis that began in 2001.[16] The study was approved by the local institutional review boards at its 6 centers. Parents of participants aged < 18 years provided written informed consent with participant assent; all participants aged ≥18 years provided written informed consent.

Study Participants

This analysis is restricted to youth attending the SEARCH clinic visit and whose diabetes mellitus was prevalent in 2001 or incident in 2002–2005 (n=3354; 42% of 8031 ascertained by SEARCH surveillance system). We excluded those with (1) a missing food frequency questionnaire (n=280); (2) provider-defined diabetes mellitus other than type 1 or type 2 (maturity-onset diabetes of the young, hybrid, secondary, unknown type, and missing type; n=27); (3) diabetes duration <6 months (n=372); (4) fasting <8 hours (n=480); and (5) eating much more or much less than typical (n=154), leaving 2130 youth (1810 T1DM, 320 T2DM) for descriptive analyses. For regression analyses, youth missing key analytical variables were excluded, and outcome-specific sample sizes are presented within the tables. The higher proportion of missing data for low-density lipoprotein (LDL) particle density and adipocytokines was due to the limited time period during which these measures were conducted.

Outcome Measures

Physical examinations at the study visits were conducted according to standardized protocols by trained and certified staff. Height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively. Body mass index (BMI) was calculated as weight (kg)/height squared (m^2) and converted to BMI *Z* score.[17] Waist circumference was measured just above the uppermost lateral border of the right ilium following National Health and Nutrition Examination Survey protocol.[18] A fiberglass tape was used for youth with a waist circumference up to 150 cm, and a flexible steel tape was used otherwise.

Blood A_{1c} samples were obtained only if there was no episode of diabetic ketoacidosis within the prior month. Specimens were processed at the site and shipped within 24 hours to the Northwest Lipid Metabolism and Diabetes Research Laboratories in Seattle, WA. Measurements of plasma cholesterol, triglycerides, and high-density lipoprotein (HDL) cholesterol were performed on a Hitachi 917 autoanalyzer (Boehringer Mannheim Diagnostics, Indianapolis, IN). LDL cholesterol was calculated by the Friedewald equation for individuals with triglyceride concentration <400 mg/dL (4.52 mmol/L) and by the BetaQuantification procedure for those with triglyceride concentration ≥400 mg/dL.[19] Assessment of lipoprotein cholesterol distribution was performed after density gradient ultracentrifugation and calculation of the LDL relative flotation rate for characterization of LDL particle density. Adiponectin and leptin were measured with a commercial radioimmunoassay procedure.[20] Apolipoprotein B (apoB) was measured by a nephelometric system (BNII, Behring Diagnostics) calibrated with the World Health Organization international reference material for apoB.[21] A_{1c} was measured by a dedicated ion-exchange high-performance liquid chromatography instrument (TOSOH, Bioscience, Inc., San Francisco, CA).

Dietary Assessment and DASH Score

The SEARCH food frequency questionnaire has been described.[22] It consisted of 85 food lines for which the participant indicated whether the item(s) was consumed in the past week (yes/no) and, if yes, for how many days and in what average portion. Food groups were created by either collapsing food lines on the basis of their major components or by disaggregating composite foods into constituent foods. The food frequency questionnaire was primarily self-administered after staff instruction.

Adherence to the DASH diet was assessed with an index variable (ie, a score) comprising 8 DASH food groups (grains, vegetables, fruits, dairy, meat, nuts/seeds/legumes, fats/oils, and sweets),[23,24] as described in detail.[13] For each food group, a maximum score of 10 could be achieved when the intake met the recommendation, and lower intakes were scored proportionately. Reverse scoring was applied for meat, fats/oils, and sweets, and a score of 0 was applied to intakes ≥200% of the upper recommended level. The resulting 8 component scores were summed to create the overall DASH adherence score, which ranged from 0 to 80. Following the DASH eating plan guidelines,[24] we assigned each individual the energy level closest to his or her estimated energy requirement on the basis of age, sex, and physical activity.[13]

Covariates

Race and ethnicity were obtained through self-report with the standard census questions.[25] Physical activity and sedentary behavior were assessed with questions identical to or slightly modified from those in the Youth Risk Behavior Surveillance System.[26,27] Smoking, parental education, and family income were based on self-report.

