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Association between Dietary Diversity Score and Nutrient Adequacy in Patients with Calcium Oxalate Kidney Stone

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ABSTRACT

Background: Nephrolithiasis is a global health problem that is growing exponentially in the developed and developing countries. This study aimed to determine the dietary diversity score (DDS) and its association with nutrient adequacy in patients with calcium oxalate kidney stone. **Methods:** The present cross-sectional study was conducted on 276 male patients with calcium oxalate kidney stone. The validity and reliability of dietary intake was assessed by the 147-item food frequency questionnaire. Based on the USDA Food Guide Pyramid, the five food groups (grains, vegetables, fruits, meats, and dairy products) were used to determine the DDS. The nutrient adequacy ratio and the mean adequacy ratio were calculated using the Recommended International Standards. **Results**: The mean of the body mass index of the participants was 27.49 ± 4.01 kg/m^2. Mean of the total DDS was also 5.62 ± 1.29. Participants in the highest DDS tertile had higher energy and fat intake than those in the lowest tertile (P-trend < 0.05). The highest and lowest DDS were observed in the fruit and vegetable groups: 1.58 ± 0.53 and 0.91 ± 0.29, respectively. The total DDS had a positive correlation with the adequacy of energy intake and macronutrients including protein and fats ($P < 0.05$). Furthermore, a significant positive correlation was found between the total DDS and the mean adequacy ratio ($P < 0.01$, r = 0.2). **Conclusion**: The findings showed that patients with calcium oxalate kidney stone did not have an appropriate level of total DDS (DDS < 6), indicating that they did not receive diverse nutrients.

Keywords: *Dietary diversity score; Nephrolithiasis; Calcium oxalate; Nutrient*

Introduction

Currently, nephrolithiasis is a global health problem that is growing exponentially in the developed and developing countries (Alatab *et al.*, 2016). According to the recent studies, at least 15% of adults in North America have kidney stone (Scales Jr *et al.*, 2012). Kidney stone is mainly composed of calcium oxalate crystals (Sakhaee *et al.*, 2012). The prevalence of kidney stone in men is higher than in women because of unknown causes (Curhan *et al.*, 1993). Dietary diversity score is an appropriate index to assess the whole food intake (Hann *et al.*, 2001, Hatløy *et al.*, 1998).

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Dietary diversity is defined as the number of different foods consumed in a given period; in the other words, choosing different foods from different food groups (grains, vegetables, fruits, meats, and dairy products) (Mirmiran *et al.*, 2004, United States Department of Agriculture, 1992). Dietary diversity is expressed based on the USDA (The United States Department of Agriculture) Food Guide Pyramid (United States Department of Agriculture, 1992), which plays an important role in chronic diseases. A diverse diet reduces the risk of overeating and undereating (Gersovitz *et al.*, 1978). Therefore, this study aimed to determine the dietary diversity and its association with the adequacy of macronutrients intake in people with calcium oxalate kidney stone.

Materials and Methods

Study design and participants: This cross-sectional study was conducted on 276 male patients with calcium oxalate kidney stone with a mean age of 42 ± 11 years. The participants were selected from the hospitalized patients in Moheb and Hasheminejad Hospitals in Tehran using convenience sampling method. Participants in the age group of 18-65 years who did not have any diseases such as hyperparathyroidism, hyperthyroidism, irritable bowel syndrome (IBS), and inflammatory bowel disease (IBD) were selected. Those with dietary intake of < 800 kcal and > 4200 kcal were excluded from the study (Curhan *et al.*, 1993, Maddahi *et al.*, 2017).

Dietary assessment: The validity and reliability of dietary intake was assessed using the 147-item food frequency questionnaire (FFQ) (Mirmiran *et al.*, 2010). Participants were asked about their dietary intake over the past year. These data were collected from the patients suffering from calcium oxalate kidney stone less than three months. To estimate the dietary intake, nutritionist 4 software, designed for Iranian foods was used.

