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The ratio of dietary diversity score versus energy density in relation to anthropometric and biochemical variables among patients with chronic kidney diseases

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Summary. *Background:* Some evidence showed that dietary diversity score (DDS), a diet quality index, was not always related to healthy outcomes. It seems that DDS to energy density ratio (DDS/ED) can overcome limitations of DDS. The aim of current study was to assess the association between either dietary DDS or DDS/ED and nutrient intake, anthropometric and biochemical measures in subjects with chronic kidney disease (CKD). *Methods:* Two hundred seventy patients with CKD were randomly selected for this cross-sectional study. Dietary intakes were assessed using a 168-item semi quantitative food frequency questionnaire. Moreover, anthropometric indices, lipid profile, blood urea nitrogen (BUN) and high sensitivity C-reactive protein were measured. *Results:* Body mass index (BMI) had a significant negative trend across quartiles of DDS and DDS/ED. Also, a negative trend for waist circumference was observed across quartiles of DDS/ED. Although the trends of selenium ($P<0.01$) and niacin ($P=0.03$) were significant across the quartiles of DDS, higher nutrient adequacy ratios for all important nutrients were observed among those in the top quartile of DDS/ED compared to the lowest quartile. We observed a significant trend of mean adequacy ratio just across quartiles of DDS/ED. Compared with the top quartile of DDS/ED (not DDS), the risk of overweight/obesity in the lowest quartiles was higher in adjusted model ($P<0.001$). The trend of the risk of elevated lipid profiles, BUN and hs-CRP across quartiles of DDS/ED and quartiles of DDS was not significant. *Conclusion:* Our results showed that DDS/ED corrected the failure of DDS in relation to risk of obesity. Moreover, it was observed that DDS/ED was better indicator of nutrient intake in comparison with DDS among patients with CKD. It is suggested that future studies use DDS/ED instead of DDS. Also, in clinical practice, dietitians should emphasize on diversity in low energy-dense food groups.

Key words: Dietary diversity score, energy density, chronic kidney disease

Introduction

Diabetic nephropathy is a prevalent type of chronic kidney disease (CKD). Diabetes is known as a reason of renal disorders which leads to diabetic nephropathy (1). Diabetic nephropathy, an angiopathy in capillaries of glomeruli, is the major kidney-related disease induced by diabetes (2). Recommended diet for diabetic nephropathic patients and subjects with CKD is restriction in protein, phosphorus, potassium and sodium (3). These limitations may affect on nutrient intake and diet quality. Assessment of dietary intake in diabetic patients with initial nephropathy has been shown that protein and fat intake among these patients is higher than recommended amounts (4). Furthermore, the prevalence of high degree of malnutrition is high among subjects with CKD (5). Moreover, diet quality and nutrient intake among diabetic patients should be improved essentially (6). So, the quality of diet should be assessed in these patients for the prevention and improvement of malnutrition.

Dietary diversity score (DDS) is a suitable index to assess diet quality (7). A direct relationship between DDS and micronutrient intake was reported previously (7). Moreover, an inverse association between DDS and diabetic risk factors such as obesity (8) and metabolic syndrome (9) has been shown in published documents. Nevertheless, evidence regarding the relationship between health outcomes and DDS is contradictory. Some studies reported that high dietary diversity may lead to increased body mass index (BMI) and obesity (10, 11). Obesity is considered as a potential risk factor for diabetes and progression of kidney disease (12). Therefore, unfavorable dietary diversity may increase the risk of disease progression in patients with CKD. Researchers acknowledged that dietary diversity in food groups with high fat and sugar content is responsible for higher energy intake and therefore, direct association between DDS and obesity (10). It seems that the dietary diversity in energy-dense food groups is responsible for direct association between DDS and obesity. Although DDS and energy density (ED) are inversely associated to each other (7), there has not been enough attention to the impact of dietary diversity in energy dense food groups. We hypothesized that DDS to ED ratio (DDS/ED) would correct the failure of DDS in relation to obesity. According to our supposition, DDS/ED might be a good indicator of dietary intake among patients with CKD and it would show rational relationship with anthropometrical and biochemical variables. Therefore, the aim of this study was to evaluate the association between either DDS or DDS/ED and nutrient intake, anthropometric and biochemical measures in patients with CKD.

