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Original Article

The association between Dietary Approaches to Stop Hypertension and incidence of chronic kidney disease in adults: the Tehran Lipid and Glucose Study

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ABSTRACT

Background. This study was conducted to examine the association of adherence to the Dietary Approaches to Stop Hypertension (DASH)-style diet with incident chronic kidney disease (CKD) among an Iranian population.

Methods. We followed-up 1630 participants (50.5% women, mean age: 42.8 years) of the Tehran Lipid and Glucose Study for 6.1 years, who were initially free of CKD. Baseline diet was assessed using a valid and reliable 168-item food frequency questionnaire. A DASH-style diet, based on scoring eight components (fruits, vegetables, whole grains, nuts and legumes, low-fat dairy, red and processed meats, sweetened beverages and sodium) was used. Estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease Study equation and CKD was defined as eGFR <60 mL/min/1.73 m^2. Odds ratio (OR) using multivariable logistic regression was reported for the association of incident CKD with DASH-style diet score.

Results. The incidence of CKD among those in the top quintile of the DASH-style diet was 30%, 18% lower than those in the bottom quintile. After controlling for age, sex, smoking, total energy intake, body mass index, eGFR, triglycerides, physical activity, hypertension and diabetes, adherence to the DASH-style diet was found to be inversely associated with incident CKD (OR: 0.41; 95% confidence interval: 0.24–0.70). In addition, higher scores of fruits, whole grains, nuts and legumes, sweetened beverages and sodium were inversely associated with incidence of CKD.

Conclusion. Results revealed that after 6.1 years of follow-up, adherence to the DASH-style diet was associated with a lower risk of incident CKD among adults.

Keywords: chronic kidney disease, diet quality, Dietary Approaches to Stop Hypertension, dietary pattern, glomerular filtration rate

INTRODUCTION

Chronic kidney disease (CKD) is a major health problem that is related to higher risk of comorbidities and mortality [1]. The estimated glomerular filtration rate (eGFR) is traditionally considered to be the best overall index of kidney function in health and disease [2]. Moderately decreased kidney filtration is a powerful predictor of cardiovascular disease and initiation of CKD [3]. Risk factors related to development of CKD include diabetes, hypertension, dyslipidemia and smoking [4].

Increasing evidence suggests that lifestyle modifications such as weight reduction, exercise and dietary manipulations could have protective effects [5, 6]. Of lifestyle factors, diet appears to play more important role in the prevention and development of CKD [7–9]. Previous studies have mainly focused on particular nutrients or foods in relation to CKD [8, 9]. Investigations of single foods or nutrients in relation to disease do not always consider the potential synergy among foods and nutrients and their findings are difficult to use in public health [10]. Therefore, the approach of dietary patterns in nutritional epidemiology provides a comprehensive method to diet–disease

relations and considers all interactions or synergistic effects among individual foods or nutrients [11].

The Dietary Approaches to Stop Hypertension (DASH) is a dietary pattern basically designed for patients with hypertension [12], and its beneficial effects on stroke, cardiovascular disease and metabolic syndrome have been documented [13, 14]. Two studies have investigated the relation ship between DASH-style diet and CKD [15, 16]; one is a prospective study of women participants from the Nurses' Health Study, which shows that adherence to DASH diet is associated with decreased risk of eGFR decline [15], and the other, a cross-sectional study, indicated that higher scores of DASH-style diet were inversely associated with prevalence of CKD in poor urban participants [16].

In this regard, limited data are available from developing nations, and to the best of our knowledge, the association between DASH-style diet and CKD has not been investigated in the Middle East and North Africa region, where the dietary intakes differ greatly from those in Western countries. We have previously demonstrated that higher intakes of plant protein and lower intake of animal protein have favorable effects on kidney function [8]; thus, a dietary pattern that has a higher ratio of plant protein to animal protein, such as the DASH-style dietary pattern, may be a good measure of habitual dietary intake and is more generalizable to the whole population. The purpose of the present study was to determine the association between adherence to DASH-style diet and incidence of CKD in a population-based cohort study.

