Dietary fibre intake in relation to the risk of incident chronic kidney disease

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Abstract

The purpose of this study was primarily to evaluate the association of total fibre intake from fruits, vegetables, cereals and legumes with the incidence of CKD in a population-based prospective study. We followed up 1630 participants of the Tehran Lipid and Glucose Study for 6-1 years, who were initially free of CKD. Baseline diet was assessed by a valid and reliable FFQ. 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 per 1·73 m². OR using multivariable logistic regression was reported for the association of incident CKD with tertiles of dietary fibre intake. After adjustment for age, sex, smoking, total energy intake, physical activity, diabetes and using angiotensin-converting-enzyme inhibitor, the OR for subjects in the highest compared with the lowest tertile of total fibre intake was 0·47 (95 % CI 0·27–0·86). In addition, for every 5 g/d increase in total fibre intake, the risk of incident CKD decreased by 11 %. After adjusting for potential confounders, OR for participants in the highest compared with the lowest tertile of fibre from vegetables was 0·63 (95 % CI 0·43–0·95) and from legumes it was 0·68 (95 % CI 0·47–0·98). We observed inverse associations between total fibre intake and risk of incident CKD, which demonstrate that fibre intake, mainly from legumes and vegetables, may reduce the occurrence of CKD.

Key words: Fruits; Vegetables; Legumes; Kidney function

Chronic kidney disease (CKD) is a prevalent complex disease and is fast becoming a growing public health problem, leading to premature mortality or poor quality of life, exposing a heavy burden on healthcare systems1,2. Evidence available reveals that the global prevalence of CKD has a sharply increasing trend, affecting 10–15 % of general populations3,4. Ageing, hypertension, diabetes, hyperlipidaemia, smoking and poor dietary intake have been identified as risk factors for CKD occurrence5,6. Higher dietary intake of plant protein, vitamin C, Mg, K, n-6 fatty acids and lower intake of animal protein and Na are documented as the potential factors for prevention of CKD occurrence7,8. Yet, dietary guidelines have not been developed for the prevention of kidney dysfunction.

Although a great deal of research has been conducted on the importance of dietary fibre intake in the prevention of CVD, diabetes and cancer, encouraging healthcare organisations to recommend dietary fibre intake9,10, findings on the dietary fibre and kidney function are limited and inconsistent11–15.

One cohort study indicates that subjects in the highest quartile of dietary cereal fibre, compared with those in the lowest, had a 50 % decreased risk for incidence of CKD; however, total fibre intake was not associated with the occurrence of CKD11. Xu et al.12 showed that higher total fibre intake was positively associated with estimated glomerular filtration rate (eGFR) among elderly men. In addition, greater dietary total fibre intake was associated with reduced risk of incident kidney stones in postmenopausal women13.

Previous studies on dietary fibre intake and kidney function have been conducted in developed countries. The Tehran Lipid and Glucose Study (TLGS) is a large prospective cohort study with different dietary habits required for substantiating and persuasion of preventive dietary recommendations. Current TLGS analyses showed that plant-based diets rich in fibre were related to a decrease in incident CKD; total dietary fibre intake was also associated with reduced CVD risk16, and fruit fibre was associated with decreased the metabolic syndrome17.

Abbreviations: CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; TLGS, Tehran Lipid and Glucose Study.

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The purpose of this study was primarily to evaluate the association of total fibre intake with the risk of incident CKD. We also evaluated the association of dietary fibre from fruits, vegetables, cereals and legumes with the incidence of CKD in a population-based prospective study.

Methods

Study population

This study was conducted within the framework of the TLGS, an ongoing community-based prospective investigation aimed at preventing non-communicable diseases (NCD) by developing programmes promoting healthy lifestyles and reducing NCD risk factors in a sample of residents under coverage of three medical health centres 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 (2002–2005), III (2006–2008), IV (2009–2011) and V (2012–2015) are prospective follow-up surveys.

From among the 12,523 participants examined in the third survey of the TLGS, 3,462 were randomly selected for dietary assessment, of whom 2,417 participants were aged ≥27 years. Subjects with a history of myocardial infarction or stroke due to the possibility of major changes in diet were excluded (n=34). In addition, subjects (n=113) who under- or over-reported energy intakes (<3347 kJ/d (<800 kcal/d) or >17,573 kJ/d (>4200 kcal/d), respectively) 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 up until survey V (response rate: 87%), with a median duration of 6-1 years (25–75 interquartile range: 5.6–6.5; Fig. 1).