Research Design and Methods

Subjects

Among diabetic nephropathic patients referred to Alzahra University Hospital, nephrology clinics or one nutrition clinic in Isfahan, 270 patients with diabetic nephropathy were selected for current study using convenience sampling method (from July 2010 to June 2012). To calculate sample size, blood urea nitrogen (BUN) was considered as main variable. Mean and standard deviation were 22 mg/dl and 5 mg/dl, respectively (13). We included patients with fasting blood glucose >126 mg/dL, (or use hypoglycemic agents and insulin), proteinuria >300 mg/day and glomerular filtration rate >90 mL/min (14). Diabetic nephropathy was diagnosed by a nephrologist. All subjects signed a written consent. This study was ethically approved by Research Council and Ethical Committee of Isfahan University of Medical Science, Isfahan, Iran.

Dietary assessment

At the first visit, one 168-item semi quantitative food frequency questionnaire (FFQ) was filled out by trained assistants. Standard serving size of each food item was also included in the FFQ. We asked participants to report their usual dietary intake during previous year. Household measures were used to convert reported portion sizes to gram. Reported food consumption in the FFQ was converted to gram and then nutrient contents were analyzed by Nutritionist IV software (N-Squared Computing, Salem, OR). Subjects who overstated or understated dietary intakes were excluded (n=30).

According to the Food Guide Pyramid (US Department of Agriculture Food Guide Pyramid. Washington, DC: USDA, 1996.) and Haines *et al*. study (15), five major food groups and 23 subgroups were considered. Refined bread, biscuits, macaroni, whole bread, cornflakes, rice and refined meal were considered as subgroups of bread/grain group. Fruits were divided into two subgroups (fruit and fruit juice, berries and citrus). Seven subgroups for vegetables food group (vegetables, potatoes, tomatoes, starchy vegetables, legumes, yellow vegetables, green vegetables) and four subgroups for meats food groups (red meat, poultry, fish, egg) were considered. Cheese, yoghurt and milk were determined as subgroups of dairy food group.

According to reported criteria by Food Guide Pyramid, who consumed at least one-half serving/day of each food group, considered as 'consumer'. Maximum diversity score was determined 10 for all groups. So, each major group received 2 score points. For calculation diversity score within each group, following formula was used:

DDS within each group = (number of consumed subgroups/number of total subgroups) ×2

For instance, DDS of vegetable group for a patient, who consumed three out of seven defined subgroups of vegetables, would be (3/7) ×2 = 0.85. Total score was calculated by the sum of computed scores of major groups (7).

Energy density (g/kcal) was computed by dividing total weight of consumed foods (except for beverages) by daily energy intake (7).

We calculate nutrient adequacy ratio (NAR) by dividing daily intake of a nutrient to dietary recommended intake (16) for it. To estimate mean adequacy ratio (MAR), the sum of all calculated NARs divided by the number of NARs presented as percentage.

Assessment of other variables

For anthropometric assessments, patients wore minimal indoor cloths and removed their shoes. Weight was measured by digital scale (Secca. Hamburg, Germany) to the nearest 0.1 kg. Height was measured by standard tape to the nearest 1 cm. By dividing weight (kg) by square of height (m^2), BMI was calculated. Waist circumference (WC) was measured by an inelastic tape and with no pressure. All anthropometric variables were measured by trained assistant. BMI≥25 was considered as overweight/obese (17). Abdominal obesity among men and women was defined as WC≥102 and WC≥88, respectively (18). Socioeconomic status was assessed by questions regarding income, occupation, education, number of family members and marriage. Physical activity was measured using one-day physical activity record.

Biochemical variables

After 12 hours fasting, a blood sample was obtained from each subject. Drawn samples were centrifuged at 3000×g for 10 min. Triglyceride and total cholesterol were measured by enzymatic colorimetric tests. To measure high density lipoprotein cholesterol (HDL-C), we blocked low density lipoprotein cholesterol (LDL-C), very low density lipoprotein (VLDL) and chylomicrons by antibodies and then, HDL-C was assessed by enzymatic measurement of the unblocked cholesterol. LDL-C concentration was also measured by same method. We used Immunoturbidimetry method to measure hs-CRP. Blood urea nitrogen (BUN) level was assessed by urease containing kits. All biochemical kits were provided by Pars Azmoon Inc.