MATERIALS AND METHODS

Study population

This study was conducted within the framework of the Tehran Lipid and Glucose Study (TLGS), an ongoing community-based prospective investigation, aimed at preventing non-communicable diseases (NCD) by developing programs promoting healthy lifestyles and reducing NCD risk factors [17]. The TLGS was conducted on a sample of residents under coverage of three medical health centers in District No. 13 of Tehran, the capital city of Iran. The baseline survey was a cross-sectional study conducted from 1999 to 2001, and surveys II (2002–05), III (2006–08), IV (2009–11) and V (2012–15) are prospective follow-up surveys.

In the third survey of the TLGS (2006–08), from among 12 523 participants examined, 3462 were randomly selected for dietary assessment (Figure 1). For the current study, 2417 men and women, aged ≥27 years, were selected. Subjects with a history of myocardial infarction or stroke were excluded because of possible changes in diet ($n = 34$). In addition, subjects who reported daily energy intakes outside the range of 800–4200 kcal/day ($n = 113$) and those with missing data on covariates ($n = 52$) were excluded; some individuals fell into more than one exclusion category. To evaluate the incidence, we also excluded subjects who had CKD at baseline ($n = 360$). Finally, 1630 participants were followed until survey V (response

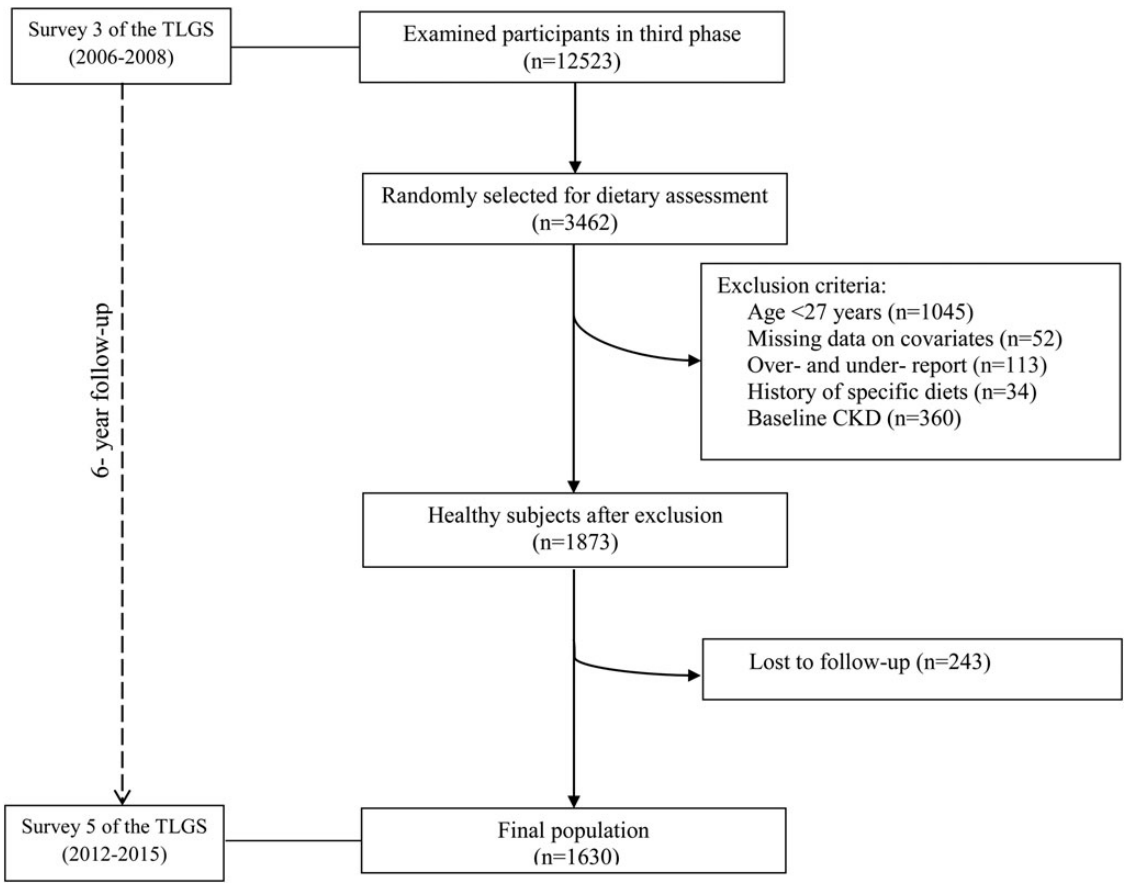

FIGURE 1: Flow chart of the TLGS participants.

rate: 87%), with a median duration of 6.1 years (25–75 interquartile range: 5.6–6.5).

