The relationship between food insecurity with cardiovascular risk markers and metabolic syndrome components in patients with diabetes: A population-based study from Kerman coronary artery disease risk study

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Background: We sought the prevalence of food insecurity and whether cardiovascular risk markers and metabolic syndrome components are significantly different in categories of food insecurity in patients with type 2 diabetes. Materials and Methods: In this cross-sectional study, 520 patients with type 2 diabetes from the Kerman coronary artery disease risk study aged between 23 and 87 years (60.8 ± 11.4) who selected by one-stage cluster sampling were assigned into four groups of “food secure” and “mild,” “moderate,” and “severe” food insecure. Household food insecurity was assessed by a 9-item household food insecurity access scale questionnaire. Results: The prevalence of food security and mild, moderate, and severe food insecurity in patients with diabetes was 24.4%, 33.1%, 28.9%, and 13.6%, respectively. There was a significant difference among the food-secure/insecure sex groups (P = 0.001). The prevalence of food insecurity and risk factors such as total cholesterol, high low-density lipoprotein cholesterol, and visceral obesity in mild food-insecure females was significantly higher than males (P < 0.001, 0.001, and 0.001, respectively). The fasting blood sugar significantly increased (P = 0.020) in diabetic females with food security than the other female groups. Diastolic blood pressure significantly increased (P = 0.028) in diabetic females with severe food insecurity than the other female groups. The glycosylated hemoglobin significantly increased (P = 0.013) in diabetic males with severe food insecurity than the other male groups. Food insecurity odds ratio in females was 1.74 (95% confidence interval [CI]: 1.10–2.70), 2.39 (95% CI: 1.48–3.88), and 2.73 (95% CI: 1.49–5.01) times higher than in males for mild, moderate, and severe food insecurity, respectively. Conclusion: Food insecurity may deteriorate some cardiometabolic biomarkers in type 2 diabetes. Improving food security in patients with diabetes may help reduce cardiovascular disease.

Key words: Cardiovascular risk markers, food insecurity, Kerman coronary artery disease risk study, metabolic syndrome components, type 2 diabetes

INTRODUCTION

One potentially modifiable risk factor for adverse diabetes outcomes among socially underprivileged populations is food insecurity, which is defined as “limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways.”[11] Food insecurity is a risk for developing chronic health conditions such as diabetes, hypertension, hyperlipidemia, and cardiovascular disease.
The risk of clinical diabetes was 50% higher among adults living in food-insecure households compared with adults living in food-secure households. Food insecurity was associated with self-reported hypertension and hyperlipidemia but not diabetes. However, food insecurity was associated with the laboratory or examination evidence of hypertension and diabetes. These data showed that food insecurity was associated with cardiovascular risk factors.

A cross-sectional analysis of the National Health and Nutrition Examination Survey data revealed that the prevalence of metabolic syndrome (MetS) was higher among members of households with marginal and very low food security than among fully food secure contributors. In another similar study, participants experiencing food insecurity had higher glycosylated hemoglobin (HbA1c), poorer self-efficacy, and low consumption of fruit and vegetables. In contrast, another study has not found differences in diastolic blood pressure (BP), hyperlipidemia, and concentrations of total cholesterol (TC), blood glucose, and HbA1c by food security status. Another study found that the 10-year predicted risk for cardiovascular disease was increased among food insecure participants aged 30–59 years, particularly those with very low food security.

Subsequently, those considerations suggest that food insecurity could be associated with increased cardiovascular disease risk. Therefore, our understanding of the extent and nature of food insecurity remains limited due to the lack of population-level data. Then, based on previous conflicting studies in concern with the relationship between food insecurity and some of these indicators, this paper investigated the prevalence of food insecurity and whether cardiovascular risk markers and MetS components were significantly different in various categories of food insecurity in patients with type 2 diabetes as part of a population-based study from the Kerman coronary artery disease risk study (KERCADRS).
disease, (3) noninsulin therapy; (4) patients receive either diet therapy or diet therapy with combination of oral antidiabetic medications, (5) no history of myocardial infarction (MI), stroke, cardiovascular disease, active cancer, liver, kidney, and thyroid dysfunction, and infectious diseases. The exclusion criteria were the opposite of inclusion criteria. Patients were selected by census and the total number of patients with diabetes was 851 in the KERCADR study, of whom 325 patients were not accessible. Therefore, from 526 patients, six patients did not have complete data. As a result, the exact number of patients was 520.