Statistical analysis

Normal distribution of variables was tested by Kolmogorov-Smirnov test and histogram curve. All statistical analyses were done by IBM Statistical Package for the Social Sciences (SPSS) Version 20.0 (IBM Corp. Released 2011 Armonk, NY: IBM Corp). First, second, third and top quartiles of DDS/ED was defined as ≤5.1302, 5.1303-6.5417, 6.5418-8.1975 and >8.1976, respectively. First to last quartiles of DDS was defined as ≤5.8975, 5.8976-6.2300, 6.2301-6.700 and >6.701, respectively. Chi-square analysis was used to test the difference in qualitative variables across quartiles of independent (DDS/ED and DDS) variables. To find a statistical difference in quantitative variables across quartiles of DDS/ED and quartiles of DDS, we used one-way analysis of variance. Multiple logistic regression was run to calculate odds ratio (OR) of overweight/obesity, elevated BUN, hs-CRP

and abnormalities in lipid profiles across quartiles of DDS/ED and quartiles of DDS. Obesity and abdominal obesity were defined as BMI≥25 kg/m and waist circumference≥99.5 or ≥94.25 cm for men and women, respectively (19). As the range of TC was high among the majority of subjects (178-298 mg/dl), TC>median was considered as high TC. Triglyceride ≥150 mg/dl, LDL ≥130 mg/dl and BUN ≥21 mg/dl were used for classifying subjects to calculate OR. Although high hs-CRP was defined as hs-CRP>3 mg/dl (20), the measured values for hs-CRP were lower than 3 mg/dl through this population. Therefore, hs-CRP ≥median was considered as increased hs-CRP. Estimated risk was adjusted for potential confounders (age, sex, socioeconomic, marriage, smoking, physical activity, energy intake) in complementary models. P<0.05 was considered as statistical significant level. OR with 95% of confidence interval and mean±SD were used for reporting results.

Table 1. General characteristics of 270 diabetic nephropathy patients included in analyses

Variables	Quartiles of dietary diversity score to energy density ratio				P for trend[1]	Quartiles of dietary diversity score				P for trend[1]
	Q1 (≤5.1302) (n=67)	Q2 (5.1303-6.5417) (n=68)	Q3 (6.5418-8.1975) (n=68)	Q4 (>8.1976) (n=67)		Q1 (≤5.8975) (n=67)	Q2 (5.8976-6.2300) (n=71)	Q3 (6.2301-6.700) (n=68)	Q4 (>6.701) (n=64)	
Age (y)[2]										
total	68.37±10.14	64.45±9.44	65.40±8.84	65.52±10.42	0.10	69.23±9.70	64.82±9.64	63.50±8.89	66.22±10.3	<0.01
men	70.58±9.34	63.35±8.78	65.16±8.79	64.63±11.83	0.03	69.28±9.58	62.25±9.37	65.32±11.51	66.15±11.19	0.10
women	66.47±10.53	65.02±9.80	65.53±8.98	65.87±9.92	0.92	69.31±9.98	65.56±9.68	61.68±7.93	66.23±9.96	0.01
Female n(%)	14 (20.9)	18 (26.2)	17 (25.0)	19 (27.9)	12 (18.6)	23 (32.0)	13 (19.8)	19 (29.7)		
BMI (kg/m^2)[2]										
total	25.68±3.48	23.62±4.20	22.99±3.00	22.20±2.98	<0.001	26.11±3.58	23.35±3.17	23.01±2.29	22.26±3.39	<0.001
men	25.11±2.83	21.60±4.96	21.85±2.34	21.58±3.14	<0.001	25.48±2.93	21.50±2.28	22.33±2.13	19.89±1.76	<0.001
women	26.18±3.93	24.65±3.38	23.65±3.18	22.45±2.91	<0.001	26.89±4.10	23.88±3.21	23.70±2.28	22.87±3.44	<0.001
WC (cm) [2]										
total	103.79±9.78	103.35±10.78	101.85±11.13	98.30±12.27	0.01	102.94±10.06	99.57±12.97	101.68±11.64	103.34±9.30	0.19
men	104.29±9.00	104.87±9.29	102.28±10.59	97.68±11.81	0.09	102.57±9.99	104.12±8.65	101.56±11.51	103.77±10.07	0.83
women	103.36±10.51	102.58±11.49	101.60±11.55	98.54±12.57	0.22	103.34±10.28	98.23±13.76	101.79±11.95	103.23±9.20	0.10
Quartiles of socioeconomic status scores n(%)										
Q1	7 (10.4)	7 (10.3)	5 (7.4)	8 (11.9)	0.87	8 (11.9)	7 (9.9)	7 (10.3)	5 (7.8)	0.87
Q2	16 (23.9)	19 (27.9)	27 (39.7)	24 (35.8)	0.33	19 (28.4)	24 (33.8)	19 (27.9)	24 (37.5)	0.76
Q3	24 (35.8)	24 (35.3)	25 (36.8)	21 (31.3)	0.94	25 (37.3)	21 (29.6)	28 (41.2)	20 (31.2)	0.62
Q4	20 (29.9)	18 (26.5)	11 (16.2)	14 (20.9)	0.37	15 (22.4)	19 (26.8)	14 (20.6)	15 (23.4)	0.81
Quartiles of physical activity status (MET.h/day) n(%)										
Q1	2 (3.0)	4 (5.9)	11 (16.2)	5 (7.5)	0.04	3 (4.5)	6 (8.5)	7 (10.3)	6 (9.4)	0.65
Q2	43 (64.2)	31 (45.6)	37 (54.4)	42 (62.7)	0.49	40 (59.7)	40 (56.3)	36 (52.9)	37 (57.8)	0.95
Q3	22 (32.8)	32 (47.1)	19 (27.9)	19 (28.4)	0.17	24 (35.8)	25 (35.2)	23 (33.8)	20 (31.2)	0.89
Q4	0	1 (1.5)	1 (1.5)	1 (1.5)	1.00	0	0	2 (2.9)	1 (1.6)	0.56
Married n(%)	16 (24.5)	17 (24.9)	17 (25.3)	17 (25.3)	0.52	17 (25.3)	18 (25.7)	17 (25.3)	15 (23.8)	0.75
CKD stage n(%)										
Stage 3	29 (43.3)	25 (36.8)	21 (30.9)	28 (41.8)		33 (49.3)	21 (29.6)	28 (41.2)	21 (32.8)	
Stage 4	38 (56.7)	43 (63.2)	47 (69.1)	39 (58.2)	0.44	34 (50.7)	50 (70.4)	40 (58.8)	43 (67.2)	0.08