The ethics committee of the Research Institute for Endocrine Sciences of Shahid Beheshti University of Medical Sciences approved the study protocol, and written informed consent was obtained from all participants.

Measurements

Dietary measurements. Dietary intake was assessed using a 168-item food frequency questionnaire (FFQ) by expert interviewers. The reliability and validity of the FFQ has been previously reported [18, 19]. Trained dietitians during face-to-face interviews asked participants to designate their consumption frequency for each food item consumed during the previous year on a daily, weekly or monthly basis. Portion sizes of consumed foods that were reported in household measures were then converted to grams. As the Iranian Food Composition Table (FCT) is incomplete, the USDA FCT was used. For national foods not listed in the USDA FCT, the Iranian FCT was the alternative.

To study the reproducibility of the FFQ, 132 subjects (61 men and 71 women) completed a 168-item FFQ (FFQ1, FFQ2) twice, with a 14-month interval between FFQ1 and FFQ2, and to assess the validity, 12 dietary recalls (DRs) were collected (1 each month) over the 1-year interval. Intra-class correlation coefficients between FFQ1 and FFQ2 were 0.72 and 0.80 for the Iranian Traditional and the Western patterns, respectively; correlation coefficients corrected for month-to-month variation in DRs were 0.48 and 0.75 for the Iranian Traditional and the Western pattern, respectively [18]. Overall, these data indicate that the FFQ provides reasonably valid measures of the average long-term dietary intake.

The DASH-style diet score was constructed based on foods and nutrient focusing on eight components including high intakes of fruits, vegetables, low-fat dairy, nuts and legumes, and whole grains and low intakes of sodium, sweetened beverages, and red and processed meats [13]. All components were computed per 1000 kcal and were then divided into quintiles. For fruits, vegetables, whole grains, low-fat dairy, and nuts and legumes, those in the bottom quintile were given a score of 1 and those in the top quintile received a score of 5, while other quintiles for these components were given corresponding scores. For sodium, red and processed meats, and sweetened beverages, the first quintile was given a score of 5, and the highest quintile was given a score of 1; those in quintiles 4, 3 and 2 for these components were given scores of 2, 3 and 4, respectively. We summed up the component scores to obtain an overall DASH-style diet score ranging between 8 and 40.

Measurement of covariates. Information on physical activity was collected by using the Modifiable Activity Questionnaire (MAQ) to calculate metabolic equivalent task (MET) minutes per week. High reliability (98%) and moderate validity (47%) were found for the Persian translation of MAQ [20]. Light levels of physical activity were considered as MET <600 min/week. Weight was recorded in light clothing to the nearest 0.1 kg on a SECA digital weighing scale (Seca 707; Seca corporation, Hanover, MD, USA; range 0.1–150 kg) and height was measured without shoes to the nearest 0.1 cm. Body mass index (BMI) was calculated as weight (kg) divided by square of height (m^2). Arterial blood pressure was measured manually, using a mercury sphygmomanometer with a suitable cuff size for each participant after a 15 min rest in the supine position. Systolic blood pressure (SBP) was determined by the onset of the tapping Korotkoff sound, while diastolic blood pressure (DBP) was determined as the disappearance of the Korotkoff sound. Blood pressure was measured twice and the average was considered as the participant's BP.

Blood samples were taken from all participants at the TLGS research laboratory after an overnight fast of 12–14 h. Fasting plasma glucose (FPG) was measured using an enzymatic colorimetric method with glucose oxidase. Inter- and intra-assay coefficients of variation (CV) were both 2.2% for FPG. For measurement of triglycerides, we used an enzymatic calorimetric method with glycerol phosphate oxidase. Inter- and intra-assay CV for triglycerides were 0.6 and 1.6%, respectively. Serum creatinine was measured according to the standard colorimetric Jaffe_Kinetic reaction method. Both intra- and inter-assay CVs were below 3.1%; all analyses were performed using commercial kits (Pars Azmoon Inc., Tehran, Iran).