**Food security assessment**

Household food insecurity was assessed by a 9-item household food insecurity access scale (HFIAS) questionnaire, which the validity and reliability have been measured in one of the studies. The HFIAS had good internal consistency (Cronbach’s α = 0.95). The questionnaires were completed by telephone interview.

Patients were divided into four groups of “food secure” with the result “0–1,” “mild food insecure,” “moderate food insecure,” and “severe food insecure” with the results “2–7,” “8–14,” and “15–27,” respectively. Answers were scored as “has never happened or no” with “0,” “has happened once or twice or rarely” with “1,” “has happened 3–10 times or sometimes” with “2,” and “has happened more than 10 times or quite often” with “3.”

**Clinical and biochemical examinations**

MetS components include FBS, high-density lipoprotein cholesterol (HDL-C), triglyceride (TG), systolic and diastolic BP, and waist circumference (WC). Cardiovascular risk markers include weight, body mass index (BMI), TC, LDL-C, and HbA1c.

As previously in the other studies described, all measurements were performed according to the standard protocol. The patients fasted for 12–14 h before admission. FBS (KIMIA Kit, Code 890410, Iran) was measured using the glucose oxidase-peroxidase method. HDL-C (PARS Kit, Code 89022, Iran) and TG (KIMIA Kit, Code 890201, Iran) were measured by standard enzymatic procedures. BP was recorded using an automated oscillometric BP monitor (standard mercury manometer–Model RISHTER, Germany) after at least 10 min of rest in a chair and arm supported at heart level. WC was measured at the umbilical level using a nonstretchable measuring tape, without any pressure to the body surface.

Weight and BMI (weight in kilograms divided by height in meters squared) were measured and recorded in questionnaires. TC (KIMIA Kit, Code 890303, Iran) and LDL-C were calculated based on Friedewald formula (LDL-C = TC – [HDL-C + TG/5]). HbA1C (NycoCard Kit, Code 1042184, Austria) was determined based on Bio-Rad Variant high-performance liquid chromatography assay.

**Statistical analysis**

Statistical analysis was performed using SPSS software (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, version 22.0. Armonk, NY: IBM Corp.). Significance was assumed at $P < 0.05$. Normal distribution of biomarkers was investigated by Kolmogorov–Smirnov test. All the cardiometabolic biomarkers had normal distribution. We compared the MetS components and cardiovascular risk markers values between four groups of household food security/insecurity with the use of analysis of variance, in which all pairwise comparisons among the four groups were performed with the use of Tukey’s honestly significant difference procedure. The Chi-square test was used to determine the relationship between different categories of food security and the categorical variables. Multinomial logistic regression analysis was used to predict the probability of cardiometabolic biomarkers on household food security/insecurity groups. Therefore, multinomial logistic regression is a predictive analysis to explain the relationship between one dependent variable such as four food security/insecurity groups and independent variables such as cardiometabolic biomarkers, controlling for the gender variable. The outcome variable is a categorical variable that included four groups of household food-secure/insecure status. Food-secure group is a reference group in the predicted model. The odds ratios (ORs) with 95% confidence interval (CI) all of the cardiometabolic biomarkers were computed.

**RESULTS**

**Patients characteristics**

The rate of response among all respondents was 99% (520 participants from 526 patients with diabetes). Six were excluded due to incomplete data. The mean (±standard deviation [SD]) age of participants was 60.82 ± 11.42 years (56% females and 44% males). Baseline characteristics of food-secure/insecure of patients with diabetes are shown in Table 1. Absolute and relative frequency distributions of patients with diabetes in food-secure/insecure groups are also shown in Table 1. There were significant difference among the food-secure/insecure sex groups ($P = 0.001$) [Table 1]. The prevalence of food security and mild, moderate, and severe food insecurity in patients with diabetes was 24.4%, 33.1%, 28.9%, and 13.6%, respectively. Food-secure male patients (32.0%) were higher than female patients in this category (18.3%).

