Food Insecurity and Lipid Profile Abnormalities Are Associated with an Increased Risk of Nonalcoholic Fatty Liver Disease (NAFLD): A Case–Control Study

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Abstract

This case–control study aimed to assess the relationship between food insecurity, its related risk factors and NAFLD among 210 subjects. The demographic and socioeconomic characteristics, anthropometric indices, and food insecurity and depression status were assessed. The prevalence of food insecurity was 56.8% and 26.1% in cases and controls (p < .001), respectively. The chance of NAFLD in the food insecure, depressed, overweight, and obese subjects was 2.2 (95%CI: 1.12–3.43), 1.9 (95%CI: 1.02–3.62), 2.6 (95%CI: 1.81–3.92), and 2.9 (95%CI: 2.02–5.34) times higher than food secured, normal, and normal weight subjects, respectively. A higher waist circumference (men, OR = 2.9, p < .001; women, OR = 2.6, p < .001), a high waist-to-hip ratio (men, OR = 2.3, p < .001; women, OR = 2.7, p < .001), an increased waist-to-height ratio (OR = 2.9, p < .001), and a higher body fat percentage (men, OR = 3.0, p < .001; women, OR = 3.3, p < .001) were associated with an increased risk of NAFLD. The odds of NAFLD increased by increment in serum triglyceride (TG) levels (OR = 2.6, p < .001) and decreased by increase in serum high-density lipoprotein cholesterol (HDL-C) (OR = 0.34, p < .001). Compared to controls, patients with NAFLD were more likely to have higher TG/HDL-C ratio (OR = 3.3, p < .001). It seems food insecurity was an important risk factor for NAFLD. Additionally, some indicators of dyslipidemia significantly increased the risk of NAFLD.

Introduction

Food insecurity, a serious public health problem, is frequent in both developed and developing countries (Behzadifar et al. 2016; Dastgiri et al. 2007).

Keywords

Food insecurity; lipid profile; NAFLD; socioeconomic factors
Household food insecurity is defined as “limited or uncertain access to nutritionally adequate and safe foods, or limited ability to obtain acceptable foods through socially admitted ways” (Vozoris and Tarasuk 2003). It is estimated that more than 852 million people suffer from food insecurity in all over the world (Cook and Frank 2008). Food insecurity has been identified as a significant social and health problem in Iran as well (Dastgiri et al. 2006; Hoseinikhorrami et al. 2007; Ostadrahimi et al. 2006). According to a recent meta-analysis, food insecurity prevalence has been reported by 49% among Iranian households (Behzadifar et al. 2016). Food insecurity is strongly associated with poorer health outcomes (Najibi et al. 2019; Vozoris and Tarasuk 2003). Several studies have demonstrated associations between food insecurity and overweight/obesity among children and adults using both self-reported and objective measures of body mass index (BMI) (Seligman, Laraia, and Kushel 2010; Yang et al. 2018). Food insecurity has also been reported to be associated with higher anxiety and depressive symptoms (Leung et al. 2015; Najibi et al. 2019). Nevertheless, there are few studies evaluating associations between food insecurity and chronic diseases such as cardiovascular disease, diabetes, and hypertension among adults (Seligman, Laraia, and Kushel 2010; Vozoris and Tarasuk 2003). It was well established that the status of head of household, socioeconomic status (SES), educational level, race/ethnicity, family size, age, marital status, and eating habits are factors affecting food insecurity (Behzadifar et al. 2016; Mello et al. 2010; Najibi et al. 2019). In addition, previous studies have reported that food insecurity may be positively associated with some indicators of dyslipidemia (Tayie and Zizza 2009). Limited budgets for those in food-insecure households result in buying cheaper and high energy-dense diets with low amount of micronutrients, which can contribute to overweight/obesity and lipid profile abnormalities, and consequently increasing the prevalence rate of many chronic diseases like nonalcoholic fatty liver disease (NAFLD) (Kendall, Olson, and Frongillo 1996; Mello et al. 2010; Seligman, Laraia, and Kushel 2010; Tayie and Zizza 2009). NAFLD indicating excess of fat accumulation in the liver has become a growing public health problem (Amirkalali et al. 2014; Tutunchi et al. 2019b). This clinical–pathological condition affects approximately 25–30% of the adult population in both developed and developing countries (Amirkalali et al. 2014; Tutunchi et al. 2019b). However, NAFLD prevalence has been estimated to be more than 70% in obese individuals, and also in patients with diabetes and metabolic syndrome (Tutunchi et al. 2019b). It appears that NAFLD prevalence is lower in Asian countries in comparison with Western countries (Fan, Kim, and Wong 2017). However, it has recently increased along with the increase in obesity, diabetes, and metabolic syndrome in this region (Amirkalali et al. 2014; Fan, Kim, and Wong 2017). NAFLD onset and development are closely associated with dietary habits and lifestyle (Amirkalali et al. 2014; Tutunchi et al. 2019b). Major risk factors for NAFLD are sedentary
lifestyles and poor eating habits. Previous studies have reported a significant positive association between BMI and lipid accumulation in the liver resulting in a higher risk of NAFLD (Fan, Wang, and Du 2018; Tutunchi et al. 2019b; 2020b).