Statistical Analysis

Statistical analyses were conducted with the use of SAS (version 9.1, 2003; SAS Institute Inc, Cary, NC). Outcome variables with skewed distribution (eg, plasma triglycerides, adiponectin, leptin, and apoB) were log-transformed. We first evaluated a large number of potential confounders (age, gender, income, parental education, duration of diabetes mellitus, physical activity, sedentary behavior, missing doses of medication, type of diabetes treatment, study site, year of diabetes onset, lipid-lowering and antihypertensive treatment, family history of CVD and diabetes mellitus, smoking, and BMI *Z* score) and retained only those associated significantly ($P<0.05$) with at least 1 of the outcomes.

A series of multivariable linear regression models were fit, first adjusted for nonmodifiable confounders and subsequently adjusted for modifiable risk factors (physical activity, sedentary behavior, smoking, and, subsequently, BMI *Z* score). A_{1c} was included in the final models as a potential mediator. $P<0.05$ was considered significant. In addition, we estimated the level of the CVD risk factors using the least square means method at the median value of the lowest and highest tertiles of the DASH score and the differences between the tertile estimates. Back-transformations of log values were performed where applicable. We also investigated potential effect modification by race/ethnicity but found no evidence of this.

Results

Sample characteristics according to tertile of DASH adherence are summarized in Table 1. Higher levels of adherence to the DASH diet were significantly associated with race/ethnicity, higher income, not smoking, more vigorous physical activity, and less television watching, but not with age or gender, in T1DM youth. The DASH score was associated only with vigorous physical activity in T2DM youth.

In both T1DM and T2DM children, the average DASH diet scores were low, with the second tertile mean at 39.9 and 36.4, respectively, on an 80-point scale (Table 2). As expected, intake of food groups included in the DASH score differed significantly between tertiles ($P<0.05$), shown per 1000 kilocalories because of the large differences in energy requirements across the age span. Youth in the highest tertiles consumed twice as many servings of fruit and low-fat dairy products and substantially more nuts and seeds than those in the lowest. A higher adherence to DASH was not related to total energy intake.

Mean levels of CVD risk factors according to diabetes type and DASH adherence tertile are shown in Table 3. With increasing DASH adherence, we observed decreasing levels of LDL cholesterol, LDL/HDL ratios, and A_{1c} in T1DM, decreasing levels of total cholesterol, apoB, and BMI *Z* score in T1DM and T2DM, and decreasing levels of triglycerides, HDL cholesterol, and waist circumference in T2DM.

Table 4 shows the association of the DASH diet score with CVD risk factors in youth with T1DM based on a prespeci-fied, hierarchical series of analytical models. We observed significant associations of DASH diet score with LDL/HDL ratio and A_{1c}. No association was observed with HDL cholesterol, triglycerides, LDL particle density, adiponectin, or leptin (data not shown for adipocytokines), BMI *Z* score, or waist circumference. The association with total cholesterol and LDL cholesterol was inconsistent. For most outcomes, adjustment for BMI *Z* score had very little impact on the model. In absolute terms, we estimated that youth with T1DM with a DASH score in the top tertile had a 0.07 lower LDL/HDL ratio and 0.2 lower A_{1c} compared with those with a DASH score in the lowest tertile, independent of confounders. We also evaluated the role of A_{1c} as a potential intermediate factor in the relationship between DASH score and lipid levels. Adjustment for A_{1c} either attenuated or removed all significant associations with lipid levels.

As shown in Table 5, in youth with T2DM, higher DASH diet adherence was associated significantly with LDL particle density and BMI *Z* score but not with LDL or HDL cholesterol, apoB, triglycerides, waist circumference, A_{1c}, adiponectin, or leptin (data not shown). The association with cholesterol was inconsistent. In absolute terms, youth with a DASH score in the top tertile had 0.01 higher LDL particle density and a 0.24 lower BMI *Z* score than youth in the lowest DASH score tertile, independent of confounders.

