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SHORT COMMUNICATION

Change in DASH diet score and cardiovascular risk factors in youth with type 1 and type 2 diabetes mellitus: The SEARCH for Diabetes in Youth Study

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Youth with diabetes are at an increased risk of cardiovascular disease (CVD). Adherence to the Dietary Approaches to Stop Hypertension (DASH) diet has been shown to improve CVD risk. In this study, we evaluated whether changes in diet quality as characterized by DASH are associated with changes in CVD risk factors in youth with diabetes over time. Longitudinal mixed models were applied to data from 797 participants in the SEARCH for Diabetes in Youth Study representing three time points: baseline, 12- and 60-month follow-up. Data were restricted to youth whose diabetes was first diagnosed in 2002–2005. DASH-related adherence was poor and changed very little over time. However, an increase in DASH diet score was significantly associated with a decrease in HbA_{1c} levels in youth with type 1 diabetes ($\beta = -0.20$, P-value $= 0.0063$) and a decrease in systolic blood pressure among youth with type 2 diabetes ($\beta = -2.02$, P-value $= 0.0406$). Improvements in dietary quality may be beneficial in youth with type 1 or type 2 diabetes. However, further work in larger groups of youth with type 1 and 2 diabetes is desirable.

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INTRODUCTION

Observational studies and clinical trials have shown that adherence to the Dietary Approaches to Stop Hypertension (DASH) diet is associated with improved cardiovascular health and cardiovascular disease (CVD) risk in adults and youth.[1–4] Youth with diabetes are at an increased risk of developing CVD.[5] In a cross-sectional analysis, the SEARCH for Diabetes in Youth Study (SEARCH) previously reported that consumption of a more DASH-like diet was inversely related to CVD risk factors including hypertension, total cholesterol, low-density lipoprotein, low-density lipoprotein/high-density lipoprotein ratio and hemoglobin A1c (HbA_{1c}).[6,7] The DASH diet emphasizes fruits, vegetables, low-fat milk products, whole grains, fish/poultry/nuts, lean red meats and limited intake of sugar and sweets, resulting in low-saturated fat, cholesterol, total fat and sodium intake.[8] Thus, good adherence to the diet plan equates to a higher dietary quality. A few studies have examined the association of a DASH-like diet and hypertension in youth and adolescents;[7,9–11] however, no study has examined several CVD risk factors and DASH prospectively in youth with or without diabetes. This study investigated whether change in a DASH diet score was associated with change in CVD risk over multiple time points.

METHODS

SEARCH is an ongoing multicenter study of physician-diagnosed diabetes mellitus in youth aged <20 years at diagnosis beginning in 2001. Study design details have been published.[12] The study has been approved by all participating local institutional review boards. The sample included data from an initial (baseline) visit and two subsequent follow-up visits targeting 12 and 60 months. Follow-up visits were, on average, 14.7 months after the initial visit (s.d. = 3.1 months; range = 6–26 months) and 62.9 months (6.3 months; range = 29–87 months), respectively.

Data collection followed SEARCH standardized protocols.[6,7,12] Cardiovascular risk measures included diastolic blood pressure (BP), systolic BP, HDL, low-density lipoprotein, total cholesterol, triglycerides, HbA_{1c}, waist circumference and body mass index calculated as weight per height^2 (kg m^{-2}) and converted to body mass index-*Z* score.[6] DASH adherence was assessed with an index score ranging from 0 to 80 comprised of the sum of meeting recommendations on eight food groups (grains, vegetables, fruits, dairy, meat, nuts/seeds/legumes, fats/oils and sweets) based on the SEARCH 85-item food frequency questionnaire.[6,7] A maximum score of 10 could be achieved for each food group when the intake met the recommendation and lower intakes were scored proportionally. Previous reports describe diet intake according to DASH food groups and illustrate the scoring algorithm.[6,7] Food groups were created by either collapsing food items on the basis of their major components or by disaggregating composite foods into constituent foods. Duration of diabetes, age, gender, race/ethnicity, income, study site, height, weight, waist circumference and physical activity was also obtained for each participant based on SEARCH protocols.[6,7,12]

This analysis was restricted to youth whose diabetes was first diagnosed in 2002–2005, were $\geqslant 10$ years of age ($n = 1386$), had diabetes for at least 6 months at their initial visit ($n = 1014$) and had completed a baseline food frequency questionnaire. Of the 969 participants who met these criteria, youth were also excluded sequentially for missing CVD-related measures ($n = 130$) and those fasting <8 h at any visit ($n = 42$).