Definitions

Hypertension was defined as SBP/DBP ≥140/90 mmHg or current therapy for a definite diagnosis of hypertension [21]. Diabetes was defined according to the criteria of the American Diabetes Association as fasting plasma glucose ≥126 mg/dL or 2-h post 75 g glucose load ≥200 mg/dL or current therapy for a definite diagnosis of diabetes [22]. We used the Modification of Diet in Renal Disease (MDRD) equation formula to express eGFR in mL/min/1.73 m^2 of body surface area [23]. The abbreviated MDRD study equation is as follows:

$$\text{eGFR} = 186 \times (\text{Serum creatinine})^{-1.154} \times (\text{Age})^{-0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African}-\text{American}).$$

Patients were classified based on their eGFR levels by the national kidney foundation guidelines [24]: eGFR ≥60mL/min/1.73 m^2 as not having CKD and eGFR <60 mL/min/1.73 m^2 as having CKD.

Statistical analysis

All data were analyzed using the Statistical Package for the Social Sciences program (SPSS) (version 15.0; SPSS Inc., Chicago, IL, USA) and P-values <0.05 were considered statistically significant. DASH-style diet scores were categorized into the quintile cutoff points as ≤20, 21–23, 24–25, 26–27 and ≥28. Continuous variables were reported as the age-adjusted mean ± standard deviation (SD) and categorical variables as percentages. We calculated age-adjusted mean values for participants' characteristics using analysis of covariance (ANCOVA). Tests of trend for continuous and categorical variables across quintiles of the DASH-style diet score (as median value in each quintile) were conducted using linear regression and logistic regression tests, respectively.

Median (25–75 interquartile range) of follow-up time was 6.1 (5.6–6.5) years. To examine the association of incident

Table 1. Age-adjusted characteristics of participants according to their CKD status: with and without CKD[a]

	Without CKD ($n = 1410$)	With CKD ($n = 220$)	P-value[b]
Baseline			
Age (years)	42.1 ± 11.1	47.2.6 ± 11.3	<0.001
Women (%)	48.5	63.8	<0.001
Body mass index (kg/m^2)	27.4 ± 4.6	28.3 ± 4.5	<0.001
SBP (mmHg)	111.9 ± 14.6	115.5 ± 14.6	<0.001
DBP (mmHg)	73.9 ± 10.1	76.3 ± 10.3	<0.001
Angiotensin-converting enzyme inhibitor (%)	0.9	3.3	<0.001
Serum creatinine (mg/dL)	1.03 ± 0.15	1.04 ± 0.14	0.185
eGFR (mL/min/1.73 m^2)	74.3 ± 7.8	69.5 ± 8.0	<0.001
Follow-up			
SBP (mmHg)	112.2 ± 13.9	116.3 ± 14.1	<0.001
DBP (mmHg)	73.8 ± 10.1	77.0 ± 10.2	<0.001
Serum creatinine (mg/dL)	1.06 ± 0.18	1.28 ± 0.17	<0.001
eGFR (mL/min/1.73 m^2)	74.1 ± 10.3	54.7 ± 10.8	<0.001

[a]Data are represented as age-adjusted mean ± SD for continuous variables (except age) or percent for categorically distributed variables. CKD was defined as eGFR <60 mL/min/1.73 m^2.
[b]ANCOVA was used for continuous variables and logistic regression for categorical variables.

Table 2. Age-adjusted characteristics and dietary intake of study participants according to the quintiles of the DASH-style diet[a]