Legend: General characteristics of 270 diabetic nephropathy patients included in analyses

BMI: body mass index, CKD: chronic kidney disease, WC: waist circumference

[1] Derived from analysis of variance or chi-square analysis for quantitative and categorical variables, respectively.

[2] Values are mean±SD

Table 2. Nutrient adequacy ratio and mean adequacy ratio across quartiles of dietary diversity score to energy density ratio and dietary diversity score

Variables	Quartiles of dietary diversity score				P[1]	Quartiles of dietary diversity score				P[1]
	Q1 (≤5.1302) (n=67)	Q2 (5.1303-6.5417) (n=68)	Q3 (6.5418-8.1975) (n=68)	Q4 (>8.1976) (n=67)		Q1 (≤5.8975) (n=67)	Q2 (5.8976-6.2300) (n=71)	Q3 (6.2301-6.700) (n=68)	Q4 (>6.701) (n=64)	
NAR										
Magnesium	0.67±0.292	0.83±0.22	0.92±0.28	1.24±0.40	<0.001	0.87±0.32	0.92±0.33	0.94±0.44	0.90±0.36	0.39
Zinc	0.78±0.34	0.97±0.27	1.05±0.33	1.38±0.54	<0.001	0.97±0.37	1.1±0.38	1.03±0.50	1.08±0.46	0.21
Niacin	1.17±0.56	1.32±0.45	1.44±0.72	1.78±0.70	<0.001	1.44±0.64	1.48±0.68	1.54±0.77	1.22±0.44	0.03
Folate	0.61±0.24	0.68±0.19	0.78±0.22	1.08±0.50	<0.001	0.81±0.35	0.77±0.26	0.84±0.49	0.73±0.29	0.45
Potassium	0.55±0.21	0.64±0.18	0.73±0.20	1.01±0.29	<0.001	0.73±0.27	0.72±0.26	0.76±0.3	0.71±0.29	0.58
Calcium	0.85±0.38	1.08±0.39	1.16±0.40	1.55±0.59	<0.001	1.29±0.42	1.18±0.57	1.12±0.49	1.18±0.57	0.55
Selenium	1.03±0.48	1.24±0.43	1.32±0.52	1.51±0.74	<0.001	1.28±0.49	1.25±0.52	1.45±0.82	1.11±0.32	<0.01
Riboflavin	1.48±0.52	1.84±0.51	2.03±0.57	2.75±0.88	<0.001	1.95±0.74	2.08±0.79	2.01±0.77	2.06±0.85	0.54
Vitamin B_6	1.05±0.45	1.17±0.35	1.31±0.51	1.74±0.61	<0.001	1.36±0.60	1.31±0.48	1.38±0.60	1.21±0.52	0.48
Vitamin B_{12}	1.82±2.11	1.81±1.29	1.88±1.22	2.46±1.70	<0.01	2.07±2.09	1.97±1.32	2.15±1.69	1.75±1.31	0.65
Vitamin C	1.51±0.97	1.72±0.85	1.97±1.01	3.01±1.67	<0.001	2.05±1.35	2.02±1.16	2.16±1.51	1.97±1.37	0.66
Vitamin E	0.59±0.43	0.69±0.87	0.76±0.53	0.81±0.44	0.02	0.71±0.40	0.67±0.41	0.78±0.93	0.70±0.50	0.72
MAR	100.86±39.90	116.65±29.21	127.87±36.49	169.41±43.47	<0.001	128.32±42.66	129.21±42.95	134.79±48.84	121.84±46.20	0.43

