

Food insecurity and lipid profile abnormalities are associated with an increased risk of non- alcoholic fatty liver disease (NAFLD): a case-control study in northwest of Iran

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Abstract

Background Non-alcoholic fatty liver disease (NAFLD) is an important public health problem and a significant cause of morbidity and mortality. Little is known about the relation between food insecurity and NAFLD. This study aimed to assess the relationship between food insecurity, risk factors associated with food insecurity, and NAFLD prevalence in a sample of Iranian adults.

Methods In this age-matched and gender-matched case–control study, 210 subjects were recruited. NAFLD diagnosis was performed by a single expert radiologist using ultrasonography. The demographic and socioeconomic characteristics, anthropometric indices, body composition, along with food insecurity and depression status were assessed. Blood samples were collected to determine the lipid profile parameters. Chi-square, independent samples t-test, and uni- and multi-variate logistic regression tests were used. Data were analysed using SPSS V.23.0.

Results The prevalence of food insecurity was 56.8% and 26.1% in cases and controls ($P < 0.001$), respectively. According to final analysis model, food insecurity, depression, number of children ≥ 4 , overweight, and obesity were identified as significant 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, respectively. Additionally, a higher waist circumference (men, OR = 2.9, $P < 0.001$; women, OR= 2.6, $P < 0.001$), an elevated waist-to-hip ratio (men, OR=2.3, $P < 0.001$; women, OR=2.7, $P < 0.001$), an increased waist-to-height ratio (OR=2.9, $P < 0.001$), and a higher body fat percentage (men, OR=3.0, $P < 0.001$; women, OR=3.3, $P < 0.001$) were independently associated with an increased risk of NAFLD. The odds of NAFLD increased by increment in serum triglyceride (TG) levels (OR=2.6, $P < 0.001$) and decreased by increase in serum high-density lipoprotein cholesterol (HDL-C) (OR=0.34, $P < 0.001$). Compared to controls, NAFLD patients were more likely to have higher TG/HDL-C ratio (OR =3.3, $P < 0.001$).

Conclusions The prevalence of food insecurity in patients with NAFLD was significantly higher compared to controls. Food insecurity was associated with an increased risk of NAFLD, even after adjusting for potential confounding factors. Additionally, NAFLD was significantly related to some indicators of dyslipidemia.

Introduction

Food insecurity, a serious public health problem, is frequent in both developed and developing countries (1, 2). 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”(3). It is estimated that more than 852 million people suffer from food insecurity in all over the world; approximately 9 million of these people are living in developed countries and rest of them are living in the developing countries (4). Food insecurity has been identified as a significant social and health problem in Iran as well (1, 2). According to recent meta-analysis, general food insecurity prevalence has been

reported by 49% among Iranian households (2). Food insecurity is strongly associated with poorer health outcomes (3, 5). 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) (6, 7). Food insecurity has also been reported to be associated with higher anxiety and depressive symptoms (5, 8). Nevertheless, there are few studies evaluating associations between food insecurity and chronic diseases such as cardiovascular disease, diabetes, and hypertension among adults (3, 6). It was well established that the status of head of household, socio-economic status (SES), educational level, race/ethnicity, family size, age, marital status, and eating habits are factors influencing food insecurity (2, 5, 9). In addition, previous studies have reported that food insecurity may be positively associated with some indicators of dyslipidemia (10). 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 non-alcoholic fatty liver disease (NAFLD) (6, 9–11). NAFLD indicating excess of fat accumulation in the liver has become a growing public health problem (12, 13). NAFLD encompasses a broad spectrum of liver disorders ranging from simple steatosis to non-alcoholic steatohepatitis (NASH), fibrosis, NASH cirrhosis, and finally NASH-related hepatocellular carcinoma (HCC) (12, 13). This clinical–pathological condition affects approximately 25–30% of adult population in both developed and developing countries (12, 13). However, NAFLD prevalence has been estimated to be more than 70% in obese individuals, and also in patients with diabetes and metabolic syndrome (13). It appears that NAFLD prevalence is lower in Asian countries in comparison with Western countries (14). However, it has recently increased along with the increase in obesity, diabetes and metabolic syndrome in this region (12, 14). NAFLD is now considered as a major chronic liver disease in Asia (14). NAFLD onset and development are closely associated with dietary habits and lifestyle (12, 13). 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 (13, 15).