According to the recent studies, the prevalence rates of food insecurity and NAFLD are increasing in Iran (Amirkalali et al. 2014; Behzadifar et al. 2016; Fan, Kim, and Wong 2017). Given that food insecurity and NAFLD have negative health consequences and there is no previous study evaluating the association between food insecurity and NAFLD; thus, the present study was designed in order to investigate the relationship between food insecurity, risk factors associated with food insecurity and NAFLD incidence in a sample of Iranian adults.

Materials and methods

Study design and participants

The present study was a case–control study conducted in a sample of Iranian adults, aged 20–60 years (n = 210; 95 cases diagnosed with “NAFLD” and 115 controls without NAFLD matched by age, sex, and residential status from January to June 2019 at Imam Reza Hospital in Tabriz, Iran. Inclusion criteria included subjects aged from 20 to 50 years old, and those with ultrasound-diagnosed NAFLD for the cases, and those without NAFLD for the controls. Exclusion criteria included individuals with a history of kidney diseases, cardiovascular diseases, hypertension, diabetes, thyroid disorders, cancer, gastrointestinal disorders, those diagnosed with some pathological conditions affecting the liver like viral hepatitis, acute or chronic liver failure, and liver transplantation, and history of alcohol consumption in the last year, pregnancy or breast-feeding, the use of any medication for hypertension, diabetes, adhering to a specific diet during past 3 months, and any lifestyle changes. Liver ultrasonography was utilized for NAFLD diagnosis. Informed consent form was obtained from all participants before enrollment in the study. Also, information on socioeconomic and demographic characteristics including age, gender, marital status, educational level, employment status, family size, and smoking status was collected through a face-to-face interview with study participants.

Food security assessment

The 18-item USDA (US Department of Agriculture) household food security questionnaire was applied to determine household food security status (Rafiei et al. 2009). This questionnaire assessing household food security during the past 12 months has been previously validated in Iran (Mohammadzadeh,
Dorosty, and Eshraghian 2010). According to this questionnaire, food security is classified into four groups: food secure, food insecure without hunger, food insecure with moderate hunger, and food insecure with severe hunger. As shown in Table 1, scoring method for this questionnaire is described as follows: score of 1 is given to responses such as “often”, “sometimes”, “almost every month”, “some months”, and “yes” and responses such as “not correct”, “refused or did not know”, “only once or twice a month”, and “no” were scored as 0.

**Depression assessment**

The Beck Depression Inventory (BDI) (Beck et al. 1961) was applied to assess the participants’ depression status. This questionnaire consists of a 21-item self-report instrument indicating existence and severity of symptoms of depression. The BDI includes several kinds of questions and each question represents a state in the individual. The respondent should choose the option that best represents his/her current feeling. Every question includes four options, and each question was scored from 0 to 3. A total score, ranging from 0 to 63 was calculated by summing all scores. According to the BDI questionnaire, participants with a score of 19 or more than that were considered as depressed. This questionnaire is valid and reliable in Iran (Hossein Kaviani and Mousavi 2008). Cronbach’s alpha coefficient of BDI was calculated to be 0.92 in Iranian population (Hossein Kaviani and Mousavi 2008).