Patients divided into four age groups as <49, 50–64, 65–74, and >75 years. About 44% patients were in
Table 1: Absolute and relative frequency distribution of patients with diabetes in food-secure/insecure groups based on sex and age groups

| Age groups/sex | Food secure (%) | Mild food insecure (%) | Moderate food insecure (%) | Severe food insecure (%) | Total (%) | P |
|----------------|-----------------|------------------------|---------------------------|-------------------------|-----------|---|
| Male           | 74 (32.0)       | 77 (33.3)              | 56 (24.3)                 | 24 (10.4)               | 231 (100.0) | 0.001 |
| Female         | 53 (18.3)       | 95 (32.9)              | 94 (32.5)                 | 47 (16.3)               | 289 (100.0) | 0.001 |
| Total          | 127 (24.4)      | 172 (33.1)             | 150 (28.9)                | 71 (13.6)               | 520 (100.0) | 0.001 |
| <49            |                 |                        |                           |                         |           |   |
| Male           | 11 (28.2)       | 14 (35.9)              | 9 (23.1)                  | 5 (12.8)                | 39 (100.0) | 0.259 |
| Female         | 6 (12.5)        | 17 (35.4)              | 17 (35.4)                 | 8 (16.7)                | 48 (100.0) |   |
| 50-64          |                 |                        |                           |                         |           |   |
| Male           | 27 (31.0)       | 29 (33.3)              | 23 (26.4)                 | 8 (9.2)                 | 87 (100.0) | 0.035 |
| Female         | 25 (17.4)       | 43 (29.9)              | 51 (35.4)                 | 25 (17.4)               | 144 (100.0) |   |
| 65-74          |                 |                        |                           |                         |           |   |
| Male           | 25 (33.8)       | 24 (32.4)              | 16 (21.6)                 | 9 (12.2)                | 74 (100.0) | 0.329 |
| Female         | 16 (21.1)       | 27 (35.5)              | 23 (30.3)                 | 10 (13.2)               | 76 (100.0) |   |
| >74            |                 |                        |                           |                         |           |   |
| Male           | 11 (35.9)       | 10 (32.3)              | 8 (25.8)                  | 2 (6.5)                 | 31 (100.0) | 0.421 |
| Female         | 6 (28.6)        | 8 (38.1)               | 3 (14.3)                  | 4 (19.0)                | 21 (100.0) |   |

50–64 years age group that 62% were female in this age group (P = 0.035) [Table 1]. In comparison with males, the prevalence of food insecurity was higher in females. Table 1 shows that in 50–64 years age group, one-third and two-third of patients with food insecurity were males and females, respectively.

The Chi-square test revealed that more percentage of female patients in household food insecurity groups were overweight or obese with a significant difference in the moderate food-insecure group. However, this percentage difference in WC between males and females in food-secure/insecure groups was more significant, except in severe food insecure. In general, more percentage of female patients compared with male patients with a significant difference had hyperlipidemia [Table 2].

Cardiovascular risk markers

Table 3 indicates the mean (±SD) for selected cardiovascular risk markers of patients with diabetes in studied food-secure/insecure groups. There was no significant difference between both sex groups in cardiovascular risk markers such as weight, BMI, TC, and LDL-C among food-secure/insecure categories. In general, BMI and the levels of TC and LDL-C in food-secure/insecure categories for females were higher than males. The HbA1c significantly increased (P = 0.013) in diabetic males with severe food insecurity than the other male groups. However, the trends of HbA1C level in males and females among food-secure/insecure categories were conversely. Food insecurity OR in diabetic women was 1.74, 2.39, and 2.73 times higher than in men for mild, moderate, and severe food insecurity, respectively (OR = 1.74, 95% CI: 1.10–2.70; OR = 2.39, 95% CI: 1.48–3.88; OR = 2.73, 95% CI: 1.49–5.01). Mild, moderate, and severe food insecurity significantly associated with BMI (OR = 1.06, 95% CI: 1.01–1.11, P = 0.030; OR = 1.06, 95% CI: 1.01–1.12, P = 0.024; OR = 1.11, 95% CI: 1.04–1.18, P = 0.001 respectively). Interestingly, when data split by gender (results not showed), mild and severe food insecurity remained significantly associated with BMI for males and females, respectively.