Dietary diversity score and nutrient adequacy ratio: To determine the dietary diversity score (DDS), we used the method designed by Torheim et al. and Kant *et al*.(Kant *et al.*, 1993, Torheim *et al.*, 2003) in which 5 food groups (grains, vegetables, fruits, meat and dairy products) were used based on the USDA food guide pyramid. The main groups were divided into 23 subgroups, including 7 subgroups of bread, cereals, and their products (white breads, biscuits, macaroni, whole grain, corn, rice, and refined grains), 7 subgroups of vegetables (tomatoes and their products, starchy vegetables, legumes, yellow vegetables, green leafy vegetables, potatoes and so on), 2 subgroups of fruits (citrus, berries and fruit juices), 4 subgroups of meat (red meat, poultry, fish, and eggs), and 3 subgroups of dairy products (milk, yogurt, and cheese). To be considered as a consumer of these food group, at least half of the serving must be consumed according to the quantitative indicators of the food guide pyramid during the day. The final DDS is 10 and each of the 5 main groups has a maximum of 2 points. The final score is the sum of the scores of the 5 main food groups. For example, a person who has consumed at least half of the 3 main subgroups of bread and cereals, his/her score is (3:7) ×2 = 0.85 in this group, which means that the person obtained only 0.85 scores out of 2 in the bread and cereals group. Furthermore, dietary diversity was compared with the mean adequacy ratio (MAR). To obtain the MAR, the nutrient adequacy ratio (NAR) was calculated for energy intake and 12 nutrients (vitamin A, riboflavin, thiamine, vitamin C, calcium, iron, zinc, phosphorus, magnesium, protein, potassium, and fat). To calculate the NAR and MAR, the following formulas were used:

$$\mathrm{NAR} = \frac{\text{daily nutrient intake}}{\text{recommended dietary allowance}}$$

$$\mathrm{MAR} = \frac{\Sigma \mathrm{NAR}}{\text{number of nutrients}}$$

Recommended dietary allowances (RDA) was used to calculate the NAR of vitamins A, C, iron, zinc, and energy (National Research Council, 1989). To calculate the NAR of riboflavin, thiamine, calcium, phosphorus, and magnesium, dietary reference index (DRI) was used. The minimum required amount of potassium of a healthy person (2000 mg) was applied to calculate the NAR of potassium (Marshall *et al.*, 2001). The maximum recommended percentage of energy (30%) was considered to calculate the NAR of fat (Hatløy *et al.*, 1998) and MAR was calculated based on the formula mentioned in the Krebs-Smith study (Krebs-Smith *et al.*, 1987).

Other variables: Demographic information (age, gender, and education), anthropometric measurements such as weight and body mass index (BMI), health and habits information (smoking, alcohol and physical activity) were collected by a trained researcher. To measure weight and height, a digital scale with an accuracy of 100 g and a height gauge with an accuracy of 0.1 cm were used. The validity and reliability of the physical activity was assessed using an IPAQ-SF questionnaire (Lee *et al.*, 2011).

Ethical considerations: A consent letter was gained from all patients. This study was approved by the Ethics Committee of the Islamic Azad University, Science and Research Branch (ID: IR.IAU.SRB.REC.1396. 45).

Data analysis: To measure the DDS, we used the data of the food frequency questionnaire. The mean and standard deviation of demographic, anthropometric, and dietary intake in the DDS tertiles were calculated using ANOVA. To calculate the food groups' intake in the DDS tertiles, ANCOVA was used along with adjusting for energy intake. The normality of all variables was tested by Kolmogorov-Smirnov. Correlation of the total DDS with MAR and NARs was determined using Pearson correlation test. All analysis was performed by SPSS v.24 software and P-value < 0.05 was assumed as significant.

Results

The demographic and anthropometric information of the participants in the DDS tertiles were shown in **Table 1**. The participants in the highest DDS tertile had higher energy and fat intake than those in the lowest tertile (*P*-trend < 0.05). Moreover, those in the lowest DDS tertile had higher carbohydrate intake than in the highest tertile. No significant differences were found in fiber and protein intake, physical activity, BMI, nutritional status, education, smoking, and alcohol consumption between the DDS tertiles. As shown in **Table 2**, the mean of the total DDS is 5.62 ± 1.29. The mean of DDS for each of the 5 food groups were shown in **Table 2**, which indicates that the fruits group (1.58 ± 0.53) and the vegetables group (0.91 ± 0.29) had the highest and lowest DDS, respectively. The 5 food groups' intakes are represented in **Table 3**. We found that higher DDS was related to healthier diet. According to the analysis, participants in the highest DDS tertile had lower refined grains intake than those in the lowest tertile. Furthermore, participants in the highest DDS tertile had higher fruit and dairy groups intake than those in the lowest tertile. According to the **Table 4**, a positive correlation was observed between total DDS and the MAR. The total DDS was positively correlated with the adequacy of thiamine, riboflavin, potassium, phosphorus, calcium, iron, and vitamin C (*P* < 0.01). Similarly, the total DDS had a positive correlation with the adequate intake of energy and macronutrients including protein and fat (*P* < 0.05). The total DDS was not significantly correlated with the adequacy of magnesium, zinc, and vitamin A, while the MAR was correlated with the total DDS significantly.

