Original Article

# Association between dietary patterns with kidney function and serum highly sensitive C-reactive protein in Tehranian elderly: An observational study

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**Background:** Accumulating evidence suggests that diet is associated with kidney function. This study was carried out to examine the association between a posteriori dietary patterns and kidney function in older adults. **Materials and Methods:** In a cross-sectional study, 266 older adults, aged 60–83 years, were included. Anthropometric measures were recorded. Biochemical measurements of blood and urine samples were measured. Information on diet was collected using a validated semi-quantified food frequency questionnaire with 168 food items and factor analysis performed to derive major dietary patterns. Estimated glomerular filtration rate (eGFR) was calculated using the chronic kidney disease (CKD) Epidemiology Collaboration equation. **Results**: A total of 266 participants with mean body mass index (BMI) 29.75 ± 4.53 kg/m$^2$ and age, 66.2 ± 5.3 years, were included in the current study. Three major dietary patterns were identified using factor analysis based on intake data (28% of the total variance of food intake in the population). After adjustment for age, sex, BMI, and energy intake, we found a positive significant relationship between the first pattern and eGFR ($P$ = 0.031). A positive significant association between adherence to the traditional dietary pattern and urine creatinine was also observed ($P$ = 0.035). In addition, in logistic regression model and after control for covariates, a positive association was observed between adherence to traditional dietary pattern with odds of eGFR < 60 ml/min/1.73 m$^2$ ($P$ = 0.043) and urinary albumin-to-creatinine ratio ≥ 30 mg/g ($P$ = 0.038). **Conclusion:** It is concluded that higher adherence to the healthy dietary pattern may improve renal function while Iranian traditional pattern was associated with significantly increased odds of incident CKD and albuminuria.

**Key words:** Dietary patterns, inflammation, kidney function, older adults

**How to cite this article:** Eimery S, Tangestani H, Mansouri S, Kordvarkaneh H, Rahimi-Foroushani A, Shab-Bidar S. Association between dietary patterns with kidney function and serum highly sensitive C-reactive protein in Tehranian elderly: An observational study. J Res Med Sci 2020;25:19.

## INTRODUCTION

Kidney dysfunction is becoming a global epidemic health problem and is highly associated with quality of life.[1] In older adults, kidney dysfunction has been suggested as a contributing risk factor for mortality as well as cardiovascular disease (CVD).[1] The presence of microalbuminuria and moderately decreased kidney filtration function are key determinants of CVD[2] and mortality.[3] Chronic inflammation may also have a mediatory role in the progress of CVD risk in individuals with kidney dysfunction.[4] It is reported that C-reactive protein (CRP), fibrinogen, and interleukin-6 (IL-6) levels were higher in individuals with impaired kidney function.[4]

There are limited data on the association of diet, as an important modifiable risk factor, with microalbuminuria or kidney function decline. So far, most of the nutritional studies have focused on foods[5-7] and nutrients mostly in the form of supplements;[6,8,9] such as omega-3 fatty acids

| Access this article online | |
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| Quick Response Code: | Website: www.jmsjournal.net |
| | DOI: 10.4103/jrms.JRMS_812_18 |



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**Submitted:** 04-Jan-2019; **Revised:** 26-Aug-2019; **Accepted:** 04-Dec-2019; **Published:** 20-Feb-2020

which may be effective in reducing systemic inflammation and improving kidney function.[8] However, extrapolation of the results obtained from these sorts of studies to the whole population with different dietary intake is hardly possible. As a result, during the last decade, there has been a remarkable attention deviation from nutrients to dietary patterns. Individuals typically consume meals containing variety of foods and nutrients, instead of just a single nutrient.[10] There is likely to be important interactions among and within foods so that the combined and linked effect of the dietary constituents could be different from that of the single foods and nutrients.[11]

Furthermore, observations by Banerjee provide results that DASH diet is associated with greater risk of end-stage renal disease in adults with moderate chronic kidney disease (CKD) and hypertension.[12] Moreover, diets with high fruit and vegetable components have favorable effects in patients with early and advanced CKD.[13] Other studies also reported associations between dietary indexes and kidney function biomarkers.[14-18] For example, it is reported that DAL can increase the risk of CKD and have an inverse association with urine pH.[19] In contrast, a 1-year interventional study showed that the beneficial effect of MedDiet on estimated glomerular filtration rate (e-GFR) is not greater than a low-fat diet.[20] A recent published review on prospective studies reported that adherence to healthy dietary patterns, including DASH and Mediterranean dietary patterns may be beneficial in promoting kidney health and preventing CKD in the general population.[21] However, the focus of the majority of included studies was on population in adults age and the number of studies on older adults is scare. Moreover, authors have mentioned in this review, less research exists on the association of dietary patterns, particularly *a posteriori* dietary patterns and renal function in different populations.