According to the recent studies, the prevalence rates of food insecurity and NAFLD are increasing in Iran (2, 12, 14). Given that food insecurity and NAFLD have negative health consequences and there is no previous study evaluating associations between food insecurity and NAFLD; thus, this 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

This 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). This study was carried out at Imam Reza Hospital in Tabriz, Iran, from January to June 2019. The two study groups were matched in terms of age, sex, and residential status (Tabriz, around of Tabriz, and other cities). **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 socio-economic 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 (16). This questionnaire assessing household food security during the past 12 months has been previously validated in Iran (17). 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) (18) 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. Based on the BDI, scores ranging between 0–9 indicate minimal depression; 10–18 indicating mild depression; 19–29 indicating moderate depression; and 30–63 indicating severe depression. 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 (19). Cronbach's alpha coefficient of BDI was calculated to be 0.92 in Iranian population (19).

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).

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 $\text{BMI}=25\text{-}29.9$, and obesity was defined as $\text{BMI} \geq 30 \text{ kg}/\text{m}^2$. Gender-specific cut-offs were considered for WC, WHR, and BFP. Based on the National Cholesterol Education Program (NCEP), high WC cut-off value was considered 102 cm in men and 88 cm in women (20). In addition, high WHR cut-off value was considered ≥ 0.9 for males and ≥ 0.85 for females (21, 22). Moreover, high WHtR cut-off value was considered values more than 0.5 for both genders (22). Based on the World Health Organization (WHO) guideline, high BFP cut-off point was considered 25% for men and 35% for women (23).

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 (including walking, moderate-intensity, and vigorous-intensity activities), through a face-to-face interview. The IPAQ form calculates and reports physical activity in metabolic equivalents per minute (MET-min) per week. According to the IPAQ scoring protocol, physical activity levels were reported as three categories as low activity levels (< 600 MET-minutes/week), moderate activity levels (600 to < 1500 MET-minutes/week) and high activity levels (≥ 1500 MET-minutes/week).

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 (Mindray auto hematology 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), and also P values less than 0.05 were considered as statistically significant. 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.

Results

210 subjects (cases= 95, controls= 115) were enrolled in this study. Mean age was 48.8 (standard deviation [SD] 5.9) years old in patients with NAFLD and 47.3 (SD 6.2) years old in the controls. There were no significant differences in gender and age between the 2 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 ($P < 0.001$). 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 ($P = 0.003$). 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 ($P < 0.05$). There were no significant differences in height, employment status, marital status, and smoking status between the 2 groups ($P > 0.05$). NAFLD chance in overweight subjects was 2.9 (95% CI: 1.81-4.44) times higher. Moreover, obesity prevalence was 32.6% in cases, and 15.6% in controls and this difference was statistically significant ($P < 0.001$). 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 ($P < 0.001$). 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. 64.3% of patients with NAFLD and 31.3% of subjects without NAFLD had WHtR > 0.5 , and this difference was statistically significant ($P < 0.001$). Odds ratio for NAFLD in male participants with BFP $> 25\%$ and female subjects with 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 2 groups ($P < 0.05$, **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. In addition, a higher WC (men, OR = 2.9, $P < 0.001$; women, OR= 2.6, $P < 0.001$), an elevated WHR (men, OR = 2.3, $P < 0.001$; women, OR= 2.7, $P < 0.001$), an increased WHtR (OR = 2.9, $P < 0.001$), and a higher BFP (men, OR = 3.0, $P < 0.001$; women, OR= 3.3, $P < 0.001$) 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, $P < 0.001$) and decreased by increase in serum HDL-C (OR = 0.34, $P < 0.001$). Compared to controls, NAFLD patients were more likely to have higher TG/HDL-C ratio (OR = 3.3, $P < 0.001$) (**Table 4**).

Discussion

Although some previous studies have investigated the association between food insecurity and prevalence of chronic diseases among adults (5, 6), to the best of our knowledge, this is the first study evaluated the association between food insecurity, risk factors related to food insecurity, and NAFLD prevalence in Iran.