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. Habitual dietary intakes were assessed using a valid and reliable semi-quantitative FFQ by expert interviewers. 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 and monthly basis. As the Iranian food composition table (FCT) is incomplete, the United States Department of Agriculture (USDA) FCT was used. For national foods not listed in the USDA FCT, the Iranian FCT was the alternative. We calculated total dietary fibre, as well as fibre contribution from cereals, legumes, vegetables and fruits.

The reliability and validity of the FFQ, which were evaluated against twelve 24-h dietary recalls and two FFQ in a previous study, indicated that the FFQ provides reasonably valid measures of the average long-term dietary fibre intake.

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(22). Low 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; range 0-1-150 kg) and height was measured without shoes to the nearest 0.1 cm. BMI was calculated as weight (kg) divided by square of height (m2). Arterial blood pressure was measured 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, whereas 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 blood pressure.

Blood samples were taken from all participants at the TLGS research laboratory after an overnight fast of 12–14 h. Fasting plasma glucose (FPG) and 2-h plasma glucose (equivalent to 75 g anhydrous glucose; Cerestar EP) were assayed by enzymatic colorimetric method using glucose oxidase, with both inter- and intra-assay CV being <2%. Serum creatinine was measured according to the standard colorimetric Jaffe kinetic reaction method at baseline (2006–2008) and after 6 years of follow-up (2012–2015). Both intra- and inter-assay CV were below 3.1%; all analyses were performed using commercial kits (Pars Azmoon Inc.).

**Definitions**

Hypertension was defined as SBP/DBP ≥140/90 mmHg or current therapy for a definite diagnosis of hypertension(23). Diabetes was defined according to the criteria of the American Diabetes Association as FPG ≥7.0 mmol/l or 2-h post 75-g glucose load ≥11.1 mmol/l 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 per 1.73 m2 of body surface area(25). The abbreviated MDRD study equation is as follows:

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

Patients were classified based on their eGFR levels by the National Kidney Foundation guidelines(26); eGFR ≥60 ml/min per 1.73 m2 as not having CKD and eGFR <60 ml/min per 1.73 m2 as having CKD.

**Statistical analysis**

All data were analysed using the Statistical Package for the Social Sciences program (SPSS) (version 15.0; SPSS Inc.) and $P$ values <0.05 were considered statistically significant. Total dietary intake of fibre was categorised into the tertile cut-off points as ≤17.7, 17.8–26.0 and >26.1 g/d, dietary fibre from fruits, vegetables, cereals and legumes was categorised into three groups according to the tertiles of the distribution among the total population. Continuous variables were reported as a mean ± standard deviation and categorical variables as percentages. Tests of a trend for continuous variables across tertiles of the total fibre intake were conducted using ANOVA and for categorical variables $\chi^2$ test was used.

The OR and 95% CI for the incidence of CKD according to tertiles of dietary exposure was assessed with multivariable logistic regression models. In this analysis, the first tertile of dietary exposure was considered as the reference category. To calculate the trend of OR across increasing tertiles of dietary exposure, the median values of each fibre category were considered as continuous variables. Three models were considered to adjust potential confounders (model 1, crude (without any covariate); model 2, age (continuous), sex, smoking (yes/no), total energy intake (continuous), physical activity (low, moderate, heavy); and model 3, diabetes (yes/no) and using angiotensin-converting-enzyme inhibitor (yes/no)). As a further adjustment for intakes of dietary fat, n-3 fatty acids, K, Mg and hypertension did not change the relations substantially, these covariates were not considered in the final models.

**Results**

We recorded 220 (13-5%) cases of incident CKD, with a range of eGFR between 29 and 59 ml/min per 1·73 m2, after 6-1 years of follow-up. Mean age and total fibre intake of participants was 42·8 (SD 11·2) years and 23·8 (SD 11·7) g/d. General characteristics of study participants across tertiles of total fibre intake are presented in Table 1. Participants in the highest, compared with the lowest, tertile of total fibre intake were less likely to be women ($P<0.05$). No significant differences were found by means of age, BMI and eGFR and prevalence of low physical activity, current smoker, diabetes, hypertension and anti-hypertensive drug across tertiles of total fibre intake.