	DASH score quintiles					P for trend[b]
	Q1 ($n = 364$)	Q2 ($n = 411$)	Q3 ($n = 291$)	Q4 ($n = 251$)	Q5 ($n = 313$)	
Baseline						
Age (years)	39.5 ± 10.2	41.8 ± 10.6	43.7 ± 11.2	44.2 ± 11.9	46.2 ± 11.5	<0.001
Women (%)	45.9	48.4	52.6	47.4	59.1	0.002
Body mass index (kg/m^2)	27.1 ± 4.5	27.4 ± 4.5	27.8 ± 4.4	27.7 ± 4.6	28.2 ± 4.6	0.005
Current smoker (%)	14.6	11.0	8.4	9.2	6.0	0.153
Low physical activity (%)	66.9	69.9	61.1	71.0	64.8	0.352
Diabetes (%)	3.6	2.7	4.7	6.5	10.2	<0.001
Hypertension (%)	8.5	7.8	12.7	5.9	8.0	0.471
Antihypertensive drug (%)	4.2	4.6	6.2	3.8	6.0	0.809
Angiotensin-converting-enzyme inhibitor (%)	1.9	1.0	1.4	0.4	1.3	0.843
Serum creatinine (mg/dL)	1.05 ± 0.13	1.04 ± 0.14	1.03 ± 0.13	1.00 ± 0.14	1.01 ± 0.14	<0.001
eGFR (mL/min/1.73 m^2)	72.3 ± 8.2	73.3 ± 8.0	73.7 ± 8.0	73.7 ± 8.1	74.8 ± 8.1	0.013
Follow-up						
Serum creatinine (mg/dL)	1.10 ± 0.19	1.10 ± 0.18	1.08 ± 0.19	1.05 ± 0.17	1.07 ± 0.18	0.001
eGFR (mL/min/1.73 m^2)	69.7 ± 10.8	71.2 ± 10.7	71.1 ± 10.7	71.9 ± 10.7	73.1 ± 10.8	<0.001
Baseline daily intakes						
Total energy (kcal)	2391 ± 812	2382 ± 804	2289 ± 804	2276 ± 804	2195 ± 811	0.001
Protein (% energy)	13.2 ± 2.3	13.5 ± 2.3	13.7 ± 2.3	14.1 ± 2.3	14.3 ± 2.3	<0.001
Animal protein (g/1000)	19.1 ± 7.1	18.8 ± 6.9	18.8 ± 7.0	18.3 ± 7.0	17.9 ± 7.1	0.021
Plant protein (g/1000)	14.8 ± 4.1	15.5 ± 4.1	16.0 ± 3.9	16.8 ± 3.9	17.1 ± 4.0	<0.001
Carbohydrate (% energy)	56.5 ± 7.2	56.9 ± 7.1	57.9 ± 7.2	58.6 ± 7.2	59.3 ± 7.2	<0.001
Total fat (% energy)	31.9 ± 7.1	31.7 ± 7.1	31.2 ± 7.0	30.3 ± 7.0	30.1 ± 7.1	<0.001
Saturated fatty acids (% energy)	10.9 ± 5.5	10.6 ± 5.3	10.3 ± 5.4	10.2 ± 5.5	10.2 ± 5.5	0.043
Dietary fiber (g/1000 kcal)	15.8 ± 6.9	16.6 ± 6.9	16.7 ± 6.8	17.5 ± 6.8	17.9 ± 6.9	<0.001
Vitamin C (mg/1000 kcal)	46.5 ± 33.5	56.5 ± 33.0	66.9 ± 33.2	74.1 ± 33.2	87.3 ± 33.4	<0.001
Potassium (mg/1000 kcal)	1398 ± 406.2	1557 ± 401.9	1720 ± 402.4	1833 ± 402.1	1986 ± 405.1	<0.001
Magnesium (mg/1000 kcal)	146.4 ± 31.6	159.3 ± 32.0	172.0 ± 32.0	179.4 ± 31.9	192.5 ± 32.3	<0.001

[a]Data represented as age-adjusted mean ± SD for continuous variables (except age) or percent for categorical variables.
[b]Linear regression was used for continuous variables and logistic regression for categorical variables.

CKD in each quintile of DASH-style diet, multivariable logistic regression models were used and odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. In this analysis, the first quintile of DASH-style diet was considered as the reference category. Age, sex, smoking, total energy intake, BMI, eGFR, triglycerides, physical activity, hypertension and diabetes were adjusted. To calculate the trend of OR across increasing quintiles of DASH-style diet, we considered the quintile categories as continuous variables. In addition, a sensitivity analysis was conducted, using the final model, to ensure that patients whose eGFR decreased simply due to advancing age were not recorded as having developed CKD. This repeated analysis was conducted with definition of CKD as a decline in eGFR > 25% from baseline and eGFR <60 mL/min/1.73 m^2 at the end of follow-up.