Metabolic syndrome components

Table 4 indicates the mean (±SD) for MetS components of patients with diabetes in studied food-secure/insecure groups. A variation in TG levels among male and female patients with diabetes was very high. There were no significant differences in HDL-C, TG, systolic BP, and WC among food-secure/insecure categories for both gender groups. The FBS significantly increased (P = 0.020) in diabetic females with food security than the other female groups. Diastolic BP significantly increased (P = 0.028) in diabetic females with severe food insecurity than the other female groups. Trends of variations for all of the components among different food insecure categories were not regular along with the intensity of insecurity. Table 5 indicates the results of the multinomial logistic regression analysis all of the cardiometabolic biomarkers in various categories household food security. Moderate food insecurity was also associated with TG concentration (OR = 0.99, 95% CI: 0.99–0.99, P = 0.003), and severe food security was associated with HDL-C (OR = 1.03, 95% CI: 1.00–1.07, P = 0.027). No significant associations between food insecurity status and the other cardiovascular risk markers and MetS components were observed. Females in moderate food insecurity had lower risk based on HbA1c in compared with males in this group (OR = 0.75, 95% CI: 0.60–0.95, P = 0.016), and males in severe food insecurity had higher risk based on HbA1c compared with females in this group (OR = 1.81, 95% CI: 1.23–2.66, P = 0.003). Therefore, the risk of the diabetic males
with severe food insecurity was high. A similar trend was observed for FBS in males and females.

**DISCUSSION**

We sought the relationship between food insecurity with cardiovascular risk markers and MetS components in patients with type 2 diabetes in a population-based study from KERCADRS. Therefore, in addition to determining the prevalence of household food insecurity based on sex and age groups, we determined significant differences in cardiovascular risk markers and MetS components between various categories of food insecurity in patients with type 2 diabetes.

The prevalence of food insecurity in females with diabetes was higher than males with diabetes [Table 1]. This result was paralleled with the other studies. In our study, a higher proportion of patients with diabetes particularly females were food insecure. In fact, diabetes was more prevalent in food‑insecure households. This conclusion explained by Gucciardi et al. Of course, diabetes incidence may occur in every household. One of the most important reasons could be inadequate accessibility to high‑quality and/or high‑quantity foodstuff due to an inappropriate socioeconomic situation. Galesloot et al. demonstrated that severe food insecurity, indicating reduced food intake and disrupted eating patterns, may influence population's ability to follow a healthy eating pattern necessary for effective diabetes management. In another study, food‑insecure

| Table 2: Absolute and relative frequency distribution of patients with diabetes in food‑secure/insecure groups based on sex and selected risk markers |
| --- |
| **Variables/sex** | Food secure (%) | Mild food insecure (%) | Moderate food insecure (%) | Severe food insecure (%) | *P* |
| --- | --- | --- | --- | --- | --- |
| **Overweight/obesity** | | | | | |
| Male | 45 (60.9) | 50 (65.0) | 31 (55.4) | 18 (75.0) | 0.012 |
| Female | 43 (82.7) | 77 (75.8) | 77 (81.0) | 34 (75.6) | 0.170 |
| **Hypertension/sys** | | | | | |
| Male | 27 (36.5) | 26 (33.8) | 16 (29.1) | 12 (50.0) | 0.062 |
| Female | 19 (35.8) | 27 (28.4) | 33 (34.4) | 19 (40.4) | 0.168 |
| **Hypertension/diastolic** | | | | | |
| Male | 21 (28.4) | 21 (27.3) | 18 (32.7) | 11 (45.8) | 0.168 |
| Female | 12 (22.6) | 18 (18.9) | 26 (27.1) | 16 (34.0) | 0.333 |
| **Hyper‑TG** | | | | | |
| Male | 47 (63.5) | 38 (49.4) | 29 (51.8) | 16 (66.7) | 0.003 |
| Female | 35 (66.0) | 69 (73.4) | 57 (59.4) | 33 (70.2) | 0.760 |
| **Hypercholesterolemia** | | | | | |
| Male | 13 (17.6) | 11 (14.3) | 4 (7.1) | 1 (4.2) | 0.031 |
| Female | 19 (35.8) | 33 (35.1) | 22 (22.9) | 16 (34.0) | 0.168 |
| **High LDL** | | | | | |
| Male | 9 (13.4) | 10 (13.7) | 6 (11.3) | 1 (4.3) | 0.191 |
| Female | 15 (31.3) | 29 (34.1) | 20 (21.7) | 14 (32.4) | 0.018 |
| **Low HDL** | | | | | |
| Male | 69 (94.5) | 71 (92.2) | 55 (98.2) | 22 (91.7) | 0.002 |
| Female | 45 (84.9) | 83 (88.3) | 82 (85.4) | 42 (98.4) | 0.758 |
| **High WC** | | | | | |
| Male | 13 (17.6) | 19 (24.7) | 11 (19.6) | 10 (41.7) | 0.487 |
| Female | 37 (69.8) | 56 (58.9) | 57 (59.4) | 29 (63.0) | 0.082 |