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The final sample consisted of 797 participants. Of the 617 youth with type 1 diabetes, 278 had a complete 12-month follow-up visit (i.e. including diet information) and 231 had a complete 60-month follow-up visit. A total of 65 and 53 participants, respectively, had complete follow-up visits of the 180 youth with type 2 diabetes.

Statistical analyses

Statistical analyses were conducted using SAS 9.2 (SAS Institute, Cary, NC, USA) stratified by diabetes type. Longitudinal mixed-models with a random intercept to account for within-subject dependence were used to assess the relationship between the DASH diet score and CVD risk factors. Available CVD risk factor measurements were modeled as a function of baseline DASH score and change in DASH from baseline; these two captured the relationship between DASH score at baseline and the outcome as well as whether a change in DASH score was associated with the outcome longitudinally. Each model also adjusted for age, disease duration, race/ethnicity, sex, study site, income, height, body mass index-*Z* score and waist circumference.

RESULTS

Mean values of CVD risk factors and change in DASH diet score are shown by visit and diabetes type in Table 1. Dietary quality at baseline was poor with a mean of 39.8 (s.d. = 9.0) for youth with type 1 diabetes and 36.4 (s.d. = 9.6) for youth with type 2 diabetes. Additionally, DASH score did not appear to change systematically over time, with a mean change of -0.18 (s.d. = 10.1), for follow-up visit 1 and − 0.41 (s.d. = 11.2) for follow-up visit 2 in youth with type 1 diabetes. In youth with type 2 diabetes, the overall mean change in DASH score was also small, with -0.36 (s.d. = 10.7) at follow-up visit 1 and 1.99 (s.d. = 11.4) at follow-up visit 2. Several CVD risk factors increased over time in youth with type 1 diabetes, including BP, total cholesterol, triglycerides and HbA_{1c} levels. HDL and HbA_{1c} also significantly increased over time in youth with type 2 diabetes.

For each risk factor, Table 2 displays the results of the longitudinal mixed-models which separate the effect of diet at baseline from the effect of change in diet and included time-varying covariates. In youth with type 1 diabetes, change in DASH-related diet score was inversely associated with HbA_{1c} levels. Thus, a 10-point positive change (increase) in DASH score resulted in a 0.20% decrease in HbA_{1c} levels. In youth with type 2 diabetes, change in DASH score was inversely associated with systolic BP. Here, a 10-point increase in DASH score resulted in a 2.02-mm Hg decrease in systolic BP. Additionally, a significant cross-sectional relationship was observed between DASH score at baseline and low-density lipoprotein/high-density lipoprotein ratio ($\beta_1 = -0.14$, *P*-value = 0.0443) and DASH score at baseline and total cholesterol ($\beta_1 = -7.78$, *P*-value = 0.0093).

DISCUSSION

To the best of our knowledge, the effects of dietary changes characterized by a DASH diet score on CVD risk factors in youth with diabetes have not been evaluated in observational studies. In adults, greater adherence to a DASH diet has been associated with significantly reduced risk of heart failure, CVD and stroke in longitudinal studies.[1,2,13,14] However, these studies focused on the occurrence of an event rather than change in CVD risk factors over time. In adolescents, one study has shown that a DASH-style diet can help curb gains in body mass index[15] and in two others, a DASH-style diet was associated with improved BP.[9,11] In general, a high-quality diet has been shown to positively affect energy intake, vascular flow and glucose control.[16]