Dietary intakes of participants across tertile categories of total fibre intake are shown in Table 2. Participants in the top tertile of total fibre intake had higher consumption of protein, plant protein, carbohydrate and K than those in the bottom tertile ($P<0.05$); however, consumption of animal protein, total and SFA tended to decrease across tertiles of total fibre intake ($P<0.05$).

In the crude model, total fibre intake was inversely associated with an incidence of CKD (Table 3). After adjustment for age, sex, smoking, total energy intake, physical activity, diabetes and using angiotensin-converting-enzyme inhibitor, the OR for subjects in the highest compared with the lowest tertile of total fibre intake was 0·47 (95% CI 0·27, 0·86). A significant decreasing linear trend was noted across tertiles of total fibre intake for risk of incident CKD ($P_{\text{for trend}} <0.001$). In addition, the risk of incident CKD decreased by 11% for every 5 g/d increase in total fibre intake.

We also examined the association between various sources of dietary fibre and incidence of CKD. After adjusting for potential confounders, OR for participants in the highest compared with the lowest tertile of fibre from vegetables was 0·63 (95% CI 0·43, 0·93) and from legumes it was 0·68 (95% CI 0·47, 0·98). In addition, a significant decreasing linear trend was noted across tertiles of dietary fibre from vegetables and legumes for the risk of incident CKD ($P_{\text{for trend}} <0.05$). The risk of incident CKD decreased 50% for every 5 g/d increase in dietary fibre from legumes. Furthermore, there was no significant association of fibre from fruits and cereals with the risk of incident CKD.
Current smoker (%) 9
Low physical activity (%) 71
Total fat (% energy) 31
Diabetes (%) 8
Hypertension (%) 11
K (mg/d) 3861 1792 2601 794 3633 976 5347 2051
Cereal fibre (%) 38
Carbohydrate (% energy) 57
Protein (% energy) 13
Legume fibre (%) 5
Dietary fibre (g/d) 23
SFA (% energy) 10
Antihypertensive drug use (%) 3
Angiotensin-converting-enzyme inhibitor use (%) 1
Women (%) 56
BMI (kg/m²) 24
Age (years) 41
≥ 60 years from Blue Mountains Eye Study showed no signifi-
cant association of fibre intake with the prevalence of moderate
CKD(13). However, among 1110 participants aged 70–71 years,
higher intake of total fibre had desirable association with
eGFR(12). In a cross-sectional study of non-diabetic individuals
from the PREDIMED study, among subjects in the highest
quartile of fibre intake the risk of incident CKD decreased by
42%.(27) In addition, in 5416 subjects, aged >40 years, dietary
fibre consumption was found to be associated with a reduced
risk of albuminuria.(28) Besides studies investigating the
association of dietary fibre on CKD, there are studies that show
other desirable effects of dietary fibre on kidney-related
disorders.(13,29) A recent meta-analysis showed that total fibre
intake was associated with 26% lower risk of renal cell carci-
noma.(29) In addition, women with no history of kidney stones
in the highest compared with the lowest categories of dietary fibre
intake had a 22% decreased risk of stone formation.(13)

In our study, participants in the highest tertile of dietary fibre
intake showed lower consumption of animal protein and
saturated fat and higher consumption of plant protein and K in
comparison with those in the lowest tertile. Indeed, higher fibre
intake was accompanied by healthier dietary behaviour that
may affect kidney function; however, there were no differences
between participants in the tertiles of fibre intake according to
Discussion
This population-based prospective study showed that high total
fibre intake was related to lower incidence of CKD after 6-1
years of follow-up. Subjects who consumed more than 26-0 g/d
of fibre had 50% lower risk of CKD occurrence compared with
those who consumed ≤17-7 g/d. We also observed an 11% lower
risk of incident CKD per 5-g/d increase in total fibre
intake. Protective associations of specific sources of fibre with
the risk of incident CKD were observed for vegetable and
legume fibre. No association was observed between the risk of
CKD and the cereal or fruit fibre intake.