Percentage in bracket expressed within sex. Chi‑square test analyzed the relationship between two qualitative variables in food secure/insecure status classes. BMI categorized into normal, overweight, obesity and morbid obesity; Hypertension/systolic divided into normal BP (≤139 mmHg) and high BP (≥140 mmHg); Hypertension/diastolic divided into normal BP (≤89 mmHg) and high BP (≥90 mmHg); Triglyceridemia divided into normal TG (<150 mg/dl) and at risk (≥150 mg/dl); Cholesterolemia divided into desirable (<200 mg/dl), borderline (200‑239 mg/dl), and high (>240 mg/dl); LDL‑C divided into desirable and good (<129 mg/dl), borderline (130‑159 mg/dl), and high (>160 mg/dl); HDL‑C divided into undesirable or low (<40 mg/dl for male and<50 mg/dl for female), and good (≥40 mg/dl for male and≥50 mg/dl for female); Waist circumference; BP = Blood pressure; TG = Triglyceride
participants reported lower overall dietary quality and lower intake of fruit and vegetables. A suggestive mechanism might be that foods that are inexpensive and easily accessible tend to be energy dense and nutrient-rich.

| Table 3: Mean±standard deviation of selected cardiovascular risk markers of patients with diabetes in studied food-secure/insecure groups |
|----------------------------------|------------------|------------------|------------------|------------------|------------------|
|                                  | Food secure      | Mild food insecure| Moderate food insecure| Severe food insecure| Significant |
| Weight                           |                  |                  |                  |                  |                 |
| Male                             | 75.0±12.5        | 78.5±12.7        | 74.6±13.7        | 79.4±17.5        | 0.190          |
| Female                           | 68.8±8.6         | 69.7±11.5        | 72.2±13.2        | 74.4±16.8        | 0.080          |
| Total                            | 72.4±11.5        | 73.6±12.8        | 73.1±13.4        | 76.1±17.1        | 0.297          |
| BMI                              |                  |                  |                  |                  |                 |
| Male                             | 25.7±4.0         | 27.4±5.2         | 25.9±4.6         | 27.5±5.5         | 0.079          |
| Female                           | 27.7±3.1         | 28.0±4.2         | 29.0±5.1         | 29.8±6.6         | 0.094          |
| Total                            | 26.6±3.8         | 27.8±4.7         | 27.8±5.1         | 29.0±6.3         | 0.008          |
| TC                               |                  |                  |                  |                  |                 |
| Male                             | 195.8±50.4       | 186.3±47.5       | 187.2±37.2       | 197.2±25.1       | 0.462          |
| Female                           | 215.4±57.0       | 224.3±48.3       | 210.0±49.6       | 226.5±66.1       | 0.195          |
| Total                            | 204.0±54.0       | 207.2±51.4       | 201.6±46.6       | 216.6±57.2       | 0.225          |
| LDL-C                            |                  |                  |                  |                  |                 |
| Male                             | 121.0±40.4       | 116.6±40.0       | 120.8±33.9       | 125.6±25.2       | 0.745          |
| Female                           | 136.8±41.3       | 147.3±45.3       | 134.1±36.3       | 143.8±41.0       | 0.148          |
| Total                            | 127.8±41.3       | 133.3±45.5       | 129.3±35.9       | 137.4±37.1       | 0.370          |
| HbA1c                            |                  |                  |                  |                  |                 |
| Male                             | 7.9±1.7          | 8.2±1.5          | 8.2±1.8          | 9.7±1.7          | 0.013          |
| Female                           | 9.0±2.2          | 8.5±1.7          | 8.1±1.5          | 8.3±1.8          | 0.100          |
| Total                            | 8.4±2.0          | 8.4±1.6          | 8.1±1.6          | 8.7±1.8          | 0.369          |