This study found that a positive change in diet was associated with improvements in HbA_{1c} levels among youth with type 1 diabetes and systolic BP in youth with type 2 diabetes. Strengths of this study include the longitudinal modeling to examine the change in DASH diet and the cross-sectional effect of

Table 1. Mean values (s.d.) for DASH diet score and cardiovascular risk factors by visit and diabetes type

	Baseline visit	*Follow-up visit 1 (12-month)*	*Follow-up visit 2 (60-month)*
Type 1 diabetes mellitus[a]			
DASH score at baseline	39.8 (9.0)	39.7 (9.0)	39.9 (8.9)
Change in DASH score[b]	—	− 0.18 (10.1)	− 0.41 (11.2)
Diastolic BP (mm Hg)[c]	**65.4 (9.2)**	**66.9 (9.0)**	**71.5 (8.3)**
Systolic BP (mm Hg)[c]	**105.2 (10.4)**	**107.1 (10.2)**	**110.7 (9.1)**
HDL cholesterol (mg dl^{-1})	52.8 (12.3)	53.0 (11.3)	53.5 (13.7)
LDL cholesterol (mg dl^{-1})	94.1 (25.7)	94.1 (25.1)	97.3 (28.9)
LDL/HDL ratio	1.86 (0.62)	1.86 (0.64)	1.95 (0.82)
Total cholesterol (mg dl^{-1})[c]	**161.3 (31.8)**	**163.4 (31.7)**	**172.0 (37.4)**
Triglycerides (mg dl^{-1})[c]	**71.6 (41.5)**	**83.3 (61.6)**	**111.6 (143.0)**
BMI-*Z* score	0.52 (0.98)	0.50 (0.96)	0.65 (0.91)
Waist circumference (cm)[c]	77.2 (11.7)	79.3 (11.7)	86.8 (12.0)
HbA1c (%)[c]	**7.97 (1.71)**	**8.55 (1.76)**	**9.31 (2.17)**
Type 2 diabetes mellitus[d]			
DASH score at baseline	36.4 (9.6)	36.7 (9.4)	36.8 (9.9)
Change in DASH score[e]	—	− 0.36 (10.7)	1.99 (11.4)
Diastolic BP (mm Hg)	72.9 (9.9)	71.2 (10.2)	74.6 (8.2)
Systolic BP (mm Hg)	118.2 (12.5)	115.6 (11.2)	117.4 (13.2)
HDL cholesterol (mg dl^{-1})[c]	**41.6 (9.7)**	**41.6 (8.3)**	**45.7 (13.0)**
LDL cholesterol (mg dl^{-1})	102.6 (28.3)	102.4 (32.3)	108.1 (34.4)
LDL/HDL Ratio	2.57 (0.89)	2.50 (0.76)	2.50 (0.94)
Total cholesterol (mg dl^{-1})	174.3 (35.3)	174.0 (37.5)	184.5 (41.1)
Triglycerides (mg dl^{-1})	169.7 (213.4)	165.5 (172.4)	171.9 (182.8)
BMI-*Z* score[c]	**2.11 (0.77)**	**2.11 (0.58)**	**1.77 (0.84)**
Waist circumference (cm)	110.7 (23.0)	113.0 (18.4)	113.1 (21.3)
HbA1c (%)[c]	**7.21 (2.21)**	**7.80 (2.53)**	**9.37 (2.95)**

Abbreviations: BMI, body mass index; BP, blood pressure; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein. [a]617 participants for baseline visit. [b]278 participants for follow-up visit 1 and 231 for follow-up visit 2. [c]Significantly varied by visit, $P < 0.05$. [d]180 participants for baseline visit. [e]65 participants for follow-up visit 1 and 53 for follow-up visit 2. Bold values were those values that significantly varied by visit, $P < 0.05$.