Legend: Nutrient adequacy ratio and mean adequacy ratio across quartiles of dietary diversity score to energy density ratio and dietary diversity score
MAR: mean adequacy ratio, NAR: nutrient adequacy ratio
[1] Derived from analysis of variance
[2] Values are mean±SD

Results

The data of 270 diabetic nephropathic patients were included in analyses. General characteristics of subjects are illustrated in Table 1. WC in the whole population (P=0.01), BMI in both genders (P<0.001 for both) and age in men (P=0.03) had significant trend across quartiles of DDS/ED. Those in the highest quartile of the DDS had lower BMI in comparison to the lowest quartile (P<0.001). Age in women had significant decreasing trend across quartiles of DDS (P=0.01).

NARs and MAR across quartiles of DDS/ED and quartiles of DDS are shown in Table 2. Although only the trends of selenium (P<0.01) and niacin (P=0.03) was significant across the quartiles of DDS, higher NARs for all important nutrients were observed among those in the top quartile of DDS/ED compared to lowest quartile. We observed a significant trend of MAR across quartiles of DDS/ED. The trend of this variable was not significant across quartiles of DDS.

The risk of obesity, elevated BUN, hs-CRP and lipid profiles is illustrated in Table 3. Compared with the top quartile of DDS and DDS/ED, the risk of overweight/obesity in the lowest quartiles was higher in unadjusted model (P<0.001 for both). This observed risk was attenuated across DDS quartiles after adjusting for age, sex, socioeconomic, marriage, smoking, physical activity and energy intake (P=0.97) but remained significant across quartiles of DDS/ED (P<0.001). The trend of the risk of elevated lipid profiles, BUN and hs-CRP across quartiles of DDS/ED and quartiles of DDS was not significant.

Discussion

Our results showed that DDS/ED corrected the failure of DDS in relation to predict the risk of obesity. Moreover, it was observed that DDS/ED was better indicator of dietary intake among diabetic nephropathic patients in comparison with DDS. To the best of our knowledge, this is the first study that suggested

Table 3. Odds ratio (95% CIs) of overweight/obesity and elevated lipid profiles, BUN and hs-CRP among 270 diabetic nephropathy patients