More recently, Golovaty et al. (24) investigated 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 (food secure 31% compared with food insecure 34%, $P = 0.21$). In the same study, in the multivariable model, food-insecure adults were more likely to have NAFLD compared with food-secure adults (24). In the present study, food insecurity prevalence 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. It is well established that NAFLD is closely associated with overweight and obesity (12, 14). Most of previous studies have reported a significant positive association between inappropriate dietary patterns and NAFLD (12, 25). Nutritional problems in patients with NAFLD include excess consumption of energy, carbohydrates, and lipids, and vitamin and mineral deficiencies (13, 25). In fact, consumption of high-energy-dense foods increases in patients with NAFLD. These foods with a higher energy density including saturated and trans fatty acids, refined grains, and foods with added sugars, tend to have poor nutritional quality (25). On the other hand, previous investigations have also reported a positive association between food insecurity and obesity (5, 22). 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 (3, 6). Accordingly, these inappropriate eating habits in NAFLD patients may contribute to incidence of high food insecurity in these patients.

Patients with NAFLD experience symptoms such as fatigue, anxiety along with depression (26). These symptoms significantly affect patients' well-being and health-related quality of life. 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. Also, numerous population-based studies have reported high prevalence of depression in patients with NAFLD, which is in agreement with this study. Le Strat et al. (26) reported occurrence of 12-month major depression in participants with a liver disease (17.2%), which was significantly higher compared to participants without liver disease (7.0%; Adjusted OR:2.2; CI: 1.2–4.1), after adjusting for a number of socio-demographical, medical and behavioral factors. In addition, a case-control study by Elwing et al. (27) suggested that subjects with NASH showed 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 (27). Youssef et al. (28) studied the relationship between depression and severity of histological features in 567 patients with NAFLD. Subclinical and clinical depression was reported in 53% and 14% of patients with NAFLD, respectively (28). 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 (28). Depressive mood influences self-care practices inversely, and thereby elevating risk of long-term complications (29). Some previous studies have indicated the association between dietary patterns and depression (30). 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 after adjusting for non-depression drug use, job, marital status, the number of children, and BMI (30). Additionally, a recent study conducted in Korean adults demonstrated that a healthy dietary pattern rich in vegetables, soybeans, mushroom, white fish, shellfish, and fruits was associated with low depression risk. Whereas an unhealthy dietary pattern rich in white rice, meats, noodles, bread, and coffee increased the risk of depression after controlling for various social, health, and dietary confounders (31). Moreover, observational studies have found an inverse association between adherence to a Mediterranean diet and depression risk (32). Therefore, high prevalence of depression in patients with NAFLD may also be a result of poor nutritional patterns in these patients.

Results of the present study indicated that the prevalence of overweight and obesity was statistically higher in cases in comparison with the controls. Furthermore, patients with NAFLD had significantly higher WC, WHR, WHtR, and BFP compared to those in the control group. Numerous studies reported the association between BMI and NAFLD, which is in agreement with the present study (25). 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 (33). Additionally, cumulative onset rate of NAFLD was significantly higher in the group with high BMI in comparison with the group with low BMI in both sexes (33). Compared to normal BMI, NAFLD risk was found to have an approximately 4.1 to 14-fold increase in the group with higher BMI (34). Moreover, Fan et al. (15) demonstrated that higher BMI (overweight/obesity) was an independent, dose-dependent risk factor for fatty liver.

NAFLD prevalence is associated not only with higher BMI, but also is strongly related to central fat deposition (35). WC, WHR and WHtR have been considered as alternative indices for abdominal (visceral) obesity in previous studies (35, 36). Abdominal obesity is closely associated with development of metabolic diseases and adverse health outcomes. Measures of body fat distribution, such as WC, WHR, and WHtR have been indicated to be better predictors of morbidity and all-cause mortality compared to overall adiposity (35, 37). Visceral fat compared to subcutaneous fat was considered as better predictor of hepatic steatosis and was associated with NAFLD histological severity (13, 35). In line with our findings, 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 (38). Moreover, BMI and WHR were identified as the most important NAFLD prognostic factors (38). Findings of our study were also in agreement with another study on 164 cases with NAFLD and 164 controls without NAFLD, which indicated that patients with NAFLD were significantly more likely to be overweight, have abdominal obesity, and a significantly higher body fat content (39). In a recent cohort study conducted on 960 people in north of Iran, a significant positive relationship was reported between anthropometric indices (BMI, WC, WHR, and WHtR) and NAFLD (35). Fung et al. (40) demonstrated that relative risk of NAFLD in subjects with high WC was 2.99. In addition, degree of steatosis significantly elevated with the increase in the WC (40). As mentioned above, an association between overweight, obesity, food insecurity has been