Relatively limited studies investigated the association of total
fibre intake with CKD(11,12,27,28). Data of 2600 participants aged
≥50 years from Blue Mountains Eye Study showed no significant
association of fibre intake with the prevalence of moderate
CKD(13). However, among 1110 participants aged 70–71 years,
higher intake of total fibre had desirable association with
eGFR(12). In a cross-sectional study of non-diabetic individuals

Table 1. Baseline characteristics of participants according to tertiles (T) of total fibre intake
(Mean values and standard deviations; percentages)

<table>
<thead>
<tr>
<th>Tertiles of total fibre</th>
<th>T1 (n 544)</th>
<th>Mean</th>
<th>SD</th>
<th>T2 (n 543)</th>
<th>Mean</th>
<th>SD</th>
<th>T3 (n 543)</th>
<th>Mean</th>
<th>SD</th>
<th>Pfor trend*</th>
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</thead>
<tbody>
<tr>
<td>Median total fibre (g/d)</td>
<td>13-6</td>
<td>13-6</td>
<td>11-1</td>
<td>21-5</td>
<td>42-8</td>
<td>11-2</td>
<td>33-5</td>
<td>43-3</td>
<td>11-4</td>
<td>0-190</td>
</tr>
<tr>
<td>Age (years)</td>
<td>42-4</td>
<td>56-6</td>
<td>27-2</td>
<td>9-9</td>
<td>61</td>
<td>7-6</td>
<td>41-5</td>
<td>71-5</td>
<td>49-2</td>
<td>69-4</td>
</tr>
<tr>
<td>Women (%)</td>
<td>56</td>
<td>71</td>
<td>27</td>
<td>9</td>
<td>11</td>
<td>17</td>
<td>33</td>
<td>8</td>
<td>71</td>
<td>22</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24</td>
<td>15</td>
<td>60</td>
<td>9</td>
<td>12</td>
<td>13</td>
<td>22</td>
<td>22</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Current smoker (%)</td>
<td>9-9</td>
<td>6-0</td>
<td>27</td>
<td>9-9</td>
<td>11</td>
<td>13</td>
<td>27</td>
<td>9-9</td>
<td>10</td>
<td>12</td>
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<tr>
<td>Low physical activity (%)</td>
<td>56</td>
<td>71</td>
<td>27</td>
<td>9</td>
<td>11</td>
<td>17</td>
<td>33</td>
<td>8</td>
<td>71</td>
<td>22</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>56</td>
<td>71</td>
<td>27</td>
<td>9</td>
<td>11</td>
<td>17</td>
<td>33</td>
<td>8</td>
<td>71</td>
<td>22</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>56</td>
<td>71</td>
<td>27</td>
<td>9</td>
<td>11</td>
<td>17</td>
<td>33</td>
<td>8</td>
<td>71</td>
<td>22</td>
</tr>
<tr>
<td>Antihypertensive drug use (%)</td>
<td>56</td>
<td>71</td>
<td>27</td>
<td>9</td>
<td>11</td>
<td>17</td>
<td>33</td>
<td>8</td>
<td>71</td>
<td>22</td>
</tr>
<tr>
<td>Angiotensin-converting-enzyme inhibitor use (%)</td>
<td>56</td>
<td>71</td>
<td>27</td>
<td>9</td>
<td>11</td>
<td>17</td>
<td>33</td>
<td>8</td>
<td>71</td>
<td>22</td>
</tr>
<tr>
<td>eGFR (ml/min per 1.73m²)</td>
<td>73</td>
<td>4</td>
<td>8-7</td>
<td>73</td>
<td>4</td>
<td>8-7</td>
<td>73</td>
<td>4</td>
<td>8-7</td>
<td>73</td>
</tr>
</tbody>
</table>

*Tests of trend across tertiles of total fibre intake were conducted using ANOVA.

Table 2. Baseline dietary intakes of participants, according to tertiles (T) of total fibre intake