CKD and poor dietary intakes in older adults are prevalent and have a major impact on disabilities and mortality.[22] The possible association of dietary patterns and kidney dysfunction is not well understood. Therefore, this study was conducted to examine the association between major dietary patterns, kidney function and inflammation in Tehranian older adults. Our hypothesis was that healthy patterns might have a protective effect on kidney function.

## METHODS

STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) was strictly followed in writing this study. This cross-sectional study was a population-based study that carried out from June to September 2015 in Tehran, Capital city of Iran. The study was performed on 226 older adults aged more than 60 years[23] (63 males and 152 females), who were selected using a multistage cluster random-sampling method from 20 health houses in 5 districts of Tehran (northern, southern, eastern, western, and central part of Tehran). Participant inclusion criteria included enrolling older adults over 60 years old who abled to answer questions. Participants were excluded if they had type 1 diabetes, on dialysis, or had clinical symptoms of any other disease like cancer. We also excluded those with reported energy intakes <500 and >3500 kcal/day. Signed informed consent was obtained from all the participants before the beginning of the study. This study approved by the Ethics Committee of the Tehran University of Medical Sciences (Ethics number: 29544).

Weight was measured, while the participants were minimally clothed without shoes, using digital scales, and recorded to the nearest 100 g. Height was measured in a standing position, without shoes, using tape meter while shoulders were in a normal state. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared.

From all participants, 10 mL of fasting venous blood was taken after 12 h fasting. Blood samples were poured in a clean glass test tube without anticoagulant and were kept for ~ 30 at room temperature (RT) followed by centrifugation at 1500 g at RT. Serum samples were transferred to clean microtubes and were kept at − 80°C until the day of analysis. Urine sample was taken from each participant as well. Fasting serum glucose, lipid profile including triglycerides (TGs), total cholesterol, low-density lipoprotein (LDL) cholesterol, and high-density lipoprotein (HDL) cholesterol were determined using enzymatic methods. Serum albumin and creatinine were measured by colorimetric assays. All these tests were done by commercial kits (all from Pars Azmoon, Iran) using an auto-analyzer system (Selectra E, Vitalab, the Netherlands). Urinary albumin and creatinine were determined by immunoturbidometric and colorimetric methods, respectively, (both from Pars Azmoon, Iran) using an autoanalyzer (Selectra E, Vitalab, the Netherlands). ACR was calculated by dividing albumin concentration in milligrams by creatinine concentration in grams. eGFR was calculated using the CKD Epidemiology Collaboration equation, which is based on creatinine, age, sex, and a four-level variable for race.[24] Inflammatory status was evaluated using determination of highly sensitive CRP (hs-CRP) (immunoturbidometric assay, Pars Azmoon, Iran).

Usual dietary data were collected using a validated semi-quantitative food frequency questionnaire (FFQ), which contained 168 food items.[25] Trained dietitians completed the FFQ during face-to-face interviews, asking participants to report the frequency of consumption of each food item, during the past year on a daily, weekly, or monthly basis. These reports were converted to daily intakes. Analysis of dietary intake was done by Nutritionist IV.

Descriptive statistics such as mean and standard deviation (SD) were used to summarize continuous variables. The Kolmogorov–Smirnov test was conducted to evaluate the normal distribution of quantitative variables. We used principal component factor (PCA) with Varimax rotation to derive three major dietary patterns. PCA was conducted on 25 food groups and the food groups were defined according to the similarity in nutrient composition. Energy adjustment was done using the residual method.[26] Factors with an eigenvalue >1.25 were retained. Individual food items with a factor loading >0.3 were highlighted as composing that factor for simplicity. The factor scores for each dietary pattern and for each participant were calculated by summing each dietary pattern score weighted by their factor loadings. The estimated factor scores were categorized into tertiles. Association across the tertiles was evaluated by analysis of covariance for continuous variables. We developed three models to evaluate the adjusted for age and gender or adjusted for sex, age, BMI, blood pressure, and energy intake. The eGFR <60 ml/min/1.2 was classified as participants with CKD. Albuminuria was defined by a urinary albumin-to-creatinine ratio ≥30 mg/g.[27] Odds ratio (OR) and 95% confidence were obtained using logistic regression to determine the relationship of dietary patterns with kidney function. The risk was reported in crude and adjusted model for age, sex, BMI, smoking status, physical activity, blood pressure, use of medications, dietary intakes of protein, potassium, calcium, magnesium and phosphorous, supplement intake, socioeconomic status, and energy intake. In this analysis, the first tertile of exposure A significant positive as the reference category. To calculate the trend of ORs across increasing tertiles of identified dietary patterns, we considered the median of tertile categories in a regression model. Statistical tests were two-sided with 5% significance level. All analyses were performed using SPSS version 16 for Windows (SPSS Inc. Chicago, USA).