**Anthropometric measurements**

Body weights and heights were measured using a digital scale and stadiometer (Seca, Germany). Waist circumference (WC) and hip circumference (HC) were measured using the following points: the middle of the lowest gear, the iliac crest high point, and on the biggest environmental gluteal muscle, respectively. Bioimpedance Analyzer device (Tanita MC-780 S MA, Amsterdam, The Netherlands) was utilized to assess the participants’ body fat percentage (BFP).

| Food security status               | Code | Number of positive answers | Families with children under 18 (total score:18) | Families without children under 18 (total score 10) |
|-----------------------------------|------|----------------------------|-----------------------------------------------|--------------------------------------------------|
| Food secure                       | 0    | 0–2                        | 0–2                                           |
| Food insecure without hunger      | 1    | 3–7                        | 3–5                                           |
| Food insecure with moderate hunger| 2    | 8–12                       | 6–8                                           |
| Food insecure with severe hunger  | 3    | 13–18                      | 9–10                                          |

Guide to Measuring Household Food Security.
BMI was calculated through dividing weight by squared height (kg/m\(^2\)). The waist-to-hip ratio (WHR) was estimated as WC (cm) divided by HC (cm), and the waist-to-height ratio (WHtR) was estimated as WC (cm) divided by height (cm). Overweight was considered as BMI = 25–29.9 kg/m\(^2\), and obesity was defined as BMI \(\geq 30\) kg/m\(^2\). Gender-specific cutoffs were considered for WC, WHR, and BFP. Based on the National Cholesterol Education Program (NCEP), high WC cutoff value was considered 102 cm in men and 88 cm in women (Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report 2002). In addition, high WHR cutoff value was considered \(\geq 0.9\) for males and \(\geq 0.85\) for females (Kramer et al. 2013; Nikniaz et al. 2017). Furthermore, high WHtR cutoff value was considered values more than 0.5 for both genders (Nikniaz et al. 2017). Based on the World Health Organization (WHO) guideline, high BFP cutoff point was considered 25% for men and 35% for women (Ho-Pham, Campbell, and Nguyen 2011).

**Assessment of physical activity status**

An international physical activity questionnaire-short form (IPAQ-SF), previously validated in Iran was used for estimating the participants’ physical activity level. The IPAQ form calculates and reports physical activity in metabolic equivalents per minute (MET-min) per week. Physical activity levels were reported as three categories as low, moderate, and high activity levels.

**Biochemical measurements**

To determine the lipid profile parameters, blood samples (5 mL) were obtained following a 12-h overnight fast. After centrifugation at 3000 rpm for 5 min, serum levels of total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C) were assessed instantly on fresh blood samples using commercial kits by auto-analyzer.

**Sample size**

A logistic regression of a binary response variable NAFLD on a binary independent variable food insecurity with a sample size of 207 observations obtained 90% power at a 0.050 significance level to detect an odds ratio of 2.600. A two-sided Wald test was used. Information was obtained as the study proceeded up to 15 samples per group.
**Statistical analysis**

Statistical analysis of all data was performed using IBM SPSS Statistics software (IBM SPSS Statistics, Armonk, USA, version 23). The Kolmogorov–Smirnov test was applied to examine normal distribution of data. The chi-square, independent samples t-test, and univariate logistic regression tests were used. Then, significant factors in univariate analysis model were entered into multivariate logistic regression model for controlling possible confounder factors, and identifying important independent risk factors for NAFLD. The Mann–Whitney U test was used for values with skewed distribution. All statistical tests were two-sided, and p values less than 0.05 were considered statistically significant.