<table>
<thead>
<tr>
<th>Tertiles of the total fibre</th>
<th>Total population</th>
<th>T1 (n 544)</th>
<th>Mean</th>
<th>SD</th>
<th>T2 (n 543)</th>
<th>Mean</th>
<th>SD</th>
<th>T3 (n 543)</th>
<th>Mean</th>
<th>SD</th>
<th>Pfor trend*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy (kJ)</td>
<td>9703</td>
<td>3423</td>
<td>7243</td>
<td>1833</td>
<td>9259</td>
<td>2272</td>
<td>12606</td>
<td>3351</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total energy (kcal)</td>
<td>2319</td>
<td>818</td>
<td>1731</td>
<td>438</td>
<td>2213</td>
<td>543</td>
<td>3013</td>
<td>801</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein (% energy)</td>
<td>13-7</td>
<td>2-4</td>
<td>13-5</td>
<td>2-6</td>
<td>13-7</td>
<td>2-2</td>
<td>13-9</td>
<td>2-4</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal protein (g/1000)</td>
<td>18-5</td>
<td>7-0</td>
<td>19-7</td>
<td>7-6</td>
<td>18-6</td>
<td>6-1</td>
<td>17-4</td>
<td>7-2</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant protein (g/1000)</td>
<td>15-9</td>
<td>4-2</td>
<td>14-3</td>
<td>3-3</td>
<td>15-9</td>
<td>3-5</td>
<td>17-6</td>
<td>4-8</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrate (% energy)</td>
<td>57-7</td>
<td>7-2</td>
<td>55-5</td>
<td>7-3</td>
<td>57-8</td>
<td>6-7</td>
<td>59-8</td>
<td>6-9</td>
<td>&lt;0-001</td>
<td></td>
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</tr>
<tr>
<td>Total fat (% energy)</td>
<td>31-2</td>
<td>7-1</td>
<td>32-8</td>
<td>7-6</td>
<td>31-1</td>
<td>6-9</td>
<td>29-6</td>
<td>6-4</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SFA (% energy)</td>
<td>10-5</td>
<td>5-5</td>
<td>11-5</td>
<td>8-6</td>
<td>10-3</td>
<td>2-7</td>
<td>9-6</td>
<td>2-7</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dietary fibre (g/d)</td>
<td>23-8</td>
<td>11-7</td>
<td>13</td>
<td>3-1</td>
<td>21-6</td>
<td>2-4</td>
<td>36-6</td>
<td>10-7</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K (mg/d)</td>
<td>3861</td>
<td>1792</td>
<td>2601</td>
<td>794</td>
<td>3633</td>
<td>976</td>
<td>5347</td>
<td>2051</td>
<td>&lt;0-001</td>
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<tr>
<td>Cereal fibre (%)</td>
<td>38-2</td>
<td>16-9</td>
<td>36-5</td>
<td>14-4</td>
<td>37-4</td>
<td>16-2</td>
<td>38-7</td>
<td>19-7</td>
<td>0-003</td>
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<tr>
<td>Fruit fibre (%)</td>
<td>26-3</td>
<td>16-9</td>
<td>28-7</td>
<td>16-2</td>
<td>27-5</td>
<td>14-1</td>
<td>22-7</td>
<td>12-7</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable fibre (%)</td>
<td>18-3</td>
<td>9-5</td>
<td>16-9</td>
<td>9-8</td>
<td>17-9</td>
<td>8-4</td>
<td>20-0</td>
<td>10-4</td>
<td>&lt;0-001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legume fibre (%)</td>
<td>5-8</td>
<td>6-1</td>
<td>5-6</td>
<td>5-2</td>
<td>5-8</td>
<td>5-7</td>
<td>6-1</td>
<td>7-2</td>
<td>0-017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Test of trend across tertiles of total fibre intake was conducted using ANOVA.
the BMI, current smoker, physical activity and anti-hypertensive drug use. In a previous study, we observed that independent of hypertension and diabetes, higher intakes of plant protein and PUFA had a decreased effect on risk of CKD, whereas animal protein increased the risk of CKD(8). Furthermore, the foods rich in fibre are the sources of K as well. K can bind to organic anions and metabolised to bicarbonate, so that the net rate of endogenous acid production in comparison with the rate of acid production from animal foods decreased(39). Hence, plant-based diet by providing alkali might decrease the risk of CKD(31).

According to the present study, fibre from vegetables and legumes, but not from fruits and cereals, was significantly associated with incident CKD. We also found that per 5-g/d increase in intake of fibre from legumes led to 50 % lower risk of incident CKD. A previous report on cardiovascular outcomes has similarly shown the effects of fibre from different food sources(33).

In our study, we observed that, contrary to the dietary fibre from vegetables and legumes that simultaneously increased with total dietary fibre, intakes of fibre from cereals and fruits did not have a similar trend with that of total dietary fibre intake. Therefore, we found no significant relation of cereals and fruits with the incidence of CKD.