Discussion

Several observational studies in adults have shown that adherence to a DASH-like diet has positive effects on cardiovascular health, including reduced risk of hypertension, T2DM, heart failure, coronary heart disease, stroke, and overall mortality.[7–12] However, few data exist on its effect on more proximal or intermediate risk factors,[6,14,15] or for youth.[28,29]

Our study found significant associations of adherence to DASH diet with LDL/HDL ratio in youth with T1DM and with LDL particle density in youth with T2DM. Our findings with total cholesterol were suggestive of an association, but require replication. To the best of our knowledge, the only large studies of the effect of the DASH diet on lipids are the DASH and PREMIER trials, in which it was shown that the DASH intervention group experienced significant and remarkably large reductions in total (13.7 mg/dL), LDL (10.7 mg/dL), and HDL (3.7 mg/dL) cholesterol compared with the control group but no changes in triglycerides or LDL/HDL ratio.[6] The PREMIER trial reported similar findings with marked reductions in total and LDL cholesterol but no changes in triglycerides.[30] A smaller intervention study in patients with metabolic syndrome has shown significant increases in HDL cholesterol and decreases in triglycerides but used a calorie-restricted version of the DASH diet.[15]

One of the mechanisms by which a dietary pattern may affect cardiovascular risk factors may be via changes in energy intake, which in turn affect weight. In youth with T1DM, the initial inverse association of DASH diet with BMI *Z* score was explained by physical activity, sedentary behavior, and smoking. There was no association of DASH diet with waist circumference in this group. However, in T2DM youth, BMI *Z* score was strongly associated with DASH diet independent of lifestyle and other factors, whereas the association with waist circumference was inconsistent.

Similar to the findings of the national Youth Risk Behavior Surveillance System, we observed relatively high reports of vigorous physical activity.[31] Compared with objective assessment methods, it has been suggested that self-report of vigorous activity with the use of the Youth Risk Behavior Surveillance System questions may lead to overreport-ing.[32] It is conceivable that inaccuracies in measurement of physical activity impeded our ability to disentangle the mediating role of physical activity in the relationship of DASH diet and adiposity.

We observed a marked association of adherence to DASH diet with A_{1c} in youth with T1DM, a finding that, to the best of our knowledge, has not been shown before. It is tempting to speculate that a higher-quality diet may affect glucose control physiologically via nutrient constituents such as fiber that slow digestion time. Alternatively, it is conceivable that both A_{1c} and DASH scores reflect a latent construct related to general health behaviors and quality of diabetes care, but do not have a causal relation.

Previous cross-sectional and prospective studies have shown associations of A_{1c} with lipid levels,[33–36] apoB, and dense LDL.[37] In the Diabetes Control and Complications Trial, intensive glucose control significantly reduced total and LDL cholesterol and triglycerides in patients with T1DM.[34,35] Likewise, in the SEARCH population, glycemic control predicted short-term changes in lipid levels.[36] We therefore presented data on the associations between DASH diet and lipids with and without adjustment for A_{1c}. Our findings suggest that there may be multiple pathways linking dietary intake to lipid levels, some operating via concomitant changes in A_{1c} and some operating independently.

Our study has several limitations. Because of the cross-sectional design, determinations of sequence of events and causal inferences were limited. Our sample of T2DM youth was still limited and might have influenced our ability to reach definitive conclusions. Assessment of dietary intake is prone to error, resulting in misclassification of exposure measurement; however, it is unlikely that such misclassification would be differential in relation to the outcomes considered. Sodium intake is generally not well assessed by food frequency questionnaire. The association magnitudes were of moderate clinical significance. Finally, we did not explicitly adjust for multiple comparisons. We fitted our models in a hierarchical sequence from simpler to more complex and thus used a systematic approach for examining whether associations were significant. However, given the large number of CVD risk factors studied, we cannot exclude the possibility that some of the observed associations with marginal *P* values may be due to chance and could become marginally nonsignificant if replicated.

We have previously shown that dietary intake in youth with diabetes mellitus falls markedly short of current recommenda-tions,[22] and the overall adherence score for the DASH diet is quite low.[13] It has been suggested that very high DASH adherence levels like those in intervention settings may be needed to affect health outcomes. However, the low overall dietary quality in our population did not preclude us from finding associations. In T1DM, higher adherence to the DASH diet was significantly associated with LDL/HDL ratio and A_{1c}. In youth with T2DM, DASH adherence was significantly associated with LDL particle density and BMI. In conclusion, the DASH dietary pattern may prove beneficial in the prevention and management of CVD risk in this vulnerable population of youth with diabetes mellitus, among whom there is clearly much room for improvement in the quality of dietary intake.