Variables	Quartiles of dietary diversity score				P	Quartiles of dietary diversity score				P
	Q1 (≤5.1302) (n=67)	Q2 (5.1303-6.5417) (n=68)	Q3 (6.5418-8.1975) (n=68)	Q4 (>8.1976) (n=67)		Q1 (≤5.8975) (n=67)	Q2 (5.8976-6.2300) (n=71)	Q3 (6.2301-6.700) (n=68)	Q4 (>6.701) (n=64)	
Model 11										
Overweight/ obesity[3]	7.48(3.20-17.52)	3.74(1.59-8.84)	2.69(1.12-6.46)	1	<0.001	6.00(2.77-12.99)	1.40(0.64-3.07)	0.93(0.40-2.13)	1	<0.001
Abdominal Obesity[4]	0.75(0.19-2.94)	0.98(0.20-4.76)	0.72(0.18-2.81)	1	0.94	2.89(0.89-9.41)	3.70(1.09-14.33)	2.92(0.85-10.09)	1	0.17
High TC[5]	0.66(0.33-1.30)	0.81(0.41-1.69)	0.97(0.49-1.90)	1	0.65	0.81(0.41-1.61)	0.77(0.39-1.52)	0.94(0.47-1.86)	1	0.86
High TG[6]	0.83(0.42-1.65)	0.72(0.36-1.42)	0.81(0.41-1.60)	1	0.82	0.81(0.41-1.61)	0.54(0.27-1.08)	0.79(0.40-1.56)	1	0.36
High LDL[7]	1.27(0.64-2.50)	0.86(0.44-1.70)	1.16(0.59-2.28)	1	0.69	1.80(0.90-3.59)	1.49(0.75-2.94)	1.15(0.58-2.28)	1	0.34
High BUN[8]	1.27(0.64-2.52)	1.10(0.56-2.17)	1.10(0.56-2.17)	1	0.92	0.98(0.49-1.97)	1.49(075-2.94)	0.96(0.48-1.92)	1	0.51
High hs-CRP[10]	0.94(0.48-1.85)	0.77(0.39-1.51)	0.77(0.32-1.42)	1	0.74	0.67(0.34-1.35)	1.09(0.55-2.14)	1.00(0.50-1.98)	1	0.51
Model 22										
Overweight/ obesity	9.17(3.70-22.77)	4.81(1.94-11.95)	3.23(1.29-8.06)	1	<0.001	0.95(0.21-4.28)	0.81(0.21-3.09)	0.75(0.18-3.13)	1	0.97
Abdominal Obesity	0.23 (0.03-1.49)	0.51(0.08-3.18)	0(0.10-2.23)	1	0.48	1.30(0.28-5.99)	2.86(0.66-12.37)	3.32(0.85-13.08)	1	0.27
High TC	0.67(0.33-1.35)	0.89(0.44-1.77)	0.93(0.47-1.84)	1	0.69	1.01(0.45-2.27)	0.82(0.41-1.63)	1.00(0.48-2.06)	1	0.91
High TG	0.71(0.35-1.45)	0.70(0.35-1.41)	0.80(0.40-1.60)	1	0.73	1.09(0.48-2.48)	0.60(0.29-1.22)	0.95(0.46-1.97)	1	0.37
High LDL	1.18(0.59-2.37)	0.83(0.42-1.65)	1.16(0.59-1.29)	1	0.72	1.42(0.63-3.19)	1.46(0.73-2.91)	1.20(0.49-2.10)	1	0.59
High BUN	1.28(0.64-2.58)	1.04(0.52-2.09)	1.14(0.57-2.28)	1	0.90	1.76(0.77-4.05)	1.70(0.84-3.44)	1.21(0.58-2.53)	1	0.39
High hs-CRP	0.95(0.47-1.90)	0.79(0.40-1.58)	0.73(0.37-1.44)	1	0.78	0.88(0.39-1.98)	1.21(0.60-2.41)	1.19(0.58-2.45)	1	0.80

Legend: Odds ratio (95% CIs) of overweight/obesity and elevated lipid profiles, BUN and hs-CRP among 270 diabetic nephropathy patients; BUN: blood urea nitrogen, hs-CRP: high sensitivity C-reactive protein, LDL: low density lipoprotein, TG: triglyceride, TC: total cholesterol; [1]Model 1: unadjusted model.; [2]Model 2: adjusted for age, sex, socioeconomic, marriage, smoking, physical activity and energy intake; [3]BMI≥25 kg/m2; [4]waist circumference≥99.5 or ≥94.25 cm for men and women, respectively; [5]TC>median; [6]triglyceride ≥150 mg/dl; LDL ≥130 mg/dl; [9]BUN ≥21 mg/dl, [10]hs-CRP ≥median

using DDS/ED instead of DDS and compared the function of these two indicators in relation to other diet qualities among diabetic nephropathic patients.

Previous studies reported that there was a direct significant association between DDS and MAR (21, 22). In contrast to our study in which the subjects were diabetic nephropathic patients, these studies were conducted on healthy individuals. On the other hand, if dietary diversity in nutrient-poor foods, i.e., fatty and/or sweetened foods (23), was high, DDS would be not positively correlated with nutrient intake. It seems that in our study population, dietary diversity in nutrient rich-foods was not as high as enough to show a positive correlation with adequate nutrient intake. In contrast, DDS/ED, a modified form of DDS in which the role of ED has been considered, could show a favorable association with NARs and MAR. There is a direct relation between dietary ED and consumption of low-nutrient-density foods (24). Therefore, we could exclude dietary diversity in low nutrient-density foods by using DDS/ED instead of DDS. This explanation may justify our findings regarding the association between DDS and DDS/ED and risk of obesity. A positive relationship between DDS and energy intake and subsequently BMI has been reported previously (10, 11). Our results showed that there was a significant trend for risk of overweight/obesity across quartiles of DDS/ED after adjusting for confounders. Similar result was not observed for DDS. Several studies reported that ED had a direct association with obesity (25-27). Furthermore, the effect of low energy-dense diets on treatment of obesity was assessed in several clinical trials (28, 29). As dietary ED is a risk factor for obesity (30), dietary diversity in energy dense foods