The beneficial effects of dietary fibre from legumes and vegetables on kidney function can be explained by several potential factors: first, dietary fibre from legumes may decrease the glycaemic index of consumer foods leading to a delay in the postprandial glycaemia(34). Second, dietary fibre sources (vegetables and legumes) are also rich in antioxidants and vitamins. Third, vegetable and legume fibre consumption can decrease the risk of incident CKD by attenuating known risk factors such as diabetes, hypertension, hyperlipidaemia

### Table 3. Incident chronic kidney disease according to the dietary fibre intake and per 5-g increase in intake among participants of the Tehran Lipid and Glucose Study

(Odds ratios and 95 % confidence intervals)

<table>
<thead>
<tr>
<th>Tertiles of dietary fibre</th>
<th>T1</th>
<th>OR</th>
<th>95 % CI</th>
<th>T2</th>
<th>OR</th>
<th>95 % CI</th>
<th>T3</th>
<th>OR</th>
<th>95 % CI</th>
<th>Per 5-g increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fibre (median)</td>
<td>13-6</td>
<td>21.5</td>
<td>33.5</td>
<td>81/544</td>
<td>85/543</td>
<td>54/543</td>
<td>1.06</td>
<td>0.76</td>
<td>1.47</td>
<td>0.63</td>
</tr>
<tr>
<td>Case/total</td>
<td>Model 1†</td>
<td>Ref.</td>
<td>1.06</td>
<td>0.76</td>
<td>1.47</td>
<td>0.63</td>
<td>0.44</td>
<td>0.91</td>
<td>0.001</td>
<td>0.94</td>
</tr>
<tr>
<td>Model 2‡</td>
<td>Ref.</td>
<td>0.98</td>
<td>0.68</td>
<td>1.39</td>
<td>0.46</td>
<td>0.29</td>
<td>0.76</td>
<td>0.001</td>
<td>0.88</td>
<td>0.81</td>
</tr>
<tr>
<td>Model 3§</td>
<td>Ref.</td>
<td>0.97</td>
<td>0.68</td>
<td>1.38</td>
<td>0.47</td>
<td>0.28</td>
<td>0.76</td>
<td>0.001</td>
<td>0.89</td>
<td>0.81</td>
</tr>
<tr>
<td>Fruit fibre (median)</td>
<td>1.96</td>
<td>5.14</td>
<td>10.28</td>
<td>75/543</td>
<td>77/544</td>
<td>68/543</td>
<td>1.03</td>
<td>0.73</td>
<td>1.45</td>
<td>0.89</td>
</tr>
<tr>
<td>Case/total</td>
<td>Model 1†</td>
<td>Ref.</td>
<td>1.03</td>
<td>0.73</td>
<td>1.45</td>
<td>0.89</td>
<td>0.63</td>
<td>1.27</td>
<td>0.512</td>
<td>0.93</td>
</tr>
<tr>
<td>Model 2‡</td>
<td>Ref.</td>
<td>1.01</td>
<td>0.71</td>
<td>1.44</td>
<td>0.82</td>
<td>0.56</td>
<td>1.20</td>
<td>0.291</td>
<td>0.89</td>
<td>0.77</td>
</tr>
<tr>
<td>Model 3§</td>
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<td>1.02</td>
<td>0.72</td>
<td>1.46</td>
<td>0.82</td>
<td>0.56</td>
<td>1.21</td>
<td>0.312</td>
<td>0.89</td>
<td>0.77</td>
</tr>
<tr>
<td>Vegetable fibre (median)</td>
<td>1.81</td>
<td>3.51</td>
<td>6.20</td>
<td>79/544</td>
<td>74/543</td>
<td>68/543</td>
<td>0.91</td>
<td>0.65</td>
<td>1.28</td>
<td>0.84</td>
</tr>
<tr>
<td>Case/total</td>
<td>Model 1†</td>
<td>Ref.</td>
<td>0.91</td>
<td>0.65</td>
<td>1.28</td>
<td>0.84</td>
<td>0.59</td>
<td>1.19</td>
<td>0.341</td>
<td>0.97</td>
</tr>
<tr>
<td>Model 2‡</td>
<td>Ref.</td>
<td>0.76</td>
<td>0.53</td>
<td>1.09</td>
<td>0.63</td>
<td>0.43</td>
<td>0.93</td>
<td>0.024</td>
<td>0.86</td>
<td>0.67</td>
</tr>
<tr>
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<td>Ref.</td>
<td>0.75</td>
<td>0.53</td>
<td>1.08</td>
<td>0.63</td>
<td>0.43</td>
<td>0.93</td>
<td>0.026</td>
<td>0.87</td>
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</tr>
<tr>
<td>Cereal fibre (median)</td>
<td>3.83</td>
<td>7.00</td>
<td>13.18</td>
<td>89/544</td>
<td>63/543</td>
<td>68/543</td>
<td>0.67</td>
<td>0.67</td>
<td>0.95</td>
<td>0.73</td>
</tr>
<tr>
<td>Case/total</td>
<td>Model 1†</td>
<td>Ref.</td>
<td>0.67</td>
<td>0.67</td>
<td>0.95</td>
<td>0.73</td>
<td>0.52</td>
<td>1.03</td>
<td>0.099</td>
<td>0.94</td>
</tr>
<tr>
<td>Model 2‡</td>
<td>Ref.</td>
<td>0.66</td>
<td>0.46</td>
<td>0.94</td>
<td>0.76</td>
<td>0.51</td>
<td>1.13</td>
<td>0.211</td>
<td>0.98</td>
<td>0.80</td>
</tr>
<tr>
<td>Model 3§</td>
<td>Ref.</td>
<td>0.66</td>
<td>0.46</td>
<td>0.95</td>
<td>0.75</td>
<td>0.50</td>
<td>1.11</td>
<td>0.180</td>
<td>0.97</td>
<td>0.79</td>
</tr>
<tr>
<td>Legume fibre (median)</td>
<td>0.30</td>
<td>0.79</td>
<td>2.34</td>
<td>86/544</td>
<td>74/543</td>
<td>60/543</td>
<td>0.84</td>
<td>0.60</td>
<td>1.17</td>
<td>0.66</td>
</tr>
<tr>
<td>Case/total</td>
<td>Model 1†</td>
<td>Ref.</td>
<td>0.84</td>
<td>0.60</td>
<td>1.17</td>
<td>0.66</td>
<td>0.46</td>
<td>0.94</td>
<td>0.026</td>
<td>0.48</td>
</tr>
<tr>
<td>Model 2‡</td>
<td>Ref.</td>
<td>0.82</td>
<td>0.58</td>
<td>1.16</td>
<td>0.67</td>
<td>0.46</td>
<td>0.97</td>
<td>0.035</td>
<td>0.51</td>
<td>0.22</td>
</tr>
<tr>
<td>Model 3§</td>
<td>Ref.</td>
<td>0.84</td>
<td>0.59</td>
<td>1.19</td>
<td>0.68</td>
<td>0.47</td>
<td>0.98</td>
<td>0.038</td>
<td>0.50</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Ref.†, referent values. The tertile range for each category was ≤17.7, 17.8–26.0 and >26.1 g/d for fibre intake; ≤3, 3.5–7.2 and >7.3 g/d for fruit fibre; ≤2.6, 2.7–4.5 and >4.6 g/d for vegetable fibre; ≤5.4, 5.5–9.4 and >9.5 g/d for cereal fibre; and ≤0.5, 0.6–1.2 and >1.3 g/d for legume fibre.