Acknowledgments

The SEARCH for Diabetes in Youth Study is indebted to the many youth and their families and their healthcare providers, whose participation made this study possible.

Sources of Funding: The authors wish to acknowledge the involvement of the General Clinical Research Centers at the Medical University of South Carolina (grant M01 RR01070); Seattle Children's Hospital and the University of Washington School of Medicine (grants M01RR00037 and M01RR001271); Colorado Pediatric General Clinical Research Center (grant M01 RR00069); and the Institutional Clinical and Translational Science Award, National Institutes of Health/National Center for Research Resources at the University of Cincinnati (grant 1UL1RR026314-01). The SEARCH for Diabetes in Youth Study is funded by the Centers for Disease Control and Prevention (PA No. 00097 and DP-05-069) and supported by the National Institute of Diabetes and Digestive and Kidney Diseases. Site contract numbers are as follows: Kaiser Permanente Southern California (U01 DP000246), University of Colorado Health Sciences Center (U01 DP000247), Pacific Health Research Institute (U01 DP000245), Children's Hospital Medical Center (Cincinnati) (U01 DP000248), University of North Carolina at Chapel Hill (U01 DP000254), University of Washington School of Medicine (U01 DP000244), and Wake Forest University School of Medicine (U01 DP000250). The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention and the National Institute of Diabetes and Digestive and Kidney Diseases.

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Clinical Perspective

Since the publication of the landmark findings of the Dietary Approaches to Stop Hypertension (DASH) trial, the DASH diet has become well known as an effective whole-diet approach to hypertension prevention and blood pressure reduction. However, little is known about its impact on other cardiovascular disease risk factors, especially in youth with type 1 and type 2 diabetes mellitus. In this cross-sectional study, we explored the association of DASH diet with blood lipid levels, lipoproteins, adipocytokines, and measures of adiposity and glycemic control in 2130 youth aged 10 to 22 years with physician-diagnosed diabetes mellitus. Dietary intake was assessed by food frequency questionnaire, categorized into the DASH food groups, and assigned an adherence score. In both type 1 and type 2 diabetes mellitus youth, the average DASH diet scores were low, suggesting very poor dietary intake quality in this population. Of the various cardiovascular disease risk factors evaluated, we found that among youth with type 1 diabetes mellitus, higher adherence to the DASH diet was significantly associated with lower levels of low-density lipoprotein/high-density lipoprotein ratio and A_{1c}. In youth with type 2 diabetes mellitus, higher adherence to the DASH diet was significantly associated with higher low-density lipoprotein particle density and lower body mass index *Z* score. In conclusion, the DASH dietary pattern may prove beneficial in the prevention and management of cardiovascular disease risk in this vulnerable population of youth with diabetes mellitus, among whom there is clearly much room for improvement in the quality of dietary intake.

Table 1

Characteristics of the 2130 Youth in the Study Sample by Diabetes Type and DASH Adherence Score

	T1DM (n=1810) Tertiles of DASH Score				T2DM (n=320) Tertiles of DASH Score			
	1 (Lowest)	2 (Medium)	3 (Highest)	P^*	1 (Lowest)	2 (Medium)	3 (Highest)	P^*
DASH score, mean (SD)	30.0 (4.6)	39.9 (2.4)	49.9 (4.7)	<0.0001	25.9 (4.9)	36.4 (2.3)	46.7 (5.0)	<0.0001
Age, mean (SD), y	15.0 (3.0)	14.7 (3.1)	14.9 (3.1)	0.304	16.8 (2.8)	16.8 (2.8)	16.3 (3.0)	0.323
Female, %	52.6	46.8	47.1	0.080	66.0	65.4	63.5	0.924
Race/ethnicity, %				<0.0001				0.087
Non-Hispanic white	72.3	79.3	81.9		17.0	22.4	14.9	
Black	12.1	5.9	4.6		41.5	38.3	29.0	
Hispanic	10.9	9.9	9.9		13.2	19.6	25.2	
Other	4.6	4.8	3.5		28.3	19.6	30.8	
Household income, %				<0.0001				
<$25 000	15.2	12.7	8.6		50.0	42.7	51.1	0.299
$25 000–$74 999	47.7	44.8	40.1		44.2	44.9	35.2	
≥$75 000	37.0	42.4	51.2		5.8	12.4	13.6	
No high school diploma, %	4.2	3.5	3.3	0.712	16.0	13.1	14.0	0.821
Watch television >2 h/d, %	60.6	55.6	48.3	<0.0001	79.8	75.5	72.0	0.413
Vigorous physical activity ≥2 d/wk, %	70.5	76.2	83.9	0.0001	62.3	62.6	79.4	0.009
Smoking, %	12.1	7.4	4.6	<0.0001	15.1	17.8	9.3	0.195