reported in previous studies (7, 22). Therefore, both general and abdominal obesity may also indirectly increase the risk of NAFLD. Although some cross-sectional studies failed to identify a direct relationship between obesity and food insecurity in adults (41, 42), most previous studies carried out in Iran and other countries have reported a significant positive association between obesity and food insecurity (5, 22). Prior studies have identified several potential mechanisms including physiological, behavioral, and psycho-social-cultural factors related to this association (43). Generally, behavioral mechanisms resulting in poor dietary quality and physical inactivity are most important factors contributing to the increase in the prevalence of obesity (22, 43). 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 towards greater energy efficiency, elevated storage of body fat, obesity, and subsequently development of NAFLD (5, 43). In addition, depression related to food insecurity and its subsequent effect on eating behavior is another possible factor influencing relationship between food insecurity, obesity and associated metabolic disorders like NAFLD.

Our findings indicated that patients with NAFLD had lower physical activity levels in comparison with the controls. In agreement with our result, previous studies have demonstrated that individuals with less physical activity are more likely to be affected with NAFLD (44). Increased physical activity decreases hepatic fat content and improves insulin resistance. Improved insulin resistance decreases excess delivery of free fatty acids and glucose for free fatty acid synthesis to the liver. Besides, exercise enhances fatty acid oxidation, reduces fatty acid synthesis, and prevents mitochondrial and hepatocellular damage, in the liver (44).

In the present study, patients with NAFLD had lower SES. In addition, family size, number of children, and children with the ages less than 18 years old were significantly higher in patients with NAFLD in comparison with the controls. In agreement with our findings, many previous studies have found a significant positive relationship between household size, number of children, having children with the ages under 18 years old, lower SES and food insecurity (5, 22, 45). These socio-demographic factors may influence household food security, resulting in changes in dietary patterns and risk of NAFLD. Several studies have demonstrated that NAFLD is more prevalent among men and elderly people (46). Gender distribution was similar between two groups of the present study. Moreover, there was no significant difference in age of the study participants.

In the present work, NAFLD 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 (47–49). 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 (48). In the same study, a significant relationship between TC, HDL-C, LDL-C and VLDL-C and increasing grades of NAFLD was also reported (48). In line with our findings, Tomizawa et al (47) reported that serum concentrations of TG was significantly higher and serum levels of HDL-C was significantly lower in patients with NAFLD compared to those without NAFLD. Importantly, among markers of hyperlipidemia,

TG was the strongest predictor of NAFLD ($\chi^2 = 9.89$, $P = 0.0017$). More recently, a cross-sectional study showed that TG/HDL-C ratio was associated with NAFLD in an apparently healthy population, after adjustment for confounding factors (50). A population-based cohort study also demonstrated that higher TG/HDL-C was an independent predictor of incident fatty liver (50). 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 (51). Consistently, a close association between TG/HDL-C and NAFLD was found in our present study.

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 had also some limitations. Sample size was relatively small and the study population did not reflect general population, therefore our results may not be generalized to other populations.

Conclusions

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. Future strategies should also assess whether healthy eating habits will decrease the growing burden of NAFLD among at-risk adults.

Abbreviations

BDI = Beck Depression Inventory, BFP = Body Fat Percentage, BMI = Body Mass Index, HC= Hip Circumference, HCC = Hepatocellular Carcinoma, IPAQ-SF = International Physical Activity Questionnaire-Short Form, MDD = Major Depressive Disorder, NAFLD = Non-Alcoholic Fatty Liver Disease; NASH = Non-Alcoholic Steatohepatitis, NCEP = National Cholesterol Education Program; OR = Odds Ratio, SES = Socio-economic Status, WC = Waist Circumference, WHO = World Health Organization, WHR = Waist-to-Hip Ratio, WHtR = Waist-to-Height Ratio.

Declarations

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.

Availability of data and material

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.

Competing interests

The authors declare that they have no competing interests.

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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; MAJ was the statistic counsellor; AO and MSA contributed to the final revisions of the manuscript. All approved the final version of this manuscript.

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References

1. Dastgiri S, Tutunchi H, Ostadrahimi A, Mahboob S: Sensitivity and specificity of a short questionnaire for food insecurity surveillance in Iran. *Food Nutr Bull* 28(1):55-8, 2007.
2. Behzadifar M, Behzadifar M, Abdi S, Malekzadeh R, Arab Salmani M, Ghoreishinia G, Falahi E, Mirzaei M, Shams Biranvand N, Sayehmiri K: Prevalence of Food Insecurity in Iran: A Systematic Review and Meta-analysis. *Arch Iran Med* 19(4):288-94, 2016.
3. Vozoris NT, Tarasuk VS: Household food insufficiency is associated with poorer health. *J Nutr* 133(1):120-6, 2003.
4. Cook JT, Frank DA: Food security, poverty, and human development in the United States. *Ann N Y Acad Sci* 1136:193-209, 2008.