**Results**

A total of 210 subjects (cases = 95, controls = 115) were enrolled in this study. Mean age was 48.8 (standard deviation [SD] 5.9) years in patients with NAFLD and 47.3 (SD 6.2) years in the controls. There were no significant differences in gender and age between the two groups as shown in Table 2. Food insecurity prevalence was 56.8% in cases and 26.1% in controls, and this difference was statistically significant (p < .001). Odds ratio for NAFLD in the food-insecure subjects was 2.7 (95% CI: 1.37–3.93) times more in comparison with the controls. 46.3% of the patients with NAFLD and 24.3% of the subjects without NAFLD were depressed and this difference was statistically significant (p = .003). NAFLD chance in depressed participants was 2.3 (95% CI: 1.34–3.51) times more in comparison with non-depressed ones. Compared with the controls, patients with NAFLD had significantly lower educational level, physical activity, economic level, and income and also higher family size, number of children, and children with the ages less than 18 years old (p < .05). There were no significant differences in height, employment status, marital status, and smoking status between the two groups (p > .05). NAFLD chance in overweight subjects was 2.9 (95% CI: 1.81–4.44) times higher compared to non-obese subjects. Moreover, obesity prevalence was 32.6% in cases, and 15.6% in controls and this difference was statistically significant (p < .001). NAFLD chance in male participants with WC >102 was 3.1 (95% CI: 2.12–5.76) times higher compared to those with WC<102. Furthermore, 57.4% of female patients with NAFLD and 30.5% of female subjects without NAFLD had WC>88, and this difference was statistically significant (p < .001). The chance of NAFLD in male participants with WHR ≥ 0.9 and female subjects with WHR ≥ 0.85 was 2.5 (95% CI: 1.92–3.91) and 2.7 (95% CI: 1.69–3.31) times higher, respectively. And, 64.3% of patients with NAFLD and 31.3% of subjects without NAFLD had WHtR > 0.5, and this difference was statistically significant (p < .001). Odds ratio for NAFLD in male participants with BFP > 25% and female subjects with
Table 2. Demographic and socioeconomic characteristics, food insecurity and depression status, anthropometric indices, body composition, and physical activity status in NAFLD and non-NAFLD participants.