One-way ANOVA analyzed the differences between cardiovascular risk markers in food secure/insecure status classes both genders. ANOVA = Analysis of variance; HbA1c = Glycosylated hemoglobin; LDL-C = Low-density lipoprotein cholesterol; TC = Total cholesterol; BMI = Body mass index

| Table 4: Mean±standard deviation of selected metabolic syndrome components of patients with diabetes in studied food-secure/insecure groups |
|----------------------------------|------------------|------------------|------------------|------------------|------------------|
|                                  | Food secure      | Mild food insecure| Moderate food insecure| Severe food insecure| Significant |
| FBS                              |                  |                  |                  |                  |                 |
| Male                             | 160.5±52.9       | 167.6±60.6       | 157.3±59.9       | 191.2±69.9       | 0.104          |
| Female                           | 196.5±87.8       | 180.5±59.5       | 169.8±55.6       | 156.7±59.4       | 0.020          |
| Total                            | 175.5±71.6       | 174.7±60.1       | 165.2±63.7       | 168.4±64.8       | 0.474          |
| HDL-C                            |                  |                  |                  |                  |                 |
| Male                             | 33.6±8.5         | 33.5±9.3         | 33.9±8.0         | 36.3±8.2         | 0.562          |
| Female                           | 38.3±9.9         | 37.6±9.8         | 38.7±10.0        | 40.0±9.8         | 0.569          |
| Total                            | 35.6±9.4         | 35.8±9.8         | 36.9±9.6         | 38.8±9.4         | 0.092          |
| TG                               |                  |                  |                  |                  |                 |
| Male                             | 216.5±172.4      | 183.0±104.2      | 174.2±101.1      | 176.5±81.5       | 0.214          |
| Female                           | 233.3±193.7      | 215.4±110.5      | 176.8±79.3       | 218.9±180.4      | 0.058          |
| Total                            | 223.5±181.0      | 200.8±108.6      | 175.8±87.7       | 204.6±154.9      | 0.027          |
| Systolic BP                      |                  |                  |                  |                  |                 |
| Male                             | 131.6±21.4       | 130.0±19.2       | 129.3±17.0       | 130.5±20.9       | 0.925          |
| Female                           | 133.2±23.8       | 126.4±20.3       | 127.9±20.4       | 133.3±23.9       | 0.146          |
| Total                            | 132.2±22.3       | 128.0±19.9       | 128.4±19.2       | 132.4±22.8       | 0.190          |
| Diastolic BP                     |                  |                  |                  |                  |                 |
| Male                             | 82.5±12.2        | 81.8±8.4         | 81.4±9.1         | 82.4±11.3        | 0.928          |
| Female                           | 82.1±12.2        | 79.5±10.5        | 80.4±8.7         | 84.7±10.2        | 0.028          |
| Total                            | 82.3±12.2        | 80.5±9.6         | 80.8±8.9         | 83.9±10.6        | 0.064          |
| WC                               |                  |                  |                  |                  |                 |
| Male                             | 93.1±10.1        | 95.0±10.1        | 93.0±11.8        | 97.2±12.5        | 0.291          |
| Female                           | 91.7±9.0         | 90.7±11.7        | 91.0±12.5        | 93.6±14.7        | 0.557          |
| Total                            | 92.5±9.6         | 92.6±11.2        | 91.7±12.3        | 94.8±14.0        | 0.325          |

One-way ANOVA analyzed the differences between metabolic syndrome components in food secure/insecure status classes both genders. FBS = Fasting blood sugar; HDL-C = High-density lipoprotein cholesterol; TG = Triglyceride; WC = Waist circumference; BP = Blood pressure; ANOVA = Analysis of variance
Therefore, micronutrient deficiency due to lack of micronutrient dense foods in a dietary pattern is more prevalent in food-insecure patients with type 2 diabetes. Consequently, food insecurity might be associated with deterioration of glycemic control in patients with type 2 diabetes.[3, 18-20] In another word, due to low socioeconomic status in food-insecure households, food insecurity was associated with less obedience to recommended self-care activities and worse glycemic control.[19]