## RESULTS

Two hundred and twenty-six older adults aged 60–83 years (66.2 ± 5.3) were evaluated in which 152 of them (67.3.1%) were female. The average BMI for participants was 29.75 ± 4.53 kg/m$^2$. The anthropometric and clinical characteristics of the study participants are shown in Table 1. Biochemical biomarkers including serum creatinine (1.18 ± 0.92 mg/dl), serum urea (33.74±14.41 mg/dl), serum microalbumin (4.78±2.7 mcg/mg), urinary microalbumin (69.79 ± 64.54 µg/ml), urinary creatinine (2.45 ± 1.41 mg/dl), and eGFR (66.24 ± 38.68 ml/min) have been reported as means and SD in Table 1.

**Table 1: Biochemical and clinical characteristics of the 226 older adults**

| | Minimum | Maximum | Mean±SD* |
|---|---|---|---|
| Anthropometry | | | |
| Age (years) | 60.00 | 83.00 | 67.04±5.77 |
| Height (cm) | 132.50 | 180.50 | 156.25±8.01 |
| Weight (kg) | 39 | 117.40 | 72.62±12.04 |
| BMI (kg/m$^2$) | 11.18 | 48.87 | 29.75±4.53 |
| WC (cm) | 63 | 135 | 99.22±10.37 |
| SBP (mmHg) | 90 | 204 | 142.08±22.02 |
| DBP (mmHg) | 50 | 122 | 84.69±14.71 |
| Biochemical characteristics | | | |
| TG (mmol/l) | 44 | 533 | 176.38±88.12 |
| T-chol (mmo/l) | 99.00 | 358 | 203.73±47.96 |
| HDL-C (mg/dl) | 4 | 81 | 49.26±12.99 |
| LDL-C (mg/dl) | 36 | 230 | 119.20±41.84 |
| FBS (mmol/l) | 66 | 378 | 110.43±41.66 |
| hs-CRP (mg/l) | 0.10 | 31.40 | 3.57±4.49 |
| Creatinine serum (mg/dl) | 0.10 | 11 | 1.18±0.92 |
| Urea serum (mg/dl) | 13 | 181 | 33.74±14.41 |
| Microalbumin serum (mcg/mg) | 3.10 | 45 | 4.78±2.71 |
| Urine characteristic | | | |
| Creatinine (mg/dl) | 0.31 | 8.9 | 2.45±1.41 |
| Microalbumin (µg/ml) | 0.50 | 384.15 | 69.79±64.54 |
| ACR (mg/mmol) | 0.41 | 198.02 | 27.97±23.32 |
| eGFR (ml/min) | 3.76 | 38.08 | 66.24±38.68 |

BP=Blood pressure; BMI=Body mass index; WC=Waist circumference; SBP=Systolic BP; DBP=Diastolic BP; FBS=Fast blood sugar; TG=Triglyceride; T-chol=Total cholesterol; HDL-C=High-density lipoprotein cholesterol; LDL=Low-density lipoprotein; hs-CRP=High sensitivity C-reactive protein; e-GFR=Estimated glomerular filtration rate; ACR=Albumin/creatinine ratio; SD=Standard deviation

Factor loadings and variance of each dietary pattern are shown in Table 2. The items with factor loading higher than 0.3 were maintained in order to compose the dietary pattern. Using factor analysis, it was possible to identify three major dietary patterns, which explained 28% of the total variance of food intake in the population. The highest variance percentages were for dietary patterns which labeled healthy dietary pattern (9.48%), Western dietary pattern (9.41%), and traditional dietary pattern (9.10%). The healthy pattern characterized by high intake of curd, vegetables, fruits, fish, canned fish, and poultry and the Western pattern included egg, snack, nuts, mayonnaise, salt, and processed meat and the traditional pattern included breads, high-fat dairy, legume and soy, organ meat, boiled potato, oil and butter, caffeine, pickles, sweet dessert, and fried potato.