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Table 1. Characteristics, energy and dietary intakes of participants among tertiles of dietary diversity scores

Variables	Dietary diversity score			P-trend[a]
	Tertile1 (n = 93)	Tertile2 (n = 90)	Tertile3 (n = 84)	
Age (year)	40.18 ± 10.82[b]	44.79 ± 11.81	41.08 ± 10.76	0.014
Weight (kg)	82.16 ± 13.57	83.23 ± 12.86	84.41 ± 13.14	0.529
Body mass index (kg/m^2)	27.23 ± 4.07	27.42 ± 3.89	27.85 ± 4.08	0.583
Energy intake (kcal)[c]	2385.47 ± 641.02	2724.71 ± 572.82	3199.48 ± 693.58	<0.001
Carbohydrate, % of total energy[c]	60.30 ± 5.78	59.49 ± 5.44	58.00 ± 6.16	0.030
Protein, % of total energy [c]	13.79 ± 2.01	13.86 ± 1.80	14.40 ± 2.08	0.089
Fat, % of total energy[c]	28.10 ± 5.28	29.26 ± 5.47	30.24 ± 5.78	0.037
Fiber (g)	53.59 ± 31.94	53.31 ± 23.50	57.16 ± 18.29	0.542
Education				
Undergraduate	70 (75.3)[b]	70 (77.8)	64 (76.2)	0.880
Graduate	15 (16.1)	10 (11.1)	12 (14.3)	
Postgraduate	8 (8.6)	10 (11.1)	8 (9.5)	
Nutritional status				
Underweight	1 (1.1)	1 (1.1)	1 (1.2)	0.931
Normal	33 (35.5)	31 (34.4)	24 (28.6)	
Overweight	36 (38.7)	38 (42.2)	34 (40.5)	
Obese	23 (24.7)	20 (22.2)	25 (29.8)	
Smoking	29 (31.2)	26 (28.9)	24 (28.6)	0.916
Alcohol	19 (20.4)	18 (20)	23 (27.4)	0.427
Physical activity				
Low	47 (50.5)	43 (47.8)	33 (39.3)	0.132
Moderate	31(33.3)	21 (23.3)	27 (32.1)	
Severe	15 (16.1)	26 (28.9)	24 (28.6)	

[a]:Resulted from ANOVA; b: Mean ± SD; [c]: Obtained from the ANCOVA and adjusted for energy intake and age

Table 2. Mean of dietary diversity score in term of food groups

Variables	Mean ± SD
Grain group	0.98 ± 0.27
Vegetable group	0.91 ± 0.29
Fruits group	1.58 ± 0.53
Meat group	1.00 ± 0.49
Dairy group	1.13 ± 0.66
Total	5.62 ± 1.29

Table 3. Dietary intake of food groups among the tertiles of dietary diversity score

Dietary intake	Dietary diversity score			P-trend[a]
Foods(g/d)	Tertile1 N = 93	Tertile2 N = 90	Tertile3 N = 84	
Fruits	154.51 ± 8.68	171.20 ± 8.87	205.66 ± 9.10	<0.001
Vegetables	103.94 ± 5.74	109.17 ± 5.87	117.38 ± 6.02	0.268
Meat	9.40 ± 0.75	10.63 ± 0.77	10.46 ± 0.79	0.472
Whole grains	57.99 ± 3.51	55.03 ± 3.58	49.01 ± 3.68	0.202
Refined grains	160.22 ± 5.22	136.61 ± 5.33	124.46 ± 5.47	<0.001
Dairy	108.46 ± 8.15	129.97 ± 8.33	158.63 ± 8.54	<0.001
Fast foods	5.67 ± 0.93	7.34 ± 0.95	8.27 ± 0.97	0.148

[a]: Obtained from the ANCOVA and adjusted for energy intake and age.