DASH indicates Dietary Approaches to Stop Hypertension; T1DM, type 1 diabetes mellitus; and T2DM, type 2 diabetes mellitus.

* *P* ANOVA or χ^2 test.

Table 2

Mean Energy, Food Group, and Nutrient Intakes According to Diabetes Type and DASH Adherence Score

	T1DM (n = 1810) Tertiles of DASH Score			T2DM (n=320) Tertiles of DASH Score		
Diet Characteristic	**1 (Lowest)**	**2 (Medium)**	**3 (Highest)**	**1 (Lowest)**	**2 (Medium)**	**3 (Highest)**
DASH score, mean (SD)	30 (4.6)	39.9 (2.4)	49.9 (4.7)	25.9 (4.9)	36.4 (2.3)	46.7 (5.0)
Energy, mean (SD), kcal/d	1987 (906)	1944 (1019)	1907 (767)	1961 (1031)	1764 (811)	1905 (1130)
Food groups, mean (SD), servings per 1000 kcal						
Total grains	2.16 (0.75)	2.25 (0.77)	2.21 (0.71)*	2.02 (0.78)	2.18 (0.81)	2.12 (0.73)
High-fiber grains	0.04 (0.1)	0.05 (0.1)	0.07 (0.2)*	0.04 (0.1)	0.04 (0.1)	0.04 (0.1)
Vegetables	1.1 (0.8)	1.1 (0.8)	1.3 (1.0)*	1.3 (0.9)	1.3 (1.0)	1.7 (1.6)
Fruit	0.7 (0.6)	1.0 (0.8)	1.3 (0.8)*	0.6 (0.6)	0.9 (0.7)	1.3 (1.1)*
Total dairy	0.9 (0.6)	1.0 (0.6)	1.2 (0.6)*	0.6 (0.5)	0.8 (0.6)	0.8 (0.5)*
Low-fat dairy	0.4 (0.5)	0.6 (0.5)	0.7 (0.6)*	0.1 (0.3)	0.3 (0.6)	0.5 (0.5)*
Meat	1.6 (0.6)	1.3 (0.6)	1.1 (0.5)*	1.8 (0.7)	1.5 (0.6)	1.4 (0.6)*
Nuts and seeds	0.1 (0.3)	0.4 (0.5)	0.7 (0.8)*	0.1 (0.4)	0.3 (0.6)	0.5 (0.5)*
Fats and oils	2.4 (1.5)	2.1 (1.5)	1.7 (1.5)*	2.5 (1.5)	2.0 (1.7)	1.8 (1.7)*
Sweets	1.1 (0.8)	0.9 (0.6)	0.8 (0.5)*	1.3 (1.0)	1.1 (0.9)	0.9 (0.7)*
Nutrients, mean (SD), per 1000 kcal						
Carbohydrates, g	114 (19)	118 (18)	124 (17)*	114 (22)	119 (21)	123 (22)*
Total fat, g	44 (6)	42 (6)	41 (6)*	44 (8)	42 (7)	41 (7)*
Saturated fat, g	16 (3)	15 (2)	14 (2)*	16 (3)	15 (3)	14 (3)*
Protein, g	40 (7)	39 (5)	39 (5)*	39 (8)	38 (7)	39 (7)
Fiber, g	6 (2)	7 (2)	8 (3)*	6 (2)	7 (2)	8 (3)*
Calcium, mg	539 (223)	610 (242)	669 (242)*	378 (159)	429 (199)	510 (237)*
Magnesium, mg	123 (27)	138 (27)	155 (31)*	109 (24)	122 (25)	140 (31)*
Potassium, mg	2332 (1168)	2524 (1303)	2765 (1152)*	2077 (1225)	2066 (1025)	2591 (1516)*