may also result in obesity. Therefore, DDS cannot be a reliable indicator of diet quality by itself, because it cannot show rational result regarding obesity in all circumstances. Accordingly, we used DDS/ED as a dietary intake indicator in which the role of ED has been considered.

Energy-dense foods are often high in fat (26) and therefore, they may increase the risk of obesity. Furthermore, previous studies showed that ED of a meal was inversely associated with energy intake at the subsequent meal (31, 32). Contradictory evidence has been reported regarding the relation between DDS and obesity. In summary, DDS in non energy-dense food groups was inversely associated with obesity (8). In contrast, higher DDS in energy-dense foods was directly related with obesity (10, 11). Therefore, ED is a key point to explain the mechanism of association between DDS and obesity.

Present study has several limitations. It is a cross-sectional study which cannot show causal relationship, and therefore, findings from prospective cohort studies would be more reliable to demonstrate causal association. We used a 168-item food frequency questionnaire to evaluate one-year dietary intake of subjects. It may result in misclassification of individuals regarding DDS and DDS/ED. These results obtained from diabetic nephropathic patient; therefore, we could not generalize them to healthy population. Also, age at diagnosis and edema were not assessed.

Introducing a new and modified index is the most important strength of current study. Moreover, this study addresses diet quality of diabetic nephropathic patients which was not sufficiently reported previously.

In conclusion, our results showed that DDS/ED corrected the failure of DDS in relation to risk of obesity. Moreover, it was observed that DDS/ED was better indicator of nutrient intake in comparison with DDS among patients with CKD.

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L.A, A.E, A.F and M.H.R designed the study. M.M.N, F.M, L.A and M.H.R collected data. L.A and M.H.R run statistical analysis and drafted the manuscript

References

1. Azadbakht L, Shakerhosseini R, Atabak S, Jamshidian M, Mehrabi Y, Esmaill-Zadeh A. Beneficiary effect of dietary soy protein on lowering plasma levels of lipid and improving kidney function in type II diabetes with nephropathy. Eur J Clin Nutr 2003; 57:1292-4.
2. Berkman J, Rifkin H. Unilateral nodular diabetic glomerulosclerosis (Kimmelstiel-Wilson): report of a case. Metabolism 1973; 22:715-22.
3. European Renal Care Association. European Guidelines for the Nutritional Care of Adult Renal Patients. [Cited 20 Dec 2013] Available from: http://www.eesc.europa.eu/self-and coregulation/documents/codes/private/086-private-act.pdf.
4. Naumova R, Watts L, Gregory L, Sleĭvin B. Differences in the dietary intake of diabetics with and without early nephropathy. Vutr Boles 1990; 29:99-104.
5. Khan MS, Chandanpreet S, Kewal K, Sanjay D, Ram KJ, Atul S. Malnutrition, anthropometric, and biochemical abnormalities in patients with diabetic nephropathy. J Ren Nutr 2009; 19:275-82.
6. Delahanty L, Kriska A, Edelstein S, Amodei N, Chadwick J, Copeland K, et al. Self-reported dietary intake of youth with recent onset of type 2 diabetes: results from the TODAY study. J Acad Nutr Diet 2013; 113:431-9.
7. Azadbakht L, Esmaillzadeh A. Dietary energy density is favorably associated with dietary diversity score among female university students in Isfahan. Nutrition; 28:991-5.
8. Azadbakht L, Esmaillzadeh A. Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth. Public Health Nutr 2011; 14:62-9.
9. Azadbakht L, Mirmiran P, Azizi F. Dietary diversity score is favorably associated with the metabolic syndrome in Tehranian adults. Int J Obes (Lond) 2005; 29:1361-7.
10. Azadbakht L, Mirmiran P, Esmaillzadeh A, Azizi F. Dietary diversity score and cardiovascular risk factors in Tehranian adults. Public Health Nutr 2006; 9:728-36.
11. Jayawardena R, Byrne NM, Soares MJ, Katulanda P, Yadav B, Hills AP. High dietary diversity is associated with obesity in Sri Lankan adults: an evaluation of three dietary scores. BMC Public Health 2013; 13:314.
12. Maric C, Hall JE. Obesity, metabolic syndrome and diabetic nephropathy. Contrib Nephrol 2011; 170:28-35.
13. Azadbakht L, Atabak S, Esmaillzadeh A. Soy protein intake, cardiorenal indices, and C-reactive protein in type 2 diabetes with nephropathy: a longitudinal randomized clinical trial. Diabetes Care 2008; 31(4):648-54.
14. Meyers BD, Bennett PH. Clinical evolution of renal disease