* Pr for trend across tertiles calculated with the exposure modelled as a continuous variable.
† Model 1: crude.
‡ Model 2: adjusted for age, sex, smoking, total energy intake, physical activity.
§ Model 3: additionally adjusted for diabetes and using angiotensin-converting enzyme inhibitor.
and low-grade inflammation\(^{(35–37)}\). Higher dietary fibre intake was inversely associated with improved glycaemic control, increased insulin sensitivity and reduced risk of type 2 diabetes, all of which are well known for their harmful effects on kidney function\(^{(38,39)}\). Another potential risk factor for CKD is hypertension. The blood-pressure-lowering effect of dietary fibre was demonstrated in a recent meta-analysis\(^{(40)}\).

There are some limitations to this study that need to be mentioned. First, as in most epidemiological 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.

Of the study’s noteworthy strengths are the use of a complex validated 168-question FFQ and a prospective cohort design with high-quality data and low loss to follow-up. In addition, unlike previous studies, the present study provided data based on habitual dietary intakes in a population-based sample of participants, thereby increasing the generalisability of its results.

We observed inverse associations between total fibre intake and risk of incident CKD – results that show that high fibre intake, mainly from legumes and vegetables, may reduce the occurrence of CKD. This study provides important insight into the beneficial effects of the nutritional management for prevention of CKD and the desirable effects of dietary fibre intake in a Middle-Eastern population that is distinctly different from developed countries. Prospective studies in other populations are needed to confirm these associations and provide the evidence needed to translate these findings into clinical results.

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G. A., S. S and E. Y. designed the research; E. Y. analysed and interpreted data; and G. A., S. S. 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. All authors read and approved the final manuscript.

The authors declare that there are no conflicts of interest.

References

Dietary fibre and chronic kidney disease