| Variables                        | Cases (n = 95) | Controls (n = 115) | OR (95% CI) | p Value |
|----------------------------------|----------------|--------------------|-------------|---------|
| **Number (%)**                   |----------------|--------------------|-------------|---------|
| Food security status             |                |                    |             |         |
| Food secure                      | 41 (43.1)      | 85 (73.9)          | 1           |         |
| Food insecure                    |                |                    |             |         |
| Food insecure without hunger     | 31 (32.6)      | 25 (21.7)          | 2.7 (1.37–3.93) | <0.001* |
| Food insecure with moderate hunger| 19 (20)        | 5 (4.4)            |             |         |
| Food insecure with severe hunger | 4 (4.3)        | 0 (0)              |             |         |
| Depression status                |                |                    |             |         |
| Not depressed                    | 51 (53.6)      | 87 (75.6)          | 1           |         |
| Depressed                        | 44 (46.3)      | 28 (24.3)          | 2.3 (1.34–3.51) | 0.003*  |
| Physical activity level          |                |                    |             |         |
| High                             | 0 (0)          | 0 (0)              | 1           |         |
| Moderate                         | 28 (29.4)      | 52 (45.2)          | 1.9 (1.11–2.71) | <0.001* |
| Low                              | 67 (70.5)      | 63 (54.7)          | 2.9 (1.93–4.21) | <0.001* |
| Smoking status                   |                |                    |             |         |
| Nonsmoker                        | 49 (51.6)      | 61 (53.1)          | 1           |         |
| Current smoker                   | 46 (48.4)      | 54 (46.9)          | 1.08 (0.96 – 1.19) | 0.28*   |
| Educational level                |                |                    |             |         |
| Bachelor and higher              | 17 (17.9)      | 31 (26.9)          | 1           |         |
| Diploma and lower                | 56 (58.9)      | 79 (68.7)          | 1.7 (1.01–2.51) |         |
| Illiterate                       | 22 (23.1)      | 5 (4.3)            | 2.6 (1.48–3.91) |         |
| Economic status                  |                |                    |             |         |
| Rich                             | 11 (11.5)      | 24 (20.9)          | 1           |         |
| Average                          | 36 (37.9)      | 61 (53.1)          | 2.1 (1.67–2.45) |         |
| Poor                             | 48 (50.5)      | 30 (26)            | 2.9 (1.91–4.86) | <0.001* |
| Monthly income                   |                |                    |             |         |
| ≥6,000,000 Riyal                 | 46 (48.4)      | 78 (67.8)          | 1           |         |
| <6,000,000 Riyal                 | 49 (51.6)      | 37 (32.2)          | 2.3 (1.21–4.30) | 0.001*  |
| Family size                      |                |                    |             |         |
| <5                               | 34 (36)        | 68 (59.1)          | 1           |         |
| ≥5                               | 60 (64)        | 47 (40.9)          | 1.9 (1.01–3.91) | 0.003*  |
| Number of children               |                |                    |             |         |
| <4                               | 37 (38.9)      | 66 (57.3)          | 1           |         |
| ≥4                               | 58 (61.1)      | 49 (42.6)          | 2.2 (1.1–4.47) | 0.002*  |
| Having children <18 years        |                |                    |             |         |
| No                               | 45 (47.3)      | 71 (61.7)          | 1           |         |
| Yes                              | 50 (52.7)      | 44 (38.2)          | 2.3 (1.9–3.99) | 0.002*  |
| BMI (kg/m²)                      |                |                    |             |         |
| 18.5–24.9                        | 21 (22.1)      | 68 (59.2)          | 1           |         |
| 25–29.9                          | 43 (45.3)      | 29 (25.2)          | 2.9 (1.81–4.44) |         |
| ≥30                              | 31 (32.6)      | 18 (15.6)          | 3.1 (2.71–6.87) | <0.001* |
| WC (cm)                          |                |                    |             |         |
| ≤102                             | 11 (26.9)      | 32 (57.1)          | 1           |         |
| >102                             | 30 (73.1)      | 24 (42.9)          | 3.1 (2.12–5.76) | <0.001* |
| ≤88                              | 23 (42.6)      | 41 (69.5)          | 1           |         |
| >88                              | 31 (57.4)      | 18 (30.5)          | 2.9 (1.89–6.43) | <0.001* |
| WHR                              |                |                    |             |         |
| ≤0.9                             | 16 (39)        | 34 (60.8)          | 1           |         |
### Table 2. (Continued).

| Variables          | Cases (n = 95) | Controls (n = 115) | OR (95% CI) | p Value |
|--------------------|----------------|-------------------|-------------|---------|
| ≥0.9               | 25 (61)        | 22 (39.2)         | 2.5 (1.92–3.91) | <0.001* |
| <0.85              | 26 (48.1)      | 31 (52.6)         | 1           |         |
| ≥0.85              | 28 (68.2)      | 28 (47.4)         | 2.7 (1.69–3.31) | <0.001* |
| WHtR               |                |                   |             |         |
| ≤0.5               | 34 (35.7)      | 79 (68.6)         | 1           |         |
| >0.5               | 61 (64.3)      | 36 (31.3)         | 3.2 (2.49–6.88) | <0.001* |
| BFP                |                |                   |             |         |
| ≤25                | 12 (29.3)      | 33 (58.9)         | 1           |         |
| >25                | 29 (70.7)      | 23 (41.1)         | 3.3 (2.33–5.88) | <0.001* |
| ≤35                | 25 (46.2)      | 43 (72.8)         | 1           |         |
| >35                | 29 (53.8)      | 16 (27.2)         | 3.7 (2.40–6.13) | <0.001* |
| Employment status  |                |                   |             |         |
| Employed           | 34 (35.8)      | 52 (45.3)         | 1           |         |
| Housewife          | 61 (64.2)      | 63 (54.7)         | 1.08 (0.96–1.19) | 0.08*   |
| Marital status     |                |                   |             |         |
| Single             | 12 (12.7)      | 21 (18.2)         | 1           |         |
| Married            | 83 (87.3)      | 94 (81.8)         | 1.00 (0.90–1.14) | 0.31*   |
| Gender             |                |                   |             |         |
| Males              | 41 (43.2)      | 56 (48.7)         | 1           |         |
| Females            | 54 (56.8)      | 59 (51.3)         | 1.08 (0.96–1.19) | 0.27*   |
| Age (years)        | 48.8 (5.9)     | 47.5 (6.2)        |             | 0.24**  |
| Weight (kg)        | 76.6 (9.9)     | 62.9 (9.4)        |             | 0.001** |
| Height (cm)        | 166.5 (9.1)    | 165.9 (8.7)       |             | 0.81**  |
| BMI (kg/m²)        | 28.9 (3.9)     | 23.2 (3.6)        |             | <0.001**|
| WC (cm)            | 95.8 (10.1)    | 83.9 (9.7)        |             | <0.001**|
| HC (cm)            | 98.9 (8.8)     | 93.6 (9.2)        |             | 0.03**  |
| WHR                | 0.95 (0.09)    | 0.89 (0.07)       |             | <0.001**|
| WHtR               | 0.56 (0.09)    | 0.51 (0.06)       |             | <0.001**|
| BFP                | 31.9 (6.4)     | 28.7 (4.9)        |             | <0.001**|

