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Dietary Determinants of Non-Alcoholic Fatty Liver Disease in Lean and Non-Lean Adult Patients: A Population-Based Study in Shiraz, Southern Iran

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Abstract

Background: Dietary components predisposing to non-alcoholic fatty liver disease (NAFLD) have been conflicting to date. This study aimed to compare macro and micronutrients and food intake among non-lean and lean patients with NAFLD.

Methods: Adult people older than 18 years from seven postal districts of Shiraz, Iran, were selected using multistage cluster randomized sampling. Nutrition status was queried by a standard food frequency questionnaire and NAFLD was detected by sonography. The participants were divided into four groups: non lean-NAFLD (participants with NAFLD and BMI $\geq$ 25 kg/m^2), lean-NAFLD (participants with NAFLD, BMI $<$ 25 kg/m^2), Non lean-Non NAFLD (BMI $\geq$ 25 kg/m^2 without NAFLD), lean-non NAFLD (BMI $<$ 25 kg/m^2 without NAFLD).

Results: Of 478 participants, 204 (42.7%) were lean and 95 (19.9%) were diagnosed with NAFLD. The median age of interviewees was 42 years and male to female ratio was 0.7. Overall, starchy foods and potato intake was significantly different between the groups. In non-lean group, potato intake was higher among NAFLD compared to non-NAFLD (P = 0.02) individuals and in lean group, total starchy food intake was higher in those with NAFLD compared to the counterpart group (P = 0.02). Our study revealed that after adjusting for confounders, for each gram increase in carbohydrate intake, the chance of NAFLD increased by 1.99 times (95% CI: 1.982 - 1.997; P = 0.004). Also, for each gram increase in potato consumption, the risk of the disease increased by more than 2.5-fold (OR = 2.584; 95% CI: 1.281 - 5.213, P = 0.008). Moreover, NAFLD had an association with the intake of fat and the intake of polyunsaturated fatty acids (P = 0.01 and P = 0.02, respectively).

Conclusions: Besides studying NAFLD in obese patients, lean NAFLD patients should not be neglected and more studies should be conducted to assess their dietary intake. It seems greater attention should be given to fat and starches than before in order to prevent the rising trend of NAFLD in population.

Keywords: NAFLD, Leanness, Obesity, Body Mass Index, Nutrients

1. Background

Nonalcoholic fatty liver disease (NAFLD) has become a global health concern (1). It refers to the increased fat in the liver parenchyma while the patient does not consume significant amount of alcohol (2). It ranges from simple steatosis to non-alcoholic steatohepatitis (NASH), which can lead to cirrhosis and hepatocellular carcinoma (3). Worldwide prevalence of NAFLD is between 10% - 30% (4). In Iran, the prevalence of NAFLD and NASH is between 2.9% to 7.1% amongst general population, but Lankarani et al. showed higher prevalence in Shiraz, southern Iran (21.5%) (5). There is a strong association between NAFLD and chronic conditions such as obesity, type 2 diabetes mellitus (T2DM), hypertension, dyslipidemia, and metabolic syndrome, resulted in increasing incidence of these diseases that has made NAFLD a major health problem worldwide (3).

New evidence points to the fact that the pathophysiology of NAFLD can be affected by diet and nutrients. Understanding the impact of dietary nutrients is important in finding treatments for NAFLD and the related metabolic conditions. In general, high caloric diet, high saturated fatty acid (SFA) and cholesterol, and soft drinks may increase the fat accumulation in liver leading to progression into NASH (3). Caloric intake reduction, increase of soy protein and whey consumption, mono-unsaturated fatty acid (MUFA) supplements, omega-3 fatty acids, and probiotics are effective in prevention and treatment (3). However to date, research focusing on specific dietary components related to NAFLD produced conflicting results (6). Most evidence shows that obesity is one of the main risk factors of NAFLD, but it has been established that it can also occur in lean subjects (7). Although lean patients have less

metabolic disturbance compared to overweight or obese patients, nevertheless, NAFLD should not be neglected in normal weight and lean subjects (8). To the best of our knowledge, a few studies have been conducted to compare nutritional determinants in lean versus non-lean people with NAFLD in the world as well as in Iran. This study aimed to compare food items and macro and micronutrients intake between these two groups.