Associations between dietary pattern adherence versus kidney function biomarkers are shown in Table 3. The adherence to healthy dietary pattern resulted in higher eGFR (*P* for trend = 0.031). There was no significant difference of population characteristics through tertiles of Western dietary patterns. Adherence to traditional dietary pattern showed that participants with high intake of bread and high-fat dairy and legumes had higher level of urinary creatinine (*P* = 0.028).

**Table 2: Factor loadings matrix for three dietary patterns identified from the food frequency questionnaire (168 items, divided to 25 food groups)**

| Food groups/Items | Details | Dietary patterns | | |
|---|---|---|---|---|
| | | Healthy dietary pattern | Western dietary pattern | Traditional dietary pattern |
| Curd | Details | 0.746 | - | - |
| Vegetables | Dried mulberry, mulberry lettuce, cucumber, tomato, boiled veggies, celery, spinach, zucchini, pea, bell pepper, green bean, eggplant, garlic, cabbage, mushroom, turnip, pumpkin, raw carrot, boiled carrot, corn | 0.658 | - | - |
| Canned fish | Canned fish | 0.590 | - | - |
| Grain | White rice, spaghetti, vermicelli, noodle | 0.587 | - | - |
| Olive | Olive fruit, olive oil | 0.347 | - | - |
| Poultry | Poultry | 0.344 | 0.565 | - |
| Fruits | Cantaloupe, Persian melon, watermelon, pear, apricot, cherry, apple, peach, nectarine, greengage, fig, grapes, kiwi, grapefruit, orange, persimmon, tangerine, pomegranate, dates, plums, strawberry, banana, lemon, lime, natural orange juice, natural apple juice, natural cantaloupe juice, raisins, dried figs, dried fruits | 0.329 | −0.543 | - |
| Fish | Fish | 0.301 | −0.400 | - |
| Egg | Eggs | - | 0.459 | - |
| Snack | Crackers, chips, cheese puffs | - | 0.403 | - |
| Nuts | Peanuts, almond, pecan, soybeans, chestnuts, pistachio, egusi seeds | - | 0.378 | - |
| Mayonnaise | Mayonnaise | - | 0.361 | - |
| Salt | Salt | - | 0.359 | - |
| Processed meat | Hamburgers, lunch meat, sausage | - | 0.346 | −0.363 |
| Breads | Bread (lavash, barbari, taftan, baguette), Sangak bread, bulgur | - | - | 0.589 |
| High-fat dairy | High-fat milk, high-fat yogurt, cream cheese, cream, traditional ice cream, ice cream, cocoa milk, Greek yogurt | - | - | 0.509 |
| Low-fat dairy | Low-fat milk, plain yogurt, cheese, dough, kashk | - | - | −0.455 |
| Legume and soy | Lentils, beans, chickpeas, broad beans, dales, mung beans | - | - | 0.405 |
| Organ meat | Beef/veal/lamb meats, minced meat | - | - | 0.405 |
| Boiled potato | boiled potato | - | - | 0.400 |
| Oil and butter | Liquid oil | - | - | 0.367 |
| Caffeine | Coffee | - | - | 0.349 |
| Pickles | Pickles | - | - | 0.337 |
| Sweet dessert | Soda, sugar-containing beverages, sweets, deserts | - | - | 0.306 |
| Fried potato | Fried potato | - | - | |
| Variability (Eigenvalue) | | 9.48% (3.1) | 9.41% (2.0) | 9.10% (1.7) |

Food groups with absolute values<0.30 are not shown for simplicity

After adjustment for confounding factors (age, sex, BMI, smoking status, physical activity, blood pressure, use of medications, dietary intakes of protein, potassium, calcium, magnesium and phosphorous, supplement intake, socioeconomic status, and energy intake), the association of adherence to the healthy pattern and eGFR ($P = 0.042$) remained significant and among the population who followed the third pattern, the association with and urinary creatinine became nonsignificant ($P = 0.035$). There was no association between hs-CRP and extracted dietary patterns [Table 3].