* Logistic regression.  
** Independent t-test.  
BFP, body fat percentage, BMI, body mass index, CI, confidence interval, HC, hip circumference, OR, odds ratio, SD, standard deviation, WC, waist circumference, WHR, waist-to-hip ratio, WHtR, waist-to-height ratio.  
Statistically significant (P < 0.05).
BFP > 35% was 3.3 (95% CI: 2.33–5.88) and 3.7 (95% CI: 2.40–6.13) times higher, respectively. Moreover, there were significant differences in weight, BMI, HC, WHR, WHtR, and BFP between the two groups (p < .05, Table 2).

According to final analysis model, food insecurity, depression, number of children ≥4, overweight, and obesity were identified as independent risk factors for NAFLD. The chance of NAFLD in the food insecure, depressed, overweight, and obese subjects was 2.2 (95% CI: 1.12–3.43), 1.9 (95% CI: 1.02–3.62), 2.6 (95% CI: 1.81–3.92), and 2.9 (95% CI: 2.02–5.34) times higher than food secured, normal, and normal weight subjects, respectively. In addition, a higher WC (men, OR = 2.9, p < .001; women, OR = 2.6, p < .001), an elevated WHR (men, OR = 2.3, p < .001; women, OR = 2.7, p < .001), an increased WHtR (OR = 2.9, p < .001), and a higher BFP (men, OR = 3.0, p < .001; women, OR = 3.3, p < .001) were independently associated with an increased risk of NAFLD. (Table 3). The odds of NAFLD increased by increment in serum TG levels (OR = 2.6, p < .001) and decreased by increase in serum HDL-C (OR = 0.34, p < .001). Compared to controls, NAFLD patients were more likely to have higher TG/HDL-C ratio (OR = 3.3, p < .001) (Table 4).