5. Najibi N, Firoozi R, Shahrezaee S, Eshraghian M, Daneshi-Maskooni M, Dorosty-Motlagh A: Food insecurity is an important risk factor for type 2 diabetes: a case-control study of new referrals to the University clinics, Shiraz, Southern Iran. *BMC public health* 19(1):885, 2019.
6. Seligman HK, Laraia BA, Kushel MB: Food insecurity is associated with chronic disease among low-income NHANES participants. *J Nutr* 140(2):304-310, 2010.
7. Yang TC, Sahota P, Pickett KE, Bryant M: Association of food security status with overweight and dietary intake: exploration of White British and Pakistani-origin families in the Born in Bradford cohort. *Nutr J* 17(1):48, 2018.
8. Leung CW, Epel ES, Willett WC, Rimm EB, Laraia BA: Household food insecurity is positively associated with depression among low-income supplemental nutrition assistance program participants and income-eligible nonparticipants. *J Nutr* 145(3):622-727, 2015.
9. Mello JA, Gans KM, Risica PM, Kirtania U, Strolla LO, Fournier L: How is food insecurity associated with dietary behaviors? An analysis with low-income, ethnically diverse participants in a nutrition intervention study. *J Am Diet Assoc* 110(12):1906-1911, 2010.
10. Tayie FA, Zizza CA: Food insecurity and dyslipidemia among adults in the United States. *Prev Med* 48(5):480-485, 2009.
11. Kendall A, Olson CM, Frongillo EA, Jr: Relationship of hunger and food insecurity to food availability and consumption. *J Am Diet Assoc* 96(10):1019-1024, 1996
12. Amirkalali B, Poustchi H, Keyvani H, Khansari MR, Ajdarkosh H, Maadi M, Sohrabi MR, Zamani F: Prevalence of Non-Alcoholic Fatty Liver Disease and Its Predictors in North of Iran. *Iran J Public Health* 43(9):1275-1283, 2014.
13. Tutunchi H, Ostadrahimi A, Saghafi-Asl M, Maleki V: The effects of oleoylethanolamide, an endogenous PPAR-alpha agonist, on risk factors for NAFLD: A systematic review. *Obes Rev* 20(7):1057-1069, 2019.
14. Fan JG, Kim SU, Wong VW: New trends on obesity and NAFLD in Asia. *J Hepatol* 67(4):862-873, 2017.
15. Fan R, Wang J, Du J: Association between body mass index and fatty liver risk: A dose-response analysis. *Sci Rep* 8(1):15273, 2018.
16. Rafiei M, Nord M, Sadeghizadeh A, Entezari MH: Assessing the internal validity of a household survey-based food security measure adapted for use in Iran. *Nutr J* 8:28, 2009.
17. Mohammadzadeh A, Dorosty A, Eshraghian M: Household food security status and associated factors among high-school students in Esfahan, Iran. *Public Health Nutr* 13(10):1609-1613, 2010.

18. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J: An inventory for measuring depression. *Arch Gen Psychiatry* 4:561-571, 1961.
19. Hossein Kaviani H, Mousavi AS: Psychometric properties of the Persian version of Beck Anxiety Inventory (BAI). *TUMS* 66(2):136-140, 2008.
20. 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. *Circulation* 106(25):3143-421, 2002.
21. Kramer JR, Fischbach LA, Richardson P, Alsarraj A, Fitzgerald S, Shaib Y, Abraham NS, Velez M, Cole R, Anand B, Verstovsek G, Rugge M, Parente P, Graham DY, El-Serag HB: Waist-to-hip ratio, but not body mass index, is associated with an increased risk of Barrett's esophagus in white men. *Clin Gastroenterol Hepatol* 11(4):373-381, 2013.
22. Nikniaz L, Tabrizi JS, Sadeghi-Bazargani H, Farahbakhsh M, Nikniaz Z: Food insecurity increases the odds of obesity among Iranian women: A population-based study of northwestern Iran. *Nutr Diet* 74(5):454-459, 2017.
23. Ho-Pham LT, Campbell LV, Nguyen TV: More on body fat cutoff points. *Mayo Clin Proc* 86(6):584-585, 2011.
24. Golovaty I, Tien PC, Price JC, Sheira L, Seligman H, Weiser SD: Food Insecurity May Be an Independent Risk Factor Associated with Nonalcoholic Fatty Liver Disease among Low-Income Adults in the United States. *J Nutr* 2019. doi: 10.1093/jn/nxz212.
25. Yasutake K, Kohjima M, Kotoh K, Nakashima M, Nakamura M, Enjoji M: Dietary habits and behaviors associated with nonalcoholic fatty liver disease. *World J Gastroenterol* 20(7):1756-1767, 2014.
26. Le Strat Y, Le Foll B, Dubertret C: Major depression and suicide attempts in patients with liver disease in the United States. *Liver Int* 35(7):1910-1916, 2015.
27. Elwing JE, Lustman PJ, Wang HL, Clouse RE: Depression, anxiety, and nonalcoholic steatohepatitis. *Psychosom Med* 68(4):563-569, 2006.
28. Youssef NA, Abdelmalek MF, Binks M, Guy CD, Omenetti A, Smith AD, Diehl AM, Suzuki A. Associations of depression, anxiety and antidepressants with histological severity of nonalcoholic fatty liver disease. *Liver Int* 33(7):1062-1070, 2013.
29. Goudarzian AH, Bagheri Nesami M, Zamani F, Nasiri A, Beik S: Relationship between Depression and Self-care in Iranian Patients with Cancer. *Asian Pac J Cancer Prev* 18(1):101-106, 2017.
30. Khosravi M, Sotoudeh G, Majdzadeh R, Nejati S, Darabi S, Raisi F, Esmailzadeh A, Sorayani M. Healthy and Unhealthy Dietary Patterns Are Related to Depression: A Case-Control Study. *Psychiatry*

Investig 12(4):434-442, 2015.

31. Park S-J, Kim M-S, Lee H-J: The association between dietary pattern and depression in middle-aged Korean adults. *Nutr Res Pract* 13(4):316-322, 2019.
32. Shafiei F, Salari-Moghaddam A, Larijani B, Esmailzadeh A: Adherence to the Mediterranean diet and risk of depression: a systematic review and updated meta-analysis of observational studies. *Nutr Rev* 77(4):230-239, 2019.
33. Miyake T, Kumagi T, Hirooka M, Furukawa S, Koizumi M, Tokumoto Y, Ueda T, Yamamoto S, Abe M, Kitai K, Hiasa Y, Matsuura B, Onji M. Body mass index is the most useful predictive factor for the onset of nonalcoholic fatty liver disease: a community-based retrospective longitudinal cohort study. *J Gastroenterol* 48(3):413-422, 2013.
34. Loomis AK, Kabadi S, Preiss D, Hyde C, Bonato V, St Louis M, Desai J, Gill JM, Welsh P, Waterworth D, Sattar N. Body Mass Index and Risk of Nonalcoholic Fatty Liver Disease: Two Electronic Health Record Prospective Studies. *J Clin Endocrinol Metab* 101(3):945-952, 2016.
35. Mansour-Ghanaei R, Mansour-Ghanaei F, Naghipour M, Joukar F, Atrkar-Roushan Z, Tabatabaie M, Ghorani N. The role of anthropometric indices in the prediction of non-alcoholic fatty liver disease in the PERSIAN Guilan Cohort study (PGCS). *J Med Life* 11(3):194-202, 2018.
36. Tutunchi H, Asghari Jafarabadi M, Farrin N, Tabrizi S, Payahoo L, Ostadrahimi A: General and abdominal obesity is related to socioeconomic status and food choices: a cross-sectional study. *Nutrition & Food Science*. Ahead-of-print(ahead-of-print), doi: [10.1108/NFS-02-2019-0056](https://doi.org/10.1108/NFS-02-2019-0056) , 2019.
37. Tran NTT, Blizzard CL, Luong KN, Truong NLV, Tran BQ, Otahal P, Nelson M, Magnussen C, Gall S, Bui TV, Srikanth V, Au TB, Ha ST, Phung HN, Tran MH, Callisaya M: The importance of waist circumference and body mass index in cross-sectional relationships with risk of cardiovascular disease in Vietnam. *PLoS One* 13(5):e0198202, 2018.
38. Zheng RD, Chen ZR, Chen JN, Lu YH, Chen J: Role of Body Mass Index, Waist-to-Height and Waist-to-Hip Ratio in Prediction of Nonalcoholic Fatty Liver Disease. *Gastroenterol Res Pract* 2012:362147, 2012.
39. Das K, Das K, Mukherjee PS, Ghosh A, Ghosh S, Mridha AR, Dhibar T, Bhattacharya B, Bhattacharya D, Manna B, Dhali GK, Santra A, Chowdhury A: Nonobese population in a developing country has a high prevalence of nonalcoholic fatty liver and significant liver disease. *Hepatology* 51(5):1593-602, 2010.
40. Fung J, Lee CK, Chan M, Seto WK, Lai CL, Yuen MF: High prevalence of non-alcoholic fatty liver disease in the Chinese - results from the Hong Kong liver health census. *Liver Int* 35(2):542-549, 2015.