Logistic regression was applied for the associations of dietary patterns with CKD progression and albuminuria in unadjusted and adjusted models [Table 4]. Results showed that the OR of CKD progression (eGFR <60 ml/min/1.73 $m^2$) for patients in the highest, compared with the lowest tertile of traditional dietary pattern was 1.94 (1.63–2.51). After adjustment for age, sex, BMI, smoking status, physical activity, blood pressure, use of medications, dietary intakes of protein, potassium, calcium, magnesium and phosphorous, supplement intake, socioeconomic status, and energy intake. The OR for participants in the highest compared with the lowest tertile of the traditional dietary pattern was 1.84 ([1.42–2.38], $P = 0.043$). Moreover, after controlling for potential confounders, the traditional dietary pattern was positively associated with higher albuminuria ([OR = 2.94] [1.49–2.99], $P = 0.038$). No significant association was seen across tertiles of the dietary healthy dietary pattern and

**Table 3: Anthropometric characteristics, clinical outcomes, and biochemical parameters across three major dietary pattern tertiles**

| | Healthy dietary pattern | | | | | Western dietary pattern | | | | | Traditional dietary pattern | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | *P* | *P*¥ | T1 | T2 | T3 | *P* | *P*¥ | T1 | T2 | T3 | *P* | *P*¥ |
| Age (years) | 68.4 (5.1) | 66.5 (6.1) | 66.1 (5.7) | 0.03 | | 67.1 (5.6) | 67.3 (5.6) | 66.6 (5.5) | 0.72 | | 67.4 (6.0) | 67.7 (6.2) | 66.0 (4.7) | 0.15 | |
| Height (cm) | 156.5 (8.1) | 156.8 (7.2) | 155.3 (8.6) | 0.45 | | 155.2 (8.0) | 155.6 (7.7) | 157.9 (8.1) | 0.07** | | 153.9 (6.6) | 156.6 (8.1) | 158.1 (8.6) | 0.004* | |
| Weight (kg) | 71.6 (10) | 72.9 (14.1) | 73.2 (11.6) | 0.70 | | 69.8 (10.3) | 72.5 (12.6) | 75.4 (12.5) | 0.018 | | 71.8 (11.5) | 71.7 (11.8) | 74.2 (126) | 0.37 | |
| BMI (kg/m$^2$) | 29.4 (4.0) | 30.8 (5.4) | 28.9 (3.7) | 0.03 | | 29.4 (4.5) | 30.5 (4.8) | 29.1 (4.1) | 0.19 | | 29.5 (4.2) | 29.8 (4.6) | 29. (4.7) | 0.90 | |
| WC (cm) | 99.2 (9.2) | 99.6 (12.8) | 98.7 (8.6) | 0.87 | | 98.1 (10.1) | 99.5 (10.4) | 99.9 (10.6) | 0.51 | | 99.1 (10.5) | 98.1 (10.8) | 100.3 (9.8) | 0.45 | |
| SBP (mmHg) | 140.3 (22.3) | 145.4 (22.9) | 140.4 (20.5) | 0.27 | | 143.3 (23.4) | 144.4 (21.3) | 138.4 (21) | 0.20 | | 141.1 (20.9) | 143.9 (23.4) | 141.1 (21.7) | 0.67 | |
| DBP (mmHg) | 82.6 (15.9) | 87.8 (16.2) | 83.5 (10.9) | 0.07** | | 85.5 (16.7) | 85.7 (15.2) | 82.7 (11.6) | 0.36 | | 82.8 (11.9) | 84.5 (15.5) | 86.6 (16.2) | 0.28 | |
| Blood biochemical parameters between dietary pattern tertiles | | | | | | | | | | | | | | | |