Discussion

Although a number of previous studies have investigated the association between food insecurity and prevalence of chronic diseases among adults (Najibi et al. 2019; Seligman, Laraia, and Kushel 2010), to our knowledge, this is the first study evaluating the relationship between food insecurity and NAFLD in Iran. Recently, Golovaty et al. (Golovaty et al. 2019) examined the association of food insecurity with NAFLD among 2627 adults in the United States. They found that the estimated prevalence of NAFLD did not differ significantly by food security status. In the same study, food-insecure adults were more likely to have NAFLD compared with food-secure adults in the multivariable model (Golovaty et al. 2019). In our study, the prevalence of food insecurity was 56.8% in patients with NAFLD and 26.1% in controls, and this difference was statistically significant. Unhealthy eating habits in patients with NAFLD may contribute to this difference. Most of the previous studies have reported a significant positive association between inappropriate dietary patterns and NAFLD (Amirkalali et al. 2014; Yasutake et al. 2014). Previous investigations have also reported a positive association between food insecurity and obesity (Najibi et al. 2019; Nikniaz et al. 2017). Food-insecure adults may depend on high-energy foods, which can result in overconsumption of energy and result in obesity and obesity-related complications such as NAFLD (Seligman, Laraia, and Kushel 2010; Vozoris and Tarasuk 2003). Accordingly, these inappropriate eating habits in NAFLD patients may contribute to the incidence of high food insecurity.
In this study, NAFLD chance in depressed participants was 2.3 (95% CI: 1.34–3.51) times more in comparison with non-depressed ones. Numerous population-based studies have reported a high prevalence of depression in patients with NAFLD, which is in agreement with this study. Le Strat et al. (Le Strat, Le Foll, and Dubertret 2015) reported the occurrence of 12-month major depression in participants with a liver disease (17.2%), which was significantly higher compared to participants without liver disease, after adjusting...
for confounding factors. In addition, a case–control study by Elwing et al. (Elwing et al. 2006) suggested that subjects with NASH manifested a significant increase in their lifetime rate of major depressive disorder (MDD) in comparison with control subjects without liver disease matched for age, gender, BMI, and WHR. Interestingly, after adjusting for other clinical confounders, the diagnosis of MDD tended to be associated with steatosis grade (Elwing et al. 2006). Subclinical and clinical depression was reported in 53% and 14% of the patients with NAFLD, respectively (Youssef et al. 2013). Importantly, after adjusting for confounders, depression was significantly correlated with more severe hepatocyte ballooning and patients with subclinical depression had a higher possibility of having more severe portal fibrosis (Youssef et al. 2013). Some previous studies have indicated the association between dietary patterns and depression (Khosravi et al. 2015). In a case–control study on a sample of Iranian subjects, it was found that a healthy dietary pattern characterized by a high intake of various vegetables and nuts was associated with a low prevalence of depression (Khosravi et al. 2015). Additionally, a recent study conducted in Korean adults demonstrated that a healthy dietary pattern was associated with low depression risk. Whereas an unhealthy dietary increased the risk of depression after controlling for various confounders (Park, Kim, and Lee 2019). Therefore, high prevalence of depression in patients with NAFLD may also be a result of poor nutritional patterns in these patients.

Numerous studies reported the association between BMI and NAFLD, which is in agreement with the present study (Yasutake et al. 2014). BMI was confirmed as the most useful predictive factor for NAFLD onset in both sexes, in a community-based longitudinal cohort study on 6403 Japanese subjects (Miyake et al. 2013). Compared to normal BMI, NAFLD risk was found to have an approximately 4.1 to 14-fold increase in the group with higher BMI (Loomis et al. 2016). Fan et al. (Fan, Wang, and Du 2018) demonstrated that higher BMI was an independent, dose-dependent risk factor for fatty liver. WC, WHR, and WHtR have been considered as alternative indices for abdominal (visceral) obesity in previous studies (Brown, Karimian Azari, and Ayala 2017; Mansour-Ghanaei et al. 2018; Tutunchi et al. 2020a). Visceral fat compared to subcutaneous fat was considered as a better predictor of hepatic steatosis and was associated with NAFLD histological severity (Mansour-Ghanaei et al. 2018; Tutunchi et al. 2019b). In line with our findings, the results of a study conducted on 250 patients with NAFLD and 240 non-NAFLD individuals demonstrated that BMI, WHR, and WHtR were significantly higher in patients with NAFLD (Zheng et al. 2012). Moreover, BMI and WHR were identified as the most important NAFLD prognostic factors (Zheng et al. 2012). In a recent cohort study conducted on 960 people in the north of Iran, a significant positive relationship was reported between anthropometric indices and NAFLD (Mansour-Ghanaei et al. 2018). Fung et al. (Fung et al. 2015) demonstrated that the relative risk of NAFLD in
subjects with higher WC was 2.99. In addition, the degree of steatosis was significantly elevated with an increase in WC (Fung et al. 2015). Although some cross-sectional studies failed to identify a direct relationship between obesity and food insecurity in adults (Gulliford, Mahabir, and Rocke 2003; Isanaka et al. 2007), most previous studies carried out in Iran and other countries reported a significant positive association between obesity and food insecurity (Najibi et al. 2019; Nikniaz et al. 2017). Prior studies have identified several potential mechanisms including physiological, behavioral, and psycho-social-cultural factors related to this association (Finney Rutten et al. 2010). The intake of low-cost and less-varied diets along with high-calorie and nutrient-poor foods coupled with lower intake of fruits and vegetables and lack of physical activity may cause excess weight and obesity. Nutrient deprivation and fluctuations in eating behavior may lead to physiological shifts toward greater energy efficiency, elevated storage of body fat, obesity, and subsequently the development of NAFLD (Finney Rutten et al. 2010; Najibi et al. 2019). In agreement with the findings of the current study, many previous studies also found a significant positive relationship between household size, number of children, having children under the age of 18, lower SES, and food insecurity (Najibi et al. 2019; Nikniaz et al. 2017; Rezazadeh et al. 2016). These socio-demographic factors may influence household food security, resulting in changes in dietary patterns and risk of NAFLD.