RESULTS

The mean ± SD age of participants (50.5% women) was 42.8 ± 11.2 years and the average score of DASH-style diet was 23.7.

After 6.1 years of follow-up, we documented 220 (13.5%) cases of incident CKD with an eGFR range of 29–59 mL/min/1.73 m^2. Mean ± SD eGFR for all participants at the end of follow-up was 71.6 ± 11.2 mL/min/1.73 m^2.

Participants with CKD were more likely to be female and older, and have a higher BMI, SBP and DBP. Baseline serum creatinine did not differ significantly between CKD and non-CKD groups; however, at the end of follow-up, serum creatinine increased among participants with CKD. Baseline and follow-up eGFR were also lower among subjects with CKD compared with those free of CKD (Table 1).

Age-adjusted characteristics for study participants by quintiles of DASH-style diet are displayed in Table 2. Subjects in the highest, compared with the lowest, quintile of DASH-style diet were more likely to be women, had higher BMI and eGFR, and lower serum creatinine. Those with greater adherence to DASH-style diet had higher prevalence of diabetes than their counterparts in the lowest quintile. No significant differences were observed for angiotensin-converting enzyme inhibitor and antihypertensive drug use across quartiles of DASH-style diet. Furthermore, participants in the top quintile of DASH-style diet had higher intakes of protein, plant protein, carbohydrate, fiber, vitamin C, potassium and magnesium than those in the bottom quintile ($P < 0.05$); however, intakes of animal protein, total fat and saturated fatty acids tend to decrease across quintiles of DASH-style diet ($P < 0.05$).

No significant association was observed between the DASH-style diet and incident CKD in the crude model (Figure 2A); however, after adjustment for age, sex, smoking, total energy intake, BMI, eGFR, triglycerides, physical activity, hypertension and diabetes, the OR for participants in the highest, compared with the lowest, quintile of DASH-style diet was 0.41 (95% CI: 0.24–0.70). A significant decreasing linear trend was noted across the DASH-style diet quintiles for the risk of incident CKD (P for trend <0.001, Figure 2B). Sensitivity analyses had no substantial impact; the unadjusted and adjusted ORs were 0.91 (95% CI: 0.59–1.41) and 0.57 (95% CI: 0.36–0.91), respectively, comparing participants in the highest with the lowest quintile of the DASH-style diet.

After controlling for potential confounders, OR for participants in the highest, compared with the lowest, scores of fruit was 0.41 (95% CI: 0.23–0.74), for whole grains it was 0.59 (95% CI: 0.36–0.95), for nuts and legumes 0.52 (95% CI: 0.30–0.90), for sweetened beverages 0.54 (95% CI: 0.32–0.94) and for sodium it was 0.51 (95% CI: 0.30–0.88). In addition, a significant decreasing linear trend was noted across the scores of fruits, whole grains, nuts and legumes, sweetened beverage and sodium for the risk of incident CKD (P for trend <0.05, Table 3).