2. Methods

2.1. Study Population

This was a cross-sectional study performed in Shiraz, the major metropolitan region in southern Iran. 542 subjects were randomly selected from general population. The sample size of this study was calculated considering 95% confidence interval, 95% precision (α = 0.05), 20% estimated prevalence of NAFLD, design effect of 2, and 10% drop out rate. Proportional randomized cluster sampling was used based on postal codes. A letter was posted randomly to the postal codes of all 7 municipality districts. Those who agreed to take part in the study were asked to call back and give a list of family members to the research team. Then, an occupant older than 18 years was randomly selected and invited to come to the predetermined setting in the clinic to be interviewed face to face by trained university affiliated clinic interviewers. Demographic and nutritional information were asked in the interviews. Moreover, physical examination by a medical doctor and liver sonography by an expert sonographer were performed. Pregnant women or those who had childbirth within the past six months were excluded. Patients with diabetes, alcoholic consumers, and those with non-Iranian nationality were also excluded. Definition of lean and non-lean NAFALD was according to Vos et al. study (9). Participants were divided into four groups: non-lean NAFLD (participants with NAFLD and BMI > 25 kg/m^2), lean NAFLD (participants with NAFLD, BMI < 25 kg/m^2), non-lean/non-NAFLD (BMI > 25 kg/m^2 without NAFLD), lean non-NAFLD (BMI < 25 kg/m^2 without NAFLD).

2.2. Measurements

NAFLD was detected by abdominal ultrasonography that revealed increasing echogenicity of liver parenchyma but decreasing echogenicity of portal vein or diaphragm (5, 10).

Micro and macro nutrient intake was assessed using a validated food frequency questionnaire (FFQ) (11) by the modified nutritionist IV program for Persian food. The height of participants was measured using a tape measure to the nearest 0.1 cm, while standing without shoes, with the back against the wall, feet together, and the head, shoulders, and hips touching the wall. Their weight was measured while wearing light clothing using a Seca balance scale, with a measurement accuracy of 0.1 kg. Body mass index (BMI) was calculated as weight/height^2 (kg/m^2).

2.3. Statistical Analysis

Analyses were done using SPSS statistical software (v. 20). The data were expressed as mean $\pm$ SD and median. For variables which had normal distribution, one-way ANOVA with Turkey's post-hoc and for other variables Kruskal-Wallis test was used to compare the four groups. Mann-Whitney U test with Bonferroni correction was used as post hoc comparisons in nan-parametric analyses. Logistic regression was used to determine the relationship between food variables and NAFLD. Analyses were adjusted for age, sex (male, female), BMI, marital status (single, married), and energy intake (Kcal). Collinearity among variables was assessed using variance inflation factor (VIF). P values less than 0.05 were considered significant.

2.4. Ethics

The research project was approved by institutional review board (IRB) and the research ethics committee of health policy research center affiliated to Shiraz University of Medical Sciences (Registration number of the ethics committee: 95.01.62.11501). All participants gave their permission by signing a written informed consent.

3. Results

Out of 542 invited persons, 478 participated (participation rate of 88%) among whom, 95 (19.8%) were diagnosed with NAFLD. The median age of participants was 42 years, and male to female ratio was about 0.7. 172 (40.6%) were employed and 298 (67.4%) had diploma or higher education. Characteristics of participants are shown in Table 1. Out of all subjects, 274 (57.3%) were overweight or obese, and 204 subjects (42.7%) had BMI less than 25. Marital status (OR: 3.26; 95% CI: 1.37 - 7.75; P = 0.008), gender (OR: 1.96; 95% CI: 1.25 - 3.08; P = 0.004), BMI (OR: 1.22; 95% CI: 1.15 - 1.29; P < 0.001), and age (OR: 1.05; 95% CI: 1.03 - 1.07; P < 0.001) were associated with NAFLD. However, no association was observed between NAFLD and education, employment status, or smoking. Table 2 shows the demographic and anthropometric characteristics of participants based on BMI and NAFLD.