On the other hand, more percentage of females in compared with males in food-insecure groups with the significant difference had risk factors such as hyperlipidemia and general and visceral obesity [Table 2]. Nevertheless, these significant differences were showed between male and female patients in food secure group. The results of an 11-year study confirmed that relative risks of conventional cardiovascular risk factors for the occurrence of MI in postmenopausal women were higher than in men in all age groups.[22] Therefore, gender could act as a discrepancy factor between biomarkers. With regard to overweight and obesity, prevalence was greater in patients with diabetes, but this matter was more prevalent in food insecure groups. In another study, higher BMI was associated with severe food insecurity in patients with diabetes; moderate and severe food-insecure patients with diabetes similarly were associated with poor glycemic control.[3] The study of Holben and Pheley, HbA1c was significantly greater among males from food-insecure households than among those from food-secure households. The regular incremental trend in HbA1c was revealed among males by insecurity severity. The reason for this disparity in HbA1c between males and females was unknown. From the other viewpoint, HbA1c variation corresponded with FBS variation among males and females from food-secure/insecure households. This correspondence is predictable for HbA1c and FBS. About one-third of patients were hypertensive. However, we could find exclusively a BP increment in hypertensive participants with severe food-insecure patients. The number of patients with low HDL-C was 3.5 times more than patients with high HDL-C. The reason for this disparity is the deteriorating effect of general and visceral obesity and hypertension of patients on their HDL-cholesterol [Table 2]. Lipid and lipoprotein profiles such as TG, TC, and LDL-C levels were greater among females from food-secure/insecure households than among males from food-secure/insecure households. As we mentioned previously, this disparity is due to more prevalence of overweight/obesity and hypertension among females than males.

Overall, food insecurity was associated with a decreased likelihood of good cardiovascular health (CVH). Participants who were food insecure were significantly less likely to have good CVH compared to participants who were food secure.[23] Then, we computed OR of cardiometabolic biomarkers in food insecurity status. However, no significant associations between food insecurity status and cardiometabolic biomarkers, except for BMI and TG concentration, were observed. These results were similar to the results of Ford.[10] Nevertheless, Ford indicated that
adults aged 30–59 years with very low food security showed evidence of increased predicted 10-year cardiovascular disease risk. In contrast, Parker et al. revealed that adults in households with marginal and very low food security had a 1.80-fold (95% CI: 1.30–2.49) and 1.65-fold (95% CI: 1.12–2.42) increased odds of MetS, respectively. Generally, women are greater than men at risk of food insecurity. Food insecurity OR in nondiabetic and diabetic women was 3.2 (95% CI: 1.3–7.7) and 2.4 (95% CI: 1.02–5.5) times higher than in men. Food security scores were significantly different between males and females. In our study, household food insecurity OR in diabetic women was also 1.74, 2.39, and 2.73 times higher than in men for mild, moderate, and severe food insecurity, respectively.

One of the limitations of our study was drop out a number of patients with diabetes who did not participate in our investigation. One of the limitations of this research was to be cross-sectional; however, the second phase of this cohort study has already begun. Therefore, the patients with type 2 diabetes will be evaluated in terms of food insecurity.

CONCLUSIONS

Food insecurity may deteriorate some cardiometabolic biomarkers in type 2 diabetes. Finally, these results emphasize the need for interventions focus on prevention of household food insecurity and the decreasing prevalence of type 2 diabetes. Hence, further interventional research is needed in this population to determine associations between improvement of food security and decreasing of cardiovascular risk markers and MetS components. Therefore, food security can play a significant role in the prevention and management of diabetes, and improving food security in patients with diabetes may help reduce cardiovascular disease. Food dietary assessment and screening with a validated measure may facilitate identification of patients at risk of food insecurity.