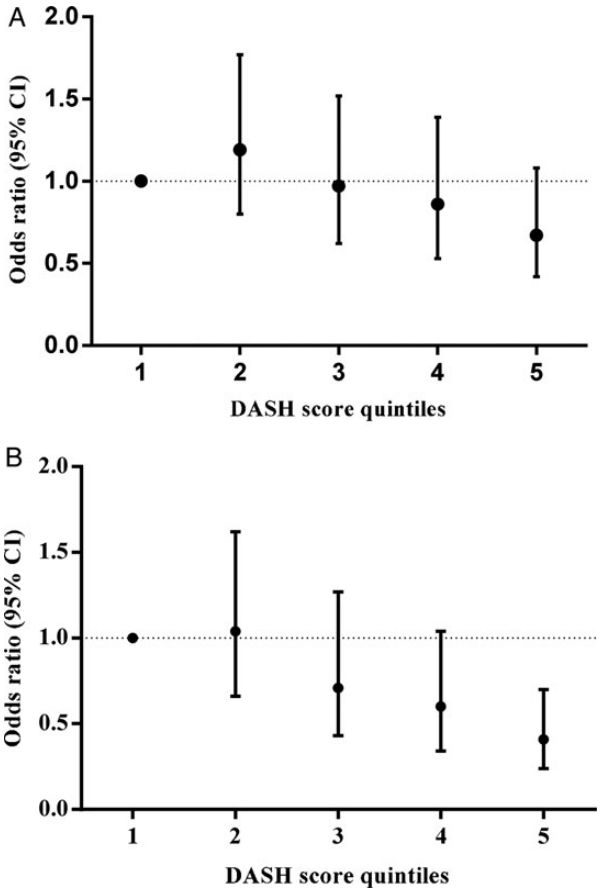

FIGURE 2: Multivariable ORs and 95% CIs of incident CKD according to quintiles of the DASH-style diet score among adults of TLGS cohort. (**A**) Crude model (P for trend = 0.052) and (**B**) adjusted for age, sex, smoking, total energy intake, BMI, triglycerides, eGFR, physical activity, hypertension and diabetes (P for trend <0.001).

DISCUSSION

In this population-based cohort study, after 6.1 years of follow-up, greater adherence to DASH-style diet was inversely associated with odds of incident CKD independent of hypertension and diabetes. In addition, higher scores of fruits, whole grains, nuts and legumes, sweetened beverages and sodium were each associated with decreased risk of incident CKD.

Findings of the current study are in agreement with recent investigations in which higher adherence to DASH-style diet was associated with beneficial effects on kidney function [15, 16]. Over 11 years of follow-up, women in the highest quartile of DASH-style diet, had 30% decreased risk of eGFR decline, independent of diabetes and hypertension [15]. Similarly, in the current study, after adjustment for diabetes and hypertension, participants who were in the highest quintile of DASH-style diet had 59% decreased odds of incident CKD. The incidence of CKD in the current study (13.5%) is comparable to that of the above-mentioned study [15] (11.3%), although the definition of kidney damage was different. Furthermore, in a cross-sectional study, lower adherence to DASH-style diet was associated with increased prevalent CKD among a poor urban population [16].

Dietary patterns emphasize foods and nutrients similar to those in the DASH-style diet, e.g. higher intakes of fruit, vegetables, low-fat dairy and whole grains and low intake of processed meat, which have been shown to improve kidney function and decrease the risk of kidney damage [15, 25]. For example, in an investigation by Nettleton *et al.*, a dietary pattern rich in whole grains, fruit and low-fat dairy foods was inversely associated with kidney dysfunction [25]. Moreover, the Western dietary pattern, characterized by higher intakes of processed

Table 3. ORs and 95% CIs of incident CKD according to quintiles of the DASH-style diet components among participants of the TLGS[a]

	DAHS component quintiles					P for trend[b]
	Q1 ($n = 364$)	Q2 ($n = 411$)	Q3 ($n = 291$)	Q4 ($n = 251$)	Q5 ($n = 313$)	
Fruit	Ref.	0.79 (0.49–1.29)	0.82 (0.50–1.35)	0.73 (0.44–1.22)	0.41 (0.23–0.74)	0.020
Vegetable	Ref.	1.53 (0.90–2.58)	1.24 (0.72–2.12)	1.10 (0.63–1.92)	0.84 (0.45–1.55)	0.429
Whole grains	Ref.	1.03 (0.65–1.58)	0.72 (0.46–1.18)	0.62 (0.41–1.08)	0.59 (0.36–0.95)	0.013
Low-fat dairy	Ref.	0.98 (0.62–1.58)	0.65 (0.39–1.09)	0.71 (0.43–1.18)	0.64 (0.38–1.08)	0.098
Nuts and legumes	Ref.	0.86 (0.53–1.39)	0.83 (0.51–1.35)	0.90 (0.55–1.47)	0.52 (0.30–0.90)	0.041
Red and processed meat	Ref.	0.68 (0.41–1.13)	0.75 (0.45–1.24)	0.75 (0.45–1.25)	0.86 (0.51–1.45)	0.791
Sweetened beverages	Ref.	1.06 (0.65–1.71)	0.81 (0.50–1.34)	0.53 (0.31–0.90)	0.54 (0.32–0.94)	0.010
Sodium	Ref.	0.95 (0.60–1.53)	0.73 (0.46–1.18)	0.59 (0.36–0.98)	0.51 (0.30–0.88)	0.016

[a]Adjusted for age, sex, smoking, total energy intake, BMI, eGFR, triglycerides, physical activity, hypertension and diabetes.
[b]To calculate the trend of OR across increasing quintiles of DASH-style diet, we considered the quintile categories as continuous variables.

and red meats, refined grains, sweets and desserts, had an inverse association with kidney function [15].