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Table 2. Longitudinal mixed modeling results for change in DASH diet score and cardiovascular disease risk factors

	β_1, *Effect of DASH score at baseline*	*s.e.*	P-*value*	β_2, *Effect of change in DASH score*	*s.e.*	P-*value*
Type 1 diabetes mellitus[a]						
Diastolic BP (mm Hg)	−0.11	0.34	0.7574	−0.07	0.39	0.8523
Systolic BP (mm Hg)	−0.18	0.37	0.6234	0.35	0.40	0.3908
HDL cholesterol (mg dl^{-1})	0.31	0.49	0.5234	−0.32	0.44	0.4701
LDL cholesterol (mg dl^{-1})	−1.81	1.11	0.1038	0.39	0.91	0.6677
LDL/HDL ratio	−0.05	0.03	0.0604	0.02	0.02	0.3565
Total cholesterol (mg dl^{-1})	−1.84	1.36	0.1764	−0.27	1.25	0.8291
Triglycerides (mg dl^{-1})	−0.35	3.08	0.9107	1.13	3.71	0.7609
BMI−*Z* score	−0.02	0.02	0.3533	0.004	0.02	0.8399
Waist circumference (cm)	0.09	0.03	0.7236	−0.02	0.23	0.9285
HbA1c (%)	−0.10	0.07	0.1698	**−0.20**	**0.07**	**0.0063**
Type 2 diabetes mellitus[b]						
Diastolic BP (mm Hg)	−0.29	0.72	0.6869	−0.10	0.79	0.8968
Systolic BP (mm Hg)	−0.85	0.85	0.3185	**−2.02**	**0.97**	**0.0406**
HDL cholesterol (mg dl^{-1})	−0.23	0.76	0.7588	0.08	0.67	0.9060
LDL cholesterol (mg dl^{-1})	−4.72	2.38	0.0504	−1.59	2.09	0.4492
LDL/HDL ratio	**−0.14**	**0.07**	**0.0443**	−0.06	0.07	0.3570
Total cholesterol (mg dl^{-1})	**−7.78**	**2.93**	**0.0093**	−1.31	2.49	0.5993
Triglycerides (mg dl^{-1})	−24.00	17.17	0.1660	−3.68	10.39	0.7236
BMI−*Z* Score	0.02	0.04	0.6071	0.05	0.04	0.1986
Waist circumference (cm)	−1.87	1.06	0.0822	−1.97	1.14	0.0864
HbA1c (%)	0.16	0.18	0.4026	−0.08	0.18	0.6492

Abbreviations: BMI, body mass index; BP, blood pressure; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein. Models adjusted for the following covariates: diabetes mellitus duration at visit, age at visit, height at visit, BMI-*Z* score at visit, waist circumference at visit, physical activity, gender, race, income at visit and study site. β_1, change per 10-unit increase in DASH score at baseline; β_2, change per 10-unit increase in change in DASH Score. [a]1126 observations were used for Type 1 diabetes participants (including 617 participants at baseline, 278 participants for follow-up visit 1 and 231 participants for follow-up visit 2). [b]298 observations were used for Type 2 diabetes participants (including 180 participants at baseline, 65 participants for follow-up visit 1 and 53 participants for follow-up visit 2). Bold values were those values with significant associations in modeling results.

baseline diet. Limitations include a small sample size; however, the modeling approach accounted for loss of follow-up by the inclusion of multiple time points. Conclusions were the same when restricting analyses to only those individuals with both baseline and follow-up 1 or follow-up 2 data. Lastly, this study did not provide information on specific changes in macro- or micronutrients.

Given the results and nutritional components of the DASH diet plan, sustaining good quality dietary intake as characterized by a DASH diet may serve as a benefit especially in youth with type 1 and type 2 diabetes.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

TLB researched data and wrote manuscript. JLC assisted in data analyses and reviewed manuscript. RAB, EJM, DD and ADL contributed to discussion and reviewed/edited the manuscript. All authors read and approved the final manuscript.

DISCLAIMER

The contents of this paper are solely the responsibility of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention and the National Institute of Diabetes and Digestive and Kidney Diseases.

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