41. Isanaka S, Mora-Plazas M, Lopez-Arana S, Baylin A, Villamor E: Food insecurity is highly prevalent and predicts underweight but not overweight in adults and school children from Bogota, Colombia. *J Nutr* 137(12):2747-2755, 2007.
42. Gulliford MC, Mahabir D, Rocke B: Food insecurity, food choices, and body mass index in adults: nutrition transition in Trinidad and Tobago. *Int J Epidemiol* 32(4):508-516, 2003.
43. Finney Rutten LJ, Yaroch AL, Colón-Ramos U, Johnson-Askew W, Story M: Poverty, Food Insecurity, and Obesity: A Conceptual Framework for Research, Practice, and Policy. *J Hunger Environ Nutr* 5(4):403-415, 2010.
44. van der Windt DJ, Sud V, Zhang H, Tsung A, Huang H: The Effects of Physical Exercise on Fatty Liver Disease. *Gene Expr* 18(2):89-101, 2018.
45. Rezazadeh A, Omidvar N, Eini-Zinab H, Ghazi-Tabatabaie M, Majdzadeh R, Ghavamzadeh S, Nouri-Saeidlou S: Food insecurity, socio-economic factors and weight status in two Iranian ethnic groups. *Ethn Health* 21(3):233-250, 2016.
46. Gan L, Chitturi S, Farrell GC: Mechanisms and implications of age-related changes in the liver: nonalcoholic Fatty liver disease in the elderly. *Curr Gerontol Geriatr Res* 2011:831536, 2011.
47. Tomizawa M, Kawanabe Y, Shinozaki F, Sato S, Motoyoshi Y, Sugiyama T, Yamamoto S, Sueishi M: Triglyceride is strongly associated with nonalcoholic fatty liver disease among markers of hyperlipidemia and diabetes. *Biomed Rep* 2(5):633-636, 2014.
48. Mahaling DU, Basavaraj MM, Bika AJ: Comparison of lipid profile in different grades of non-alcoholic fatty liver disease diagnosed on ultrasound. *Asian Pac J Trop Biomed* 3(11):907-912, 2013.
49. Chatrath H, Vuppalanchi R, Chalasani N: Dyslipidemia in patients with nonalcoholic fatty liver disease. *Semin Liver Dis* 32(1):22-29, 2012.
50. Fan N, Peng L, Xia Z, Zhang L, Song Z, Wang Y, Peng Y: Triglycerides to high-density lipoprotein cholesterol ratio as a surrogate for nonalcoholic fatty liver disease: a cross-sectional study. *Lipids Health Dis* 18(1):39, 2019.
51. Pacifico L, Bonci E, Andreoli G, Romaggioli S, Di Miscio R, Lombardo CV, Chiesa C. Association of serum triglyceride-to-HDL cholesterol ratio with carotid artery intima-media thickness, insulin resistance and nonalcoholic fatty liver disease in children and adolescents. *Nutr Metab Cardiovasc Dis* 24(7):737-743, 2014.