| TG (mmol/l) | 155.2 (73.6) | 174.1 (88.6) | 199.8 (96) | 0.007* | 0.016* | 171 (89.1) | 185.9 (87.1) | 172 (88.4) | 0.51 | 0.32 | 178.2 (80.4) | 177.5 (97.4) | 173.4 (86.6) | 0.93 | 0.81 |
| T-chol (mmo/l) | 200.6 (47.7) | 208.8 (52.9) | 201.6 (42.7) | 0.51 | 0.54 | 203.2 (47.5) | 211. (51.2) | 196.8 (44.4) | 0.19 | 0.51 | 206.4 (48.7) | 210.1 (50.4) | 194.6 (43.7) | 0.11 | 0.33 |
| HDL (mg/dl) | 50.5 (12.7) | 50.9 (12.8) | 46.2 (13) | 0.049* | 0.23 | 50.8 (1.3) | 48.5 (14.1) | 48.4 (12.8) | 0.45 | 0.36 | 51.3 (12.1) | 49.5 (14.1) | 46.8 (12.2) | 0.10 | 0.79 |
| LDL (mg/dl) | 119.0 (41.5) | 123.0 (46.6) | 115.4 (36.9) | 0.53 | 0.65 | 118.2 (42.1) | 125.2 (44.0) | 125.2 (44.0) | 0.24 | 0.62 | 119.3 (44.9) | 125.0 (41.8) | 113 (38.1) | 0.21 | 0.23 |
| FBS (mmol/l) | 103.5 (35.2) | 128.3 (55.4) | 128 (55.4) | 0.0001>* | 0.03* | 115.5 (51.0) | 106.6 (37.6) | 108.9 (33.6) | 0.43 | 0.15 | 115.3 (39.5) | 103.6 (33.3) | 112.5 (49.6) | 0.21 | 0.19 |
| hs-CRP | 3.6 (4.9) | 3.4 (4.7) | 3.63 (4.4) | 0.96 | 0.67 | 4.2 (4.8) | 3.64 (5.3) | 2.8 (2.8) | 0.18 | 0.39 | 3.1 (3.2) | 4.0 (5.8) | 3.5 (3.9) | 0.42 | 0.31 |
| Characteristics of kidney function between dietary pattern tertiles | | | | | | | | | | | | | | | |
| Creatinine (serum) | 1.14 (0.3) | 1.30 (1.18) | 1.11 (1.0) | 0.40 | 0.33 | 1.11 (0.43) | 1.35 (1.49) | 1.09 (0.36) | 0.17 | 0.33 | 1.0 (0.3) | 1.21 (1.21) | 1.2 (0.9) | 0.26 | 0.46 |
| Urea (mg/dl) (serum) | 35.2 (19.2) | 34 (10.4) | 31.9 (12) | 0.37 | 0.67 | 34 (19.3) | 34.5 (13.32) | 32.6 (8.5) | 0.72 | 0.78 | 34.6 (12.1) | 35 (19.7) | 31.5 (9.0) | 0.25 | 0.45 |
| Microalbumin (μg/mg) (serum) | 4.5 (0.3) | 5.1 (4.6) | 4.6 (0.37) | 0.28 | 0.44 | 4.6 (0.3) | 4.6 (0.43) | 5.1 (4.6) | 0.45 | 0.56 | 4.5 (0.2) | 4.6 (0.3) | 5.1 (4.6) | 0.36 | 0.38 |
| Creatinine (mg/dl) (urine) | 2.6 (1.5) | 2.4 (1.5) | 2.2 (1.0) | 0.18 | 0.69 | 2.4 (1.6) | 2.5 (1.3) | 2.3 (1.2) | 0.66 | 0.91 | 2.1 (0.9) | 2.7 (1.7) | 2.4 (1.3) | 0.028* | 0.035** |
| Microalbumin (μg/ml) (urine) | 73.5 (62.4) | 65.2 (61.3) | 70.8 (70.1) | 0.73 | 0.81 | 68.4 (68.7) | 73.2 (67.04) | 67.5 (57.3) | 0.85 | 0.78 | 63.8 (59.9) | 71 (66.1) | 73.7 (67.3) | 0.64 | 0.65 |
| ACR (mg/mmol) (urine) | 31.7 (42.2) | 24.8 (19.7) | 46.0 (108.3) | 0.17 | 0.45 | 31.0 (44.4) | 28.3 (23.8) | 43.7 (109.9) | 0.37 | 0.83 | 31.3 (42.9) | 29.5 (42) | 40.5 (98.4) | 0.57 | 0.71 |
| eGFR (ml/min) | 63.5 (31.9) | 58.4 (25) | 76.8 (52.0) | 0.01* | 0.042* | 64.6 (32.4) | 64.0 (33.8) | 70.1 (48.1) | 0.56 | 0.88 | 70.5 (51.7) | 63.2 (30.6) | 64.9 (29.8) | 0.47 | 0.35 |