DASH indicates Dietary Approaches to Stop Hypertension; T1DM, type 1 diabetes mellitus; and T2DM, type 2 diabetes mellitus. DASH-recommended servings per 1000 kcal per day: ≥3 servings of grains; ≥2 servings of fruits; ≥2 servings of vegetables; ≥1 serving of dairy; ≤1 serving of lean meats, poultry, or fish; ≥0.3 servings of nuts, seeds, or legumes; ≤1.5 servings of fats and oils; ≤0.3 servings of sweets and added sugar.

* $P<0.05$.

Table 3

Mean Cardiovascular Disease Risk Factor Levels According to Diabetes Type and DASH Adherence Score

	T1DM Tertiles of DASH Score				T2DM Tertiles of DASH Score			
Cardiovascular Disease Risk Factor	**n**	**1 (Lowest)**	**2 (Medium)**	**3 (Highest)**	**n**	**1 (Lowest)**	**2 (Medium)**	**3 (Highest)**
Total cholesterol, mg/dL	1615	171.4 (32.8)	169.4 (33.4)	166.6 (34.1)	313	186.6 (42)	185.4 (45.3)	172.5 (37.6)
LDL cholesterol, mg/dL	1615	100.4 (25.6)	99.2 (27.8)	96.8 (26.2)	313	106.4 (30.6)	111.4 (34.4)	101.9 (31.2)
HDL cholesterol, mg/dL	1616	54.4 (13.5)	53.9 (12)	54.3 (12.2)	313	43 (12.5)	43.2 (10.6)	41.8 (9.1)
LDL/HDL ratio	1615	1.95 (0.68)	1.94 (0.75)	1.86 (0.63)	313	2.60 (0.88)	2.67 (0.87)	2.52 (0.94)
Triglycerides, mg/dL	1615	84.7 (82.6)	86.2 (133.3)	78.1 (56)	254	257.4 (508.4)	153.8 (143.3)	157.6 (135.3)
LDL particle density, flotation rate	1302	0.28 (0.02)	0.28 (0.02)	0.28 (0.02)	182	0.24 (0.04)	0.26 (0.03)	0.26 (0.03)
Apolipoprotein B, mg/dL	1317	77.7 (21.7)	76.3 (22.4)	74.9 (20.9)	184	106.2 (75.8)	96.8 (27.8)	86.1 (25.1)
Body mass index *Z* score	1518	0.64 (0.86)	0.66 (0.87)	0.57 (0.89)	224	2.22 (0.63)	1.99 (0.74)	1.93 (0.77)
Waist circumference, cm	1578	78.7 (11.8)	78.8 (11.8)	78.5 (11.2)	254	114.8 (27.5)	110.6 (18.1)	106.4 (21.9)
A_{1c},%	1518	8.57 (1.69)	8.33 (1.66)	8.16 (1.47)	224	7.42 (2.41)	7.86 (2.45)	7.12 (2.08)

Values are mean (SD). DASH indicates Dietary Approaches to Stop Hypertension; T1DM, type 1 diabetes mellitus; T2DM, type 2 diabetes mellitus; LDL, low-density lipoprotein; and HDL, high-density lipoprotein.