With regard to nutrients and food items, no significant difference was observed between four study groups, except for starchy foods and potato intakes (Table 3). Association

Table 1. Demographic and Anthropometric Characteristics of Participants (n = 478) in the study of Macro and Micronutrients Determinants in Non-Alcoholic Fatty Liver Disease Among Lean and Non-Lean Adult Patients in Shiraz, Iran[a]

Characteristics	Amount/Frequency
Demographic Characteristics	
Age, y	
Median	42
1st quartile	31
3rd quartile	51
Gender	
Male	203 (42.5)
Female	275 (57.5)
Education	
Illiterate	35 (7.9)
Less than diploma	109 (24.7)
Diploma and bachelor	256 (57.9)
Master and Doctoral	42 (9.5)
Marital status	
Married	403 (84.3)
Single	75 (15.7)
Employment status	
Employed	172 (40.6)
Self-employed	60 (14.1)
Housekeeper	164 (38.7)
University Student	24 (5.7)
Unemployed	4 (0.9)
Anthropometric characteristics	
BMI	
< 25	204 (42.7)
≥ 25	274 (57.3)

Abbreviations: BMI, body mass index; NAFLD, Non-alcoholic fatty liver disease.
[a]Values are expressed as No. (%).

of macronutrient, micronutrient (such as vitamins, minerals, and fatty acids), and food items with NAFLD was measured by simple and multi logistic regression. It was shown that the association between fat intake and NAFLD was statistically significant (P = 0.014, OR = 1.023, CI 95% 1.005 - 1.041). Also, there was an association between PUFA intake and NAFLD (OR: 1.06; 95% CI 1.008 - 1.120; P = 0.02) and it was higher in lean-NAFLD group. But no significant association was detected between other macro and micronutrients and fatty liver in this study.

Moreover our study revealed that for each gram of carbohydrate intake, the chance of NAFLD increases by 1.99 times (OR = 1.99, CI 95% 1.982 - 1.997, P = 0.004) (Table 4).

The association between food items and NAFLD was assessed, with and without adjustment for confounders such as age, sex, BMI, marital status, and energy intake, but no significant relationship was observed with intake of food items. Only potato intake was related to NAFLD (OR = 2.5; 95% CI 1.281 - 5.213; P = 0.008). With each gram increase in potato consumption, the risk of NAFLD increased by 2.5-fold (Table 4).

4. Discussion

Based on literature, since there is a strong association between NAFLD and obesity, type 2 diabetes mellitus (T2DM), hypertension, dyslipidemia, metabolic syndrome, and increasing incidence of non-communicable diseases worldwide, NAFLD has become a new challenge for public health (3). The prevalence of NAFLD is reported between 10 and 30% all over the world (4), and a systematic review estimated NAFLD to be 15% - 20% in Asia (12). The prevalence of NAFLD was 43.8% in a study in the north of Iran (13), and 15.3% in another study in the south of Iran (14). In this study, 95 (19.9%) of participants were diagnosed with NAFLD among whom, 13 (2.7%) were lean and 82 (17.2%) had BMI ≥ 25. Overall, starchy foods and potato intake were significantly different between the groups. In non-lean group, potato intake was higher among NAFLD compared to non-NAFLD and in lean group, total starchy foods intake was higher in those with NAFLD compared to the counterpart group. The study showed that the chance of NAFLD would increase by an increase in carbohydrate, potato, and fat intake.

According to our results, sex, age, marital status, and BMI were associated with NAFLD. In previous studies, gender (13, 15-18), age (16, 18, 19), and weight or BMI (15, 16, 19) were associated with NAFLD. However, some studies have shown that there are no gender differences in the development of fatty liver (19).

Some studies have investigated nutritional risk factors in NAFLD. In our study, there was a significant relationship between intake of fat and carbohydrate and incidence of NAFLD. However, the sources of fat such as vegetable oil, meats, dairy, and fast-foods were not significantly associated with NAFLD although total fat diet showed a significant relationship with the disease. Polyunsaturated fatty acids were also significantly associated with NAFLD (P = 0.02) but there was no significant association between saturated fatty acids, monounsaturated, cholesterol, and omega-3 fatty acids, and NAFLD in this study.