In the present work, NAFLD is associated with some indicators of dyslipidemia including high TG and low HDL-C levels. In agreement with the present study, a growing body of evidence has shown a close relationship between NAFLD and dyslipidemia (Chatrath, Vuppallanchi, and Chalasani 2012; Mahaling, Basavaraj, and Bika 2013; Tomizawa et al. 2014; Tutunchi et al. 2020b). In a cross-sectional study, high serum levels of TG, TC, LDL-C and VLDL-C and low serum levels of HDL-C were observed in patients with NAFLD (Mahaling, Basavaraj, and Bika 2013). In the same study, a significant relationship between TC, HDL-C, LDL-C and VLDL-C and increasing grades of NAFLD was also reported (Mahaling, Basavaraj, and Bika 2013). In line with our findings, Tomizawa et al. (2014) reported that serum concentrations of TG were significantly higher and serum levels of HDL-C were significantly lower in patients with NAFLD compared to those without NAFLD. Importantly, among markers of hyperlipidemia, TG was the strongest predictor of NAFLD. More recently, a cross-sectional study showed that TG/HDL-C ratio was associated with NAFLD in an apparently healthy population, after adjustment for confounders (Fan et al. 2019). A population-based cohort study also demonstrated that higher TG/HDL-C was an independent predictor of incident fatty liver (Fan et al. 2019). Similarly, in a cross-sectional study involving a large sample of children and adolescents, the odds ratios for NAFLD increased significantly with the increasing tertile of TG/HDL-C ratio, after adjusting for confounding factors (Pacifico et al. 2014).
Consistently, a close association between TG/HDL-C and NAFLD was discovered in our present study.

The strengths of the present study were assessing food insecurity as a risk factor for NAFLD, as well as a case–control design in which the controls were selected from the same population with similar characteristics. This study also had some limitations. The sample size was relatively small and the study population does not reflect the general population. Therefore, our results may not be generalized to other populations.

Conclusions

In conclusion, the prevalence of food insecurity in patients with NAFLD was significantly higher compared to controls. Food insecurity was an important risk factor for NAFLD, even after adjusting for potential confounders. Additionally, some indicators of dyslipidemia significantly increased the risk of NAFLD. However, prospective studies with large sample sizes are required to verify our findings.

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Disclosure statement

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

All procedures performed in this study were in accordance with the ethical standards of the Ethics Committee of Tabriz University of Medical Science. (ethics code; IR.TBZMED.REC.1397.694). Informed written consent was obtained from all participants.
Consent for publication

Not applicable.

Data availability statement

The datasets generated and/or analyzed during the current study are not publicly available due to an ethical restriction but are available from the corresponding author on reasonable request.

Authors’ contributions

HT, AO, and MSA designed research and contributed to the conception of the project, development of overall research plan, and study oversight; HT was the author of the research; MEM contributed to the final revisions of the manuscript. All authors are in agreement with the manuscript and declare that the content has not been published elsewhere.

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