Table 4

Association of DASH Score With Cardiovascular Disease Risk Factors in Youth With Type 1 Diabetes Mellitus

Cardiovascular Disease Risk Factor	β^*	SE	*P*	Tertile 1†	Tertile 3†	Mean Difference (Tertile 3–Tertile 1)
Total cholesterol, mg/dL (n=1615)						
Model 1	−2.05	0.92	0.026	171.1	167.4	−3.7
Model 2	−1.53	0.93	0.101	170.7	168	−2.7
Model 3	−2.37	0.97	0.014	171.6	167.4	−4.2
Model 4	−0.95	0.89	0.285	171.5	169.8	−1.7
LDL cholesterol, mg/dL (n=1615)						
Model 1	−1.76	0.74	0.017	100.5	97.3	−3.2
Model 2	−1.42	0.75	0.060	100.2	97.7	−2.5
Model 3	−1.85	0.78	0.017	101.2	97.9	−3.3
Model 4	−1.00	0.72	0.166	100.9	99.1	−1.8
HDL cholesterol, mg/dL (n=1615)						
Model 1	0.25	0.34	0.473	53.8	54.2	0.4
Model 2	0.17	0.35	0.625	53.8	54.1	0.3
Model 3	−0.14	0.35	0.689	53.4	53.2	−0.2
Model 4	0.20	0.35	0.573	53.6	54	0.4
LDL/HDL ratio (n=1615)						
Model 1	−0.05	0.02	0.008	1.97	1.88	−0.09
Model 2	−0.04	0.02	0.034	1.97	1.89	−0.08
Model 3	−0.04	0.02	0.050	2	1.93	−0.07
Model 4	−0.03	0.02	0.080	1.98	1.92	−0.06
Log triglycerides, mg/dL (n=1615)‡						
Model 1	−0.022	0.014	0.117	71.8	69.1	−2.7
Model 2	−0.008	0.014	0.544	71.1	70	−1.1
Model 3	−0.010	0.014	0.508	72.4	71.2	−1.2
Model 4	−0.001	0.013	0.923	72.5	72.4	−0.1
LDL particle density, flotation rate (n=1302)						
Model 1	0.0006	0.0006	0.336	0.28	0.28	0
Model 2	0.0002	0.0006	0.736	0.28	0.28	0

Cardiovascular Disease Risk Factor	β*	SE	*P*	Tertile 1†	Tertile 3†	Mean Difference (Tertile 3–Tertile 1)
Model 3	0.0003	0.0006	0.682	0.28	0.28	0
Model 4	−0.00002	0.0006	0.979	0.28	0.28	0
Log apolipoprotein B, mg/dL (n=1317)‡						
Model 1	−0.012	0.0081	0.037	74.7	72.5	−2.2
Model 2	−0.012	0.0082	0.149	74.5	72.9	−1.6
Model 3	−0.017	0.0085	0.051	75.2	73	−2.2
Model 4	−0.007	0.0077	0.361	74.9	74	−0.9
Body mass index *Z* score (n=1518)						
Model 1	−0.045	0.025	0.075	0.67	0.59	−0.08
Model 2	−0.039	0.026	0.128	0.66	0.59	−0.07
Model 3						
Model 4	−0.042	0.026	0.102	0.9	0.83	−0.07
Waist circumference, cm (n=1578)						
Model 1	−0.28	0.29	0.320	79.4	78.9	−0.5
Model 2	−0.20	0.29	0.480	79.3	79	−0.3
Model 3	0.17	0.18	0.319	79.6	79.9	0.3
Model 4	−0.22	0.29	0.455	79.6	79.2	−0.4
A_{1c}, % (n=1518)						
Model 1	−0.12	0.04	0.007	8.51	8.30	−0.21
Model 2	−0.11	0.04	0.016	8.50	8.31	−0.19
Model 3	−0.11	0.04	0.014	8.49	8.29	−0.20
Model 4						

DASH indicates Dietary Approaches to Stop Hypertension; LDL, low-density lipoprotein; and HDL, high-density lipoprotein.

Model 1 is adjusted for age, sex, race, site, diabetes mellitus duration, income; model 2, model 1 +television time, vigorous physical activity, smoking; model 3, model 2+body mass index *Z*score; and model 4, model 3+A_{1c}.

* β for 10-unit DASH increase.

† Mean risk factor estimated at tertiles 1 and 3 of DASH score.

‡ Tertile 1 and 3 estimates back-transformed to original units.