Western diets through increasing fat intake have been associated with the incidence of NAFLD and its severity. Increased intake of SFA and less consumption of PUFA, espe-

Table 2. Demographic and Anthropometric Characteristics of Participants (n = 478) in the Study Based on BMI and NAFLD[a]

Item	Lean-Non NAFLD (n = 191)	Lean-NAFLD (n = 13)	Non Lean-Non NAFLD (n = 192)	Non lean-NAFLD (n = 82)
Demographic Characteristics				
Age, y				
Median	34	50	42	50
1st quartile	27	37	33	43
3rd quartile	44	67	52	55
Gender				
Male	99 (51.8)	4 (30.8)	134 (69.8)	38 (46.3)
Female	92 (48.2)	9 (69.2)	58 (30.2)	44 (53.7)
Education				
Illiterate	19 (11.0)	3 (23.1)	6 (3.5)	7 (8.9)
Less than diploma	40 (23.1)	3 (23.1)	45 (26.0)	21 (26.6)
Diploma and bachelor	97 (56.1)	6 (46.2)	107 (59.5)	46 (58.1)
Master and Doctoral	17 (9.8)	1 (7.6)	19 (11.0)	5 (6.4)
Marital status				
Married	141 (73.8)	13 (100)	173 (90.1)	76 (92.7)
Single	50 (26.2)	0	19 (9.9)	6 (7.3)
Employment status				
Employed	78 (47.0)	4 (33.3)	57 (33.3)	33 (44.0)
Self-employed	26 (15.7)	4 (33.3)	19 (11.1)	11 (14.7)
Housekeeper	43 (25.9)	4 (33.3)	87 (50.9)	30 (40.0)
University Student	15 (9.0)	0	8 (4.7)	1 (1.3)
Unemployed	4 (2.4)	0	0	0
Anthropometric characteristics				
BMI				
Median	22.5	24.1	28.0	29.3
1st quartile	20.8	22.7	26.1	27.6
3rd quartile	23.7	24.5	30.3	31.9
Weight				
Median	62	64	73	78
1st quartile	54	58	67	72
3rd quartile	67	70.5	79.7	91.3
Waist circumference				
Median	81	90	92	100
1st quartile	74	85.5	87	94
3rd quartile	87	95	98	105

Abbreviations: BMI, body mass index; NAFLD, non-alcoholic fatty liver disease.
[a]Values are expressed as No. (%).

cially n-3 PUFA, are common eating behaviors among patients with NAFLD as literature shows that SFA can worsen NAFLD progression because of its disturbance in lipid and glucose homeostasis (3).

Fish oil is rich in eicosapentaenoic and docosahexaenoic acids, the main n-3 PUFAs, that have shown to have

Table 3. Differences in Macro/Micronutrients and Food Items Daily Intakes, Among Groups Divided Based on Body Mass Index and Fatty Liver[a]