in insulin dependent and noninsulin dependent diabetes mellitus. In Principles and Practice of Nephrology. 1st ed Jacobson HR, Striker, GE, Klahr, S, editors. , Eds. Philadelphia, BC Decker, 1991, p. 464
15. Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index revised: a measurement instrument for populations. J Am Diet Assoc 1999; 99:697-704.
16. "Dietary reference intakes (DRIs): recommended intakes for individuals, vitamin/mineral," in Krause's Food & Nutrition Therapy, S. Escott-Stump and L. Mahan, Eds., Saunders Elsevier, Philadelphia, Pa, USA, 12th edition, 2008.
17. Stunkard AJ, Wadden TA. editors. Obesity: theory and therapy, 2 nd ed. New York: Raven Press; 1993. p. 45.
18. Lean ME, Han TS, Morrison CE. Waist circumference as a measure for indicating need for weight management. BMJ 1995; 311:158-61.
19. Heshmat R, Khashayar P, Meybodi HR, Homami MR, Larijani B. The appropriate waist circumference cut-off for Iranian population. Acta Med Indones 2010; 42:209-15.
20. Villalpando S, García-Guerra A, Ramírez-Silva CI, Mejía-Rodríguez F, Matute G, Shamah-Levy T, et al. Iron, zinc and iodide status in Mexican children under 12 years and women 12-49 years of age. A probabilistic national survey. Salud Publica Mex 2003; 45:S520-9.
21. Mirmiran P, Azadbakht L, Esmaillzadeh A, Azizi F. Dietary diversity score in adolescents - a good indicator of the nutritional adequacy of diets: Tehran lipid and glucose study. Asia Pac J Clin Nutr 2004; 13:56-60.
22. Steyn NP, Nel JH, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? Public Health Nutr 2006; 9:644-50.
23. Kant AK. Consumption of energy-dense, nutrient-poor foods by adult Americans: nutritional and health implications. The third National Health and Nutrition Examination Survey, 1988-1994. Am J Clin Nutr 2000; 72:929-36.
24. Kant AK, Graubard BI. Energy density of diets reported by American adults: association with food group intake, nutrient intake, and body weight. Int J Obes (Lond) 2005; 29:950-6.
25. Mendoza JA1, Drewnowski A, Cheadle A, Christakis DA. Dietary energy density is associated with selected predictors of obesity in U.S. Children. J Nutr 2006; 136:1318-22.
26. Li M1, Dibley MJ, Sibbritt DW, Yan H. Dietary habits and overweight/obesity in adolescents in Xi'an City, China. Asia Pac J Clin Nutr 2010; 19:76-82.
27. Esmaillzadeh A, Azadbakht L. Dietary energy density and the metabolic syndrome among Iranian women. Eur J Clin Nutr 2011; 65:598-605.
28. Schusdziarra V, Hausmann M, Wiedemann C, Hess J, Barth C, Wagenpfeil S, et al. Successful weight loss and maintenance in everyday clinical practice with an individually tailored change of eating habits on the basis of food energy density. Eur J Nutr 2011; 50:351-61.
29. Saquib N, Natarajan L, Rock CL, Flatt SW, Madlensky L, Kealey S, et al. The impact of a long-term reduction in dietary energy density on body weight within a randomized diet trial. Nutr Cancer 2008; 60:31-8.
30. Mendoza JA, Drewnowski A, Christakis DA. Dietary energy density is associated with obesity and the metabolic syndrome in U.S. adults. Diabetes Care 2007; 30:974-9.
31. Araya H, Vera G, Alviña M. Effect of the energy density and volume of high carbohydrate meals on short term satiety in preschool children. Eur J Clin Nutr 1999; 53:273-6.
32. Kral TV, Roe LS, Rolls BJ. Combined effects of energy density and portion size on energy intake in women. Am J Clin Nutr 2004; 79:962-8.

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