$P<0.05$ were significance. *$P<0.05$; **$P<0.1$; ¥Adjusted for age, sex, BMI, smoking status, physical activity, BP, use of medications, dietary intakes of protein, potassium, calcium, magnesium and phosphorous, supplement intake, socioeconomic status, and energy intake. BMI=Body mass index; BP=Blood pressure; WC=Waist circumference; SBP=Systolic BP; DBP=Diastolic BP; FBS=Fast blood sugar; TG=Triglyceride; T-chol=Total cholesterol; HDL-C=High density lipoprotein cholesterol; LDL=Low density lipoprotein; hs-CRP=High-sensitivity C-reactive protein; e-GFR=Estimated glomerular filtration rate; ACR=Albumin/creatinine ratio

**Table 4: Relationship of three major dietary patterns with progress of chronic kidney disease and probability of albuminuria**

| | Tertiles of identified dietary patterns | | | *P* for trend |
|---|---|---|---|---|
| | T1 | T2 | T3 | |
| Progress of CKD | | | | |
| Healthy dietary pattern | | | | |
| OR for CKD[a] | Reference | 0.97 (0.51–1.87) | 0.97 (0.51–1.87) | 0.94 |
| OR for CKD[b] | Reference | 0.96 (0.49–1.88) | 1.08 (0.54–2.15) | 0.81 |
| Western dietary pattern | | | | |
| OR for CKD[a] | Reference | 0.93 (0.47–1.84) | 1.1 (0.58–1.55) | 0.78 |
| OR for CKD[b] | Reference | 1.18 (0.74–1.75) | 1.37 (0.88–2.28) | 0.54 |
| Traditional dietary pattern | | | | |
| OR for CKD[a] | Reference | 2.54 (0.98–3.17) | 1.74 (1.63–2.51) | 0.057 |
| OR for CKD[b] | Reference | 1.44 (1.12–3.17) | 1.84 (1.42–2.38) | 0.043 |
| Probability of albuminuria | | | | |
| Healthy dietary pattern | | | | |
| OR for CKD[a] | Reference | 2.03 (0.93–4.46) | 1.97 (0.88–4.38) | 0.095 |
| OR for CKD[b] | Reference | 2.25 (0.98–5.09) | 1.94 (0.83–4.5) | 0.07 |
| Western dietary pattern | | | | |
| OR for CKD[a] | Reference | 2.11 (0.91–4.91) | 1.58 (0.63–3.93) | 0.081 |
| OR for CKD[b] | Reference | 1.81 (0.71–4.91) | 1.68 (0.75–3.26) | 0.31 |
| Traditional dietary pattern | | | | |
| OR for CKD[a] | Reference | 2.54 (0.96–3.17) | 2.94 (1.63–2.97) | 0.063 |
| OR for CKD[b] | Reference | 1.69 (1.34–2.55) | 2.94 (1.49–2.99) | 0.038 |

[a]Crude model; [b]The adjusted model considered age, sex, BMI, smoking status, physical activity, BP, use of medications, dietary intakes of protein, potassium, calcium, magnesium and phosphorous, supplement intake, socioeconomic status, and energy intake. OR=Odds ratio; CKD=Chronic kidney disease; BMI=Body mass index; BP=Blood pressure

Western dietary pattern with risk of CKD progression and albuminuria [Table 4].

## DISCUSSION

In the present study, we identified three major dietary patterns using factor analysis. The healthy pattern characterized by high intake of curd, vegetables, fruits, fish, canned fish and poultry and the Western pattern included egg, snack, nuts, mayonnaise, salt, and processed meat and the traditional pattern included breads, high-fat dairy, legume and soy, organ meat, boiled potato, oil and butter, caffeine, pickles, sweet dessert, and fried potato. We found a significant association between the healthy dietary pattern and eGFR and metabolic biomarkers in which adherence to the healthy dietary patterns resulted in higher GFR, FBS, and TG. A positive association between the traditional dietary pattern and level of urinary creatinine also was observed. All significant associations remained significant after adjusting age, sex, BMI, smoking status, physical activity, blood pressure, and use of medications, dietary intakes of protein, potassium, calcium, magnesium and phosphorous, supplement intake, socioeconomic status, and energy intake. Moreover, older adults who were in the highest tertile of the traditional dietary pattern had a significant increased odds of having incident CKD and albuminuria independent of covariates.

The current analysis demonstrated significant associations between healthy dietary pattern and lipid profile including TG and HDL; also FBS and diastolic blood pressure. Greater adherence to the first pattern resulted in higher DBP, TG, and FBS level and lower HDL levels. Some studies had suggested that various dietary intakes and patterns had different effects on cardiovascular risk factors.[28-31] The main component of the healthy dietary pattern was curd that is categorized in high-fat dairy. Vegetables, grains, and olive oil are the main factors of Mediterranean pattern which had a beneficial effect on glucose and lipid profile.[31,32] It was anticipated that participants in higher category of healthy dietary patterns have lower TG with high level of HDL. However, the results were not consistent with previous studies which may be due to higher load of curd and canned fish which is grouped as high-fat foods. In accordance with the present study, Rashidi Pour Fard *et al*.[28] found no association between FBS and different tertiles of dairy products intake. On the other hand, Forouhi[29] reported a positive association between dairy consumption and lipid profile. Moreover, Ehrampoush *et al*.[33] showed that high-fat dairy intake had negative significant effect on insulin, FBS, and lipid profile, with increased risk of metabolic syndrome. In another study,[34] it is suggested that high dairy consumption improves insulin resistance without any impact on lipid profile. Tabesh *et al*.[35] who worked on diabetic patients indicated that fruits and vegetable intake may reduce the HbA1C without any impact on lipid profile. These studies have only survey the association between a component of diet (dairy product, fruits, and vegetable) with blood profile and did not extracted dietary patterns in older adults. A dietary pattern consists of different foods and nutrients that interact with each other. Actually, the analysis of dietary patterns is a more comprehensive method compared to just considering single foods or nutrients.