Tables

Table 1: The household food security status based on the food security questionnaire final score

Food security status	Code	Number of positive answer	
		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 (Bickel et al, 2000)

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)	
	Low		67 (70.5)	63 (54.7)	2.9 (1.93-4.21)	< 0.001 *
Smoking status	Non-smoker		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 & higher		17 (17.9)	31 (26.9)	1	
	Diploma & 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)	< 0.001 *
Economic status	Rich	≥7 living items	11 (11.5)	24 (20.9)	1	
	Average	4-6 living items	36 (37.9)	61 (53.1)	2.1 (1.67-2.45)	
	Poor	≤3 living items	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	

Variables		Cases (n=95)	Controls (n=115)	OR (95% CI)	P- value	
Number (%)						
	<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	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/m ²)	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	Men	11 (26.9)	32 (57.1)	1	
	>102		30 (73.1)	24 (42.9)	3.1 (2.12- 5.76)	< 0.001 *
	≤88	Women	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	Men	16 (39)	34 (60.8)	1	
	≥0.9		25 (61)	22 (39.2)	2.5 (1.92- 3.91)	< 0.001 *
	<0.85	Women	26 (48.1)	31 (52.6)	1	
	≥0.85		28 (68.2)	28 (47.4)	2.7 (1.69- 3.31)	< 0.001 *

Variables		Cases (n=95)	Controls (n=115)	OR (95% CI)	P- value	
Number (%)						
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	Men	12 (29.3)	33(58.9)	1	
	>25		29 (70.7)	23(41.1)	3.3 (2.33-5.88)	< 0.001 *
	≤35	Women	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 *	
Mean (SD)						
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/m ²)		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 ‡	

Variables	Cases (n=95)	Controls (n=115)	OR (95% CI)	P- value
	Number (%)			
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 ($p < 0.05$)

Table 3: Odds ratio (OR) and 95% confidence intervals (CI) of variables describing the important risk factors for NAFLD

Factors		OR (95% CI)	P-value
Food security	Food secure	1	0.006*
	Food insecure	2.2 (1.12-3.43)	
Depression	Non-depressed	1	0.023*
	Depressed	1.9 (1.02-3.62)	
Number of children	<4	1	0.003*
	≥4	2.1 (1.02-3.3.98)	
BMI (Kg/m ²)	18-24.9	1	< 0.001*
	25-25.9	2.6 (1.81-3.92)	
	≥30	2.9 (2.02- 5.34)	
WC (cm)	≤102 (Men)	1	< 0.001*
	>102	2.9 (1.13-5.68)	
	≤88 (Women)	1	< 0.001*
	> 88	2.6 (1.11-4.12)	
WHR	<0.9 (Men)	1	< 0.001*
	≥0.9	2.3 (1.01-4.44)	
	<0.85 (Women)	1	< 0.001*
	≥0.85	2.7 (1.16-5.12)	
WHtR	≤0.5	1	< 0.001*
	>0.5	2.9 (1.69-5.89)	
BFP	≤25 (Men)	1	< 0.001*
	>25	3.0 (1.11-4.67)	
	≤35 (Women)	1	< 0.001*
	>35	3.3 (2.21-5.78)	

* Multivariate logistic regression.

BFP, Body fat percentage, CI, confidence interval, OR, odds ratio, WC, waist circumference, WHR, waist-to-hip ratio, WHtR, waist-to-height ratio.

Statistically significant (p < 0.05).

Table 4: Lipid profile characteristics in NAFLD and Non-NAFLD participants

Variables	NAFLD (n=95)	Non-NAFLD (n=115)	OR (95% CI)	P-value
TC (mg/dl) ¶	197.6 (37.3)	193 (34.6)	1.0 (0.99-1.03)	0.24 ‡
TG (mg/dl) †	195 (161-243)	111 (92-149)	2.6 (1.71-3.98)	<0.001 §
LDL-C (mg/dl) ¶	126.9 (21.7)	122.7 (27.4)	1.0 (0.98-1.01)	0.71‡
HDL-C (mg/dl) ¶	38.8 (5.4)	47.9 (9.4)	0.34 (0.20- 0.54)	<0.001 ‡
LDL-C/HDL-C ratio ¶	2.41 (0.69)	2.38 (0.71)	1.0 (0.99-1.01)	0.34 ‡
TC/HDL-C ratio¶	4.61(1.03)	4.57 (0.98)	1.0 (0.99-1.03)	0.22 ‡
TG/HDL-C ratio¶	3.62 (0.87)	3.11 (0.67)	3.3 (1.91-5.82)	<0.001 ‡

†Variables with non-normal numeric scales are reported as median (25th, 75th).

‡Independent samples t-test.

§Mann- Whitney U test.

¶Variables with normal numeric scales are reported as mean (SD).

HDL-C, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglycerides.

Statistically significant ($p < 0.05$).

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