	Lean-Non NAFLD (n = 191)	lean-NAFLD (n= 13)	Non Lean-Non NAFLD (n = 192)	Non Lean-NAFLD (n = 82)	P Value
Macronutrients					
Carbohydrate, g	176.05 ± 60.54 (165.0)	148.63 ± 37.03 (147.4)	168.01 ± 59.52 (158.7)	171.89 ± 58.85 (160.4)	0.19
Protein, g	63.36 ± 25.66 (59.5)	59.14 ± 13.59 (59.2)	62.47 ± 26.39 (58.9)	67.39 ± 30.84 (61.3)	0.83
Fat, g	62.20 ± 28.09 (56.3)	76.33 ± 46.11 (61.5)	59.52 ± 26.91 (54.9)	64.52 ± 29.21 (60.4)	0.49
Micronutrients					
SFA, g	17.48 ± 8.19 (15.6)	18.88 ± 7.49 (16.3)	16.89 ± 8.47 (15.2)	18.44 ± 9.17 (15.4)	0.46
MUFA, g	15.55 ± 7.19 (14.4)	20.58 ± 14.15 (15.5)	15.28 ± 7.91 (13.6)	16.56 ± 7.92 (14.5)	0.44
PUFA, g	21.23 ± 13.93 (20.0)	36.42 ± 45.99 (23.2)	20.12 ± 11.78 (20.6)	21.21 ± 14.69 (20.7)	0.62
Food items					
Bread, g	41.54 ± 28.52 (30.0)	63.28 ± 33.83 (90.0)	66.12 ± 33.80 (90.0)	63.65 ± 32.88 (90.0)	0.25
Rice, g	120.31 ± 102.87 (150)	192.83 ± 110.75 (175)	176.78 ± 119.38 (175)	175.32 ± 87.23 (175)	0.05
Potatoes, g	22.00 ± 34.99 (19.0)[b]	35.34 ± 49.87 (19.0)	30.61 ± 53.10) (19.0)	47.78 ± 60.72 (19.0)[b]	0.02
Total starch, g	183.85 ± 112.05 (273.0)[c,d]	291.45 ± 133.25 (189.0)[c]	273.51 ± 133.31 (265.0)	286.74 ± 131.91 (280.5)[d]	0.02
Total Oil, g	31.77 ± 22.30 (30.0)	34.90 ± 33.33 (30.0)	27.71 ± 16.53 (30.0)	29.87 ± 17.88 (30.0)	0.62
Red meat, g	12.96 ± 13.32 (4.0)	14.08 ± 10.09 (21.0)	13.80 ± 15.85 (4.0)	13.98 ± 15.49 (4.0)	0.93
Dairy, g	242.33 ± 184.74 (218.0)	222.46 ± 160.40 (185.0)	216.43 ± 142.68 (200.0)	236.93 ± 162.65 (223.0)	0.65
Fish, g	26.53 ± 35.66 (20.0)	23.61 ± 19.10 (20.0)	24.11 ± 37.71 (20.0)	28.96 ± 46.83 (17.1)	0.75
Fast food, g	13.68 ± 18.71 (12.0)	19.23 ± 25.10 (12.0)	14.56 ± 22.30 (12.0)	13.59 ± 17.43 (5.0)	0.90
Soft Drink, mL	78.56 ± 157.32 (30.0)	86.69 ± 136.39 (33.0)	59.47 ± 95.48 (30.0)	59.24 ± 82.26 (30.0)	0.96

Abbreviations: MUFA, mono-unsaturated fatty acid; NAFLD, non-alcoholic fatty liver disease; PUFA, Poly-unsaturated fatty acid; SFA, saturated fatty acid.
[a]Data are all expressed as: Mean ± SD (median).
[b]Significant difference between lean-non NAFLD and non-lean-NAFLD (P = 0.028).
[c]Significant difference between lean-non NAFLD and lean-NAFLD (P = 0.025).
[d]Significant difference between lean-non NAFLD and non-lean-NAFLD (P = 0.047).

protective effects (3). In our study, these fatty acids were not significantly associated with NAFLD. Perhaps their low consumption due to high price for these fatty acids can explain why we did not see any difference between the two groups. It is also a fact that fish consumption is more common in some parts of Iran which are closer to the sea (Caspian Sea and Persian Gulf); but in other regions, fish is not a common food in daily diet of people and it is rarely consumed. Although the mean daily consumption of fish was higher in our study than previous studies (20), a study in Iran revealed that the gap between the current fish consumption and the amounts necessary for maintaining healthy diet is still far from satisfactory (21).

At present, the impact of the amount and type of dietary proteins, which contribute to the development of obesity and its subsequences, is not understood well. Therefore, it is not possible to determine its effect on NAFLD because of the lack of clear evidence (3). In our study, its association with NAFLD was not significant, as well.

Consumption of dietary fructose which is primarily available in beverages has increased simultaneously with the worldwide increase of obesity, diabetes, and NAFLD. Some studies have suggested that there is a direct link (3) between the consumption of fructose in patients and NAFLD, which was nearly 2 to 3 times higher compared to controls (22). However, in our study, there was no association between fructose and NAFLD. Syrups and products containing fructose, which are common in the Western diet, are not consumed as much in Iran, and fructose in Iranian diet often comes from fruits.