The present study found a positive association between healthy dietary pattern and estimated GFR. Hsu *et al*.[30] reported a healthy dietary pattern including high intake of fish and vegetables, the same as our results, may be related to improvement of renal function among diabetic patients. They also reported a marginally negative association of meat intake and renal function. They recommended healthy pattern with moderate protein levels to normal kidney function. Hsu *et al*.[30] also found vegetable and fish dietary pattern decreased creatinine and marginally with increased eGFR. This dietary pattern in Taiwan is characterized with high level of light- or dark-colored vegetables, pond, and marine fish. Lower sodium and higher β-carotene intake may reduce risk for eGFR to decline,[6] while the modern dietary pattern with high consumption of fruit, meat, and egg has adverse effects.[30] Previous studies indicated that the main role of vegetables to improve eGFR was related to alkaline production such as citrate and lactate,[16] as we found vegetable intake was remarkable in healthy dietary pattern.

We also found that traditional dietary pattern was significantly and positively associated with higher urinary creatinine level. Secreted creatinine in urine is regarded as a marker of kidney dysfunction and severely increased in patients with reduced kidney function[36] and filtered creatinine in urine is related to muscle mass and also influenced by meat intake.[37,38] The association between urinary creatinine level and protein intake has been shown previously. Early studies suggested that this association may be due to the role of protein intake in muscle mass.[39] In another study, traditional Chinese-snack dietary pattern characterized by rice, root vegetables, soy/gluten products, noodles, and nuts was marginally associated with higher creatinine level.[39]

In contrast to our results, previous studies revealed that dietary patterns and components are associated to hs-CRP. Mazidi *et al*.[40] in a cross-sectional study in the US population examined association between dietary constituents and hs-CRP. They found age, sex, race, energy intake and BMI-adjusted dietary intake of total dietary fiber, PUFA, Vitamin A, Vitamin E, total folate, Vitamin B family, Vitamin B6, Vitamin K, Vitamin C, magnesium, iron, potassium, and copper gradually reduced with increasing hs-CRP. Moreover, dietary sugar intake was positively associated with hs-CRP level.[40] Another study also demonstrated that healthy dietary pattern, characterized by high intakes of fruit, vegetables, fish, and soy products was inversely related to hs-CRP concentrations, even after adjustment for confounders including BMI, age, alcohol consumption, physical activity, and smoking in both sexes.[41] Although in our study, the mean of hs-CRP in three identified dietary patterns showed different levels, it was not significant. It may be due to sample size in various patterns and different types of the studied population.

Compared with those in the lowest tertile of the traditional dietary pattern, those in the highest one had higher odds of incident CKD and albuminuria. Similar to our findings, previous studies[14,19,42,43] in Iran also identified and reported traditional dietary patterns which is characterized as high consumption of refined grain, egg, tea, potato, red meat, pickles, hydrogenated fat, and sugar. In studies with similar patterns, an increased risk of CKD and albuminuria was observed. Nettleton *et al*.[44] reported that a dietary pattern characterized by high intakes of legumes, tomatoes, refined grains, high-fat dairy, and red meat was positively associated with ACR. Moreover, in a study by Shi *et al*.,[16] a traditional Southern dietary pattern which was characterized with high consumption of rice, pork, and vegetables, and low intake of wheat, was associated with 4.5-fold increased odds of prevalence of CKD.

The main limitation in our study that needs to be taken into account as a cross-sectional research is that the causality relevance cannot be established. Second, filling out the questionnaire depends on memory that in the older adults, memory is the most challenging issue; however, we used a validated FFQ which has been completed by trained experts. Residual confounding is also highly possible.

## CONCLUSION

The current findings indicate that a healthy dietary pattern is associated with better kidney function, in contrast, traditional dietary pattern is associated by higher exertion of urinary creatinine and increased odds of CKD. Randomized controlled trials are required to better assess the role of dietary patterns on kidney function.

### Acknowledgments

The authors acknowledge Tehran University of Medical Sciences for the financial support for the study additionally.

### Financial support and sponsorship

This study was funded by Tehran University of Medical Sciences (Grant Number: 29544).

## Conflicts of interest

There are no conflicts of interest.

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