Financial support and sponsorship

The main project has been funded by Kerman University of Medical Sciences with the grant number 88/110.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Anderson SA. Core indicators of nutritional state for difficult-to-sample populations. J Nutr 1990;120 Suppl 11:1559-600.
2. Seligman HK, Bindman AB, Vittinghoff E, Kanaya AM, Kushel MB. Food insecurity is associated with diabetes mellitus: Results from the National Health Examination and Nutrition Examination Survey (NHANES) 1999-2002. J Gen Intern Med 2007;22:1018-23.
3. Bawadi HA, Ammari F, Abu-Jamous D, Khader YS, Bataineh S, Tayyem RF, et al. Food insecurity is related to glycemic control deterioration in patients with type 2 diabetes. Clin Nutr 2012;31:250-4.
4. Seligman HK, Jacobs EA, López A, Tschann J, Fernandez A. Food insecurity and glycemic control among low-income patients with type 2 diabetes. Diabetes Care 2012;35:233-8.
5. Cuesta Briand B, Saggars S, McManus A. ‘You get the quickest and the cheapest stuff you can’: Food security issues among low-income earners living with diabetes. Australas Med J 2011;4:683-91.
6. Seligman HK, Laraia BA, Kushel MB. Food insecurity is associated with chronic disease among low-income NHANES participants. J Nutr 2010;140:304-10.
7. Parker ED, Widome R, Netleton JA, Pereira MA. Food security and metabolic syndrome in U.S. adults and adolescents: Findings from the National Health and Nutrition Examination Survey, 1999-2006. Ann Epidemiol 2010;20:364-70.
8. Lyles CR, Wolf MS, Schilling D, Davis TC, Dewalt D, Dahlke AR, et al. Food insecurity in relation to changes in hemoglobin A1c, self-efficacy, and fruit/vegetable intake during a diabetes educational intervention. Diabetes Care 2013;36:1448-53.
9. Shariff ZM, Sulaiman N, Jalil RA, Yen WC, Yaw YH, Taib MN, et al. Food insecurity and the metabolic syndrome among women from low income communities in Malaysia. Asia Pac J Clin Nutr 2014;23:138-47.
10. Ford ES. Food security and cardiovascular disease risk among adults in the United States: Findings from the National Health and Nutrition Examination Survey, 2003-2008. Prev Chronic Dis 2013;10:E202.
11. Najafipour H, Mirzazadeh A, Haghdoot A, Shadkam M, Afshari M, Moazenzadeh M, et al. Coronary artery disease risk factors in an urban and peri-urban setting, Kerman, Southeastern Iran (KERCADS study): Methodology and preliminary report. Iran J Public Health 2012;41:86-92.
12. Yousefzadeh G, Shokoohi M, Najafipour H. Inadequate control of diabetes and metabolic indices among diabetic patients: A population based study from the Kerman Coronary Artery Disease Risk Study (KERCADS). Int J Health Policy Manag 2014;4:271-7.
13. Salarkia N, Abdollahi M, Amini M, Neyestani TR. An adapted Household Food Insecurity Access Scale is a valid tool as a proxy measure of food access for use in urban Iran. Food Sec 2014;6:275-82.
14. Hasan-Ghomi M, Ejtaheh HS, Mirimiran P, Hosseini-Esfahani F, Sarbazi N, Azizi F, et al. Relationship of food security with type 2 diabetes and its risk factors in Iranian adults. Int J Prev Med 2015;6:98.
15. Liu J, Park YM, Berkowitz SA, Hu Q, Han K, Ortaglia A, et al. Gender differences in the association between food insecurity and insulin resistance among U.S. adults: National Health and Nutrition Examination Survey, 2005-2010. Ann Epidemiol 2015;25:643-8.
16. Gucciardi E, Vahabi M, Norris N, Del Monte JP, Farnum C. The intersection between food insecurity and diabetes: A review. Curr Nutr Rep 2014;3:324-32.
17. Galesloot S, McIntyre L, Fenton T, Tyminski S. Food insecurity in Canadian adults receiving diabetes care. Can J Diet Pract Res 2012;73:e261-6.
18. Berkowitz SA, Gao X, Tucker KL. Food-insecure dietary patterns are associated with poor longitudinal glycemic control in diabetes: Results from the Boston Puerto Rican Health Study. Diabetes Care 2014;37:2587-92.
19. Heerman WJ, Wallston KA, Osborn CY, Bian A, Schlundt DG, Barto SD, et al. Food insecurity is associated with diabetes self-care.
behaviours and glycaemic control. Diabet Med 2016;33:844-50.
20. Berkowitz SA, Baggett TP, Wexler DJ, Huskey KW, Wee CC. Food insecurity and metabolic control among U.S. adults with diabetes. Diabetes Care 2013;36:3093-9.
21. Mahmoodi MR, Abadi AR, Kimiagar SM. Sex differences in myocardial infarction events between patients with and without conventional risk factors: The modares heart study. Am Heart Hosp J 2007;5:228-35.
22. Holben DH, Pheley AM. Diabetes risk and obesity in food insecure households in rural appalachian ohio. Prev Chronic Dis 2006;3:A82.
23. Saiz AM Jr., Aul AM, Malecki KM, Bersch AJ, Bergmans RS, LeCaire TJ, et al. Food insecurity and cardiovascular health: Findings from a statewide population health survey in Wisconsin. Prev Med 2016;93:1-6.