Table 4. Correlation coefficient between nutrient adequacy ratio and total dietary diversity score

Nutrient adequacy ratio	r	P-value
Total energy	0.53	<0.01
Protein	0.14	<0.05
Fat	0.14	<0.05
Vitamin A	0.05	0.09
Vitamin C	0.30	<0.01
Calcium	0.25	<0.01
Iron	0.24	<0.01
Thiamine	0.28	<0.01
Riboflavin	0.18	<0.01
Magnesium	0.04	0.10
Zinc	0.11	0.06
Potassium	0.29	<0.01
Phosphorus	0.21	<0.01
Mean adequacy ratio	0.24	<0.01

Discussion

The present cross-sectional study aimed to determine the dietary diversity score in patients with calcium oxalate kidney stone. The findings of the present study showed that the total DDS was significantly correlated with the MAR, which is consistent with the results of other studies (Mirmiran *et al.*, 2004). A significant positive correlation was also observed between the DDS and the NAR for most nutrients (Hatløy *et al.*, 1998, Mirmiran *et al.*, 2004, Torheim *et al.*, 2004). However, few studies were conducted on the association of DDS and kidney stones (Drewnowski *et al.*, 1996, Tucker, 2001).

The present study showed a reverse association between the increased DDS and carbohydrate intake in patients with calcium oxalate kidney stone. The study by Jayawardena *et al.*, which was conducted on obesity, was not consistent with the results of our study due to consumption of starch-based foods and poor variety (Jayawardena *et al.*, 2013). Some studies showed that increased glucose concentration may increase intestinal calcium absorption (Grant *et al.*, 2018).

In a study by Torheim *et al.*, participants with higher DDS had the highest energy intake due to high fat intake (Torheim *et al.*, 2004). The results of the present study also showed that increased DDS was not associated with overweight, in which it was not consistent with the results of study by Jayawardena (Jayawardena *et al.*, 2013). It seems that in order to achieve higher DDS, participants should increase their energy and fat intakes and reduce their carbohydrate intake, but in our study we cannot draw such a conclusion.

Similar to the study by Hatloy *et al.*, the fiber and protein intake had no significant association with the DDS, which can be attributed to similarity in scoring methods (Hatløy *et al.*, 1998).

According to the results, the fruits group and vegetables group had the highest and lowest DDS, respectively. This finding was consistent with the results of study by Radhika *et al.*, which was carried out on cardiovascular diseases(Radhika *et al.*, 2008). Similar to the study by Jayawardena et al., participants in the highest DDS tertile had lower refined grains intake than those in the lowest tertile (Jayawardena *et al.*, 2013). Furthermore, participants in the highest DDS tertile had higher intakes of fruit and dairy than those in the lowest tertile, which may be due to the participants' eating habits.

Contrary to the study by Fernandez et al., in the present study, energy intake and NARs of the protein and fat had a significant positive correlation with the DDS (Fernandez *et al.*, 2000). However, these findings were consistent with the findings of some other studies (Drewnowski *et al.*, 1997, Kant *et al.*, 1993).

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In the present study, a significant positive correlation was found between the NARs of vitamin C, B1, B2, Ca, P, and potassium with the total DDS. In the study by Azadbakht *et al*., the DDS of dairy group was correlated with the NAR of vitamins B2, Ca, and P(Azadbakht and Esmaillzadeh, 2009).

Few studies were conducted on the effect of DDS on chronic diseases (Drewnowski *et al.*, 1996, La Vecchia *et al.*, 1997), which results showed that the DDS was associated with metabolic syndrome and cardiovascular disease (Azadbakht *et al.*, 2005, Mehrabani *et al.*, 2016).

The present study had some limitations: first, its cross-sectional design limited the interpretation of cause-and-effect relationship; second, nutritional information was depended on the participants' memory. However, we used the food frequency questionnaire, which reflects the nutrient intake better than food recall.

Conclusions

In conclusion, the present study showed that patients with calcium oxalate kidney stone did not have good total dietary diversity scores, indicating that they did not receive diverse nutrients. It highlights the importance of dietary diversity in maintaining good health and well as the lack of diversity affected urinary stone risk factors such as increased concentration of oxalate or calcium in urinary tract.

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Conflict of interest

The authors state no conflicts of interest.

Authors' Contributions

Study concept and design: Azimi T, Eghtesadi S; Data collection: Azimi T; Statistical analyses: Azimi T; Manuscript drafting: Azimi T; Revision of manuscript: Eghtesadi S. All authors approved the final version of manuscript.

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