Several components of the DASH-style diet have also been associated with the risk of CKD. In the current study, higher intakes of low-fat dairy, fruits and whole grains had inverse association with CKD, results consistent with other studies [15, 25, 26]. In addition, previous studies have shown that higher intakes of red and processed meats, sugar-sweetened beverages and sodium, which are deemphasized in the DASH-style diet, have been reported to be positively associated with CKD [9, 25, 26].

A favorable association of higher intakes of whole grains and nuts and legumes and lower intakes of red meat with incident CKD may be attributed to the source of protein. The findings of the current study show that higher adherence to the DASH-style diet was accompanied by lower intakes of animal protein and higher intakes of plant protein. Previously, we have shown that higher intakes of animal protein and elevated animal protein to plant protein ratio had undesirable effects on the prevalence of CKD [8]. In addition, beneficial effects of fruits and vegetables on kidney function may be explained by higher intakes of fiber, vitamin C, potassium and magnesium. More potassium and magnesium and less animal protein intakes were associated with lower dietary acid load. The DASH-style diet, compared with common diets, has substantially lower dietary acid load (31 versus 78 mEq/day) [27]. Recent studies conducted on both humans and animals suggest that dietary acid reduction has a protective effect on CKD [28]. In addition, higher intakes of animal fat, cholesterol and sodium were significantly associated with eGFR decline [26].

It has been proposed and that the putative association between greater adherence to the DASH-style diet and decreased risk of CKD might be explained by the known effects of this dietary pattern and its components on several cardiometabolic risk factors, such as improved plasma lipid profiles, blood pressure, insulin sensitivity, oxidative stress, inflammation and endothelial dysfunction [29–31].

Some limitations of this investigation need to be mentioned. First, as in most epidemiologic studies, our definition of CKD is based on a limited number of isolated creatinine measurements that were not repeated within 3 months to confirm a chronic reduction in GFR. Second, despite controlling for various confounders in our analysis, residual confounding due to unknown or unmeasured confounders cannot be excluded. Third, data on the proteinuria of the participants were not obtained, and we were unable to consider this in the definition of CKD.

Of the noteworthy strength of our study, unlike previous studies, this one provided data based on habitual dietary intakes in a population-based sample of participants, thereby increasing generalizability of its results. Furthermore, the FFQ was designed to estimate typical food and beverage consumption over the previous year, thereby demonstrating infrequently consumed items and seasonal variations, which is not possible when using a single 24-h dietary recall.

Considering the growing trend of the incidence and prevalence of CKD, it is important to define a dietary pattern that might be suitable for preventing CKD in the community. The current study provides further information regarding reduction in kidney function by dietary pattern, which may be more easily adhered to by the general public. In conclusion, a diet closely resembling the DASH-style diet, with high intake of fruits and whole grains, moderate intake of nuts and legumes and low intake of sweetened beverage and sodium, was significantly associated with lower risk of incident CKD.

AUTHORS' CONTRIBUTIONS

All authors read and approved the final manuscript. G.A. and 395 E.Y designed research; E.Y. analyzed and interpreted the data; and G.A. and E.Y. drafted the initial manuscript. P.M. and F.A. supervised the project and approved the final version of the manuscript to be submitted.

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CONFLICT OF INTEREST STATEMENT

On behalf of all authors, the corresponding author hereby declares that there is no conflict of interest.

(See related article by Kovesdy and Kalantar-Zadeh. DASHing toward improved renal outcomes: when healthy nutrition prevents incident chronic kidney disease. *Nephrol Dial Transplant* 2017; 32 (Suppl 2): ii231–ii233)

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