Table 5

Association of DASH Score With Cardiovascular Disease Risk Factors in Youth With Type 2 Diabetes Mellitus

Cardiovascular Disease Risk Factor	β*	SE	*P*	Tertile 1†	Tertile 3†	Mean Difference (Tertile 3–Tertile 1)
Total cholesterol, mg/dL (n=313)						
Model 1	−4.81	2.90	0.099	185.7	176.7	−9
Model 2	−4.74	2.94	0.109	171.8	163.3	−8.5
Model 3	−7.36	3.08	0.018	186.5	173.3	−13.2
Model 4	−4.02	2.72	0.140	186.4	178.8	−7.6
LDL cholesterol, mg/dL (n=313)						
Model 1	−2.47	2.33	0.291	108.8	104.1	−4.7
Model 2	−2.49	2.37	0.293	103.8	99.4	−4.4
Model 3	−4.32	2.55	0.092	110.8	103	−7.8
Model 4	−2.16	2.31	0.352	109.1	105	−4.1
HDL cholesterol, mg/dL (n=313)						
Model 1	−0.26	0.69	0.708	42.7	42.2	−0.5
Model 2	−0.25	0.70	0.727	39.8	39.4	−0.4
Model 3	−0.77	0.72	0.289	47.1	45.8	−1.3
Model 4	−0.26	0.70	0.712	42.6	42.2	−0.4
LDL/HDL ratio (n=313)						
Model 1	−0.05	0.06	0.391	2.65	2.55	−0.1
Model 2	−0.05	0.06	0.401	2.71	2.62	−0.09
Model 3	−0.06	0.07	0.328	2.45	2.33	−0.12
Model 4	−0.04	0.06	0.480	2.65	2.57	−0.08
Log triglycerides, mg/dL (n=254)‡						
Model 1	−0.03	0.05	0.591	132.5	126.5	−6
Model 2	−0.03	0.05	0.517	121.6	115.2	−6.4
Model 3	−0.03	0.05	0.517	111.9	105.6	−6.3
Model 4	−0.02	0.04	0.635	134.8	129.5	−5.3
LDL particle density, flotation rate (n=182)						
Model 1	0.01	0.003	0.003	0.25	0.27	0.02
Model 2	0.01	0.003	0.004	0.26	0.27	0.01

Cardiovascular Disease Risk Factor	β*	SE	*P*	Tertile 1†	Tertile 3†	Mean Difference (Tertile 3–Tertile 1)
Model 3	0.01	0.003	0.015	0.26	0.27	0.01
Model 4	0.01	0.002	0.008	0.25	0.26	0.01
Log apolipoprotein B, mg/dL (n=184)‡						
Model 1	−0.05	0.03	0.068	93.1	85.3	−7.8
Model 2	−0.04	0.03	0.093	82.9	76.7	−6.2
Model 3	−0.05	0.03	0.076	83.5	76.2	−7.3
Model 4	−0.03	0.02	0.256	91.6	87	−4.6
Body mass index *Z* score (n=224)						
Model 1	−0.13	0.05	0.010	2.11	1.85	−0.26
Model 2	−0.14	0.05	0.009	2.05	1.81	−0.24
Model 3						
Model 4	−0.14	0.05	0.009	2.1	1.84	−0.26
Waist circumference, cm (n=254)						
Model 1	−2.89	1.55	0.064	108.6	103.4	−5.2
Model 2	−3.01	1.57	0.057	108.9	103.5	−5.4
Model 3	−1.16	1.08	0.286	74.3	72.3	−2
Model 4	−3.03	1.58	0.056	113.5	107.8	−5.7
A_{1c}, % (n=224)						
Model 1	−0.007	0.16	0.965	7.67	7.66	−0.01
Model 2	−0.029	0.16	0.859	6.63	6.68	0.05
Model 3	−0.023	0.17	0.889	7.17	7.13	−0.04
Model 4						

DASH indicates Dietary Approaches to Stop Hypertension; LDL, low-density lipoprotein; and HDL, high-density lipoprotein.

Model 1 is adjusted for age, sex, race, site, diabetes duration, income; model 2, model 1 +television time, vigorous physical activity, smoking; model 3, model 2+body mass index *Z* score; and model 4, model 3+A_{1C}.

* β for 10-unit DASH increase.

† Mean risk factor estimated at tertiles 1 and 3 of DASH score.

‡ Tertile 1 and 3 estimates back-transformed to original units.