In another research, the amount of soft drinks intake was almost twice in NAFLD group (P = 0.03), and they ate 27% more meat (P < 0.001) (23). However, we did not find any association between the consumption of soft drinks and lean meat and NAFLD.

Dietary carbohydrate increases blood insulin level and triglyceride concentration leading to the formation of fat in liver (3). In our study, there was a link between carbohydrates and NAFLD. It was also revealed that each gram

Table 4. Relationship Between NAFLD and Micro/ Macro Nutrients and Food Items Using Logistic Regression

	Nutrient Item	OR-Crude	95 CI%	P Value	OR-Adjusted[a]	95 CI%	P Value
Macronutrient	Protein	1.00	0.99 - 1.01	0.27	1.00	0.99 - 1.00	0.47
	Fat	1.01	0.99 - 1.01	0.11	1.02	1.01 - 1.04	0.01
	Carbohydrate	1.99	0.99 - 2.00	0.63	1.99	1.98 - 1.99	0.004
Micronutrient	SFA	1.02	0.99 - 1.04	0.18	1.03	0.99 - 1.07	0.20
	PUFA	1.03	0.99 - 1.05	0.06	1.05	1.01 - 1.12	0.02
	MUFA	1.59	0.69 - 3.71	0.27	3.07	0.93 - 10.16	0.07
	Linoleic acid	1.53	0.70 - 3.32	0.28	2.66	0.91 - 7.75	0.07
Food item	Potato	1.94	1.09 - 3.42	0.02	2.58	1.28 - 5.21	0.008
	Total starch	1.99	0.99 - 2.00	0.52	1.99	0.99 - 2.00	0.50
	Total oil	1.00	0.99 - 1.01	0.72	1.01	0.99 - 1.02	0.35
	Red meat	1.00	0.99 - 1.02	0.77	0.99	0.98 - 1.02	0.72
	Dairy	1.00	0.99- 1.00	0.77	1.00	0.99 - 1.00	0.80
	Fish	1.00	0.99 - 1.01	0.51	1.00	0.99 - 101	0.46
	Fast food	1.00	0.99 - 1.01	0.91	0.99	0.98 - 1.01	0.42
	Soft drink	1.00	0.99 - 1.00	0.67	1.00	0.99 - 1.00	0.99

Abbreviations: MUFA, mono-unsaturated fatty acid; NAFLD, non-alcoholic fatty liver disease; PUFA, poly-unsaturated fatty acid; SFA, saturated fatty acid.
[a]Adjusted with age, gender (Male, Female), BMI, marital status (single, married), energy intake (Kcal).

increase in carbohydrate consumption cant increase the chance of NAFLD as 1.99 times (P = 0.004). Based on previous studies in Iran, carbohydrate intake is much higher than the recommended amount (providing 45% - 65% of required energy). Food and agriculture organization (FAO) estimated it about 69%. (24), and according to the national food consumption survey, more than 60% - 70% of the Iranian energy intake is obtained from carbohydrates (25). In this study, there was no association between NAFLD and bread and rice consumption; but potato consumption was meaningfully associated with the disease. However, reviewing the food balance sheet of FAO (26) for Iran and other countries that have similar staple food to Iran, such as China and India, which are the main producers of rice, wheat, and potato in the world, has shown that energy intake per capita of cereals in Iran is 1,497 kilocalories which is higher than the corresponding values in China and India (1,440 and 1,394 Kcal, respectively). Energy intake per capita of potato is also higher in Iran (125 Kcal/capita/day compared to 80 in China and 46 in India). Cereals are refined in Iran; thus, they have higher amounts of glycemic index and glycemic load (25), which may lead to the development of NAFLD.

Similar to our results, in earlier studies, type and amount of carbohydrates were mentioned as important factors in the development of fatty liver in Central Asia when compared to fat intake (25). Despite the weak impact of fat on NAFLD in our study, because of the introduction of processed and high fat foods in Iranian diet, it should be given a greater attention than ever before.

Nowadays, the number of lean NAFLD patients is on the rise. Studies tend to review and determine predictors of lean NAFLD. In the present study, we compared nutrient intake in lean and non-lean NAFLD participants.

However, no significant difference was found among these groups regarding nutrients and food items. Only potato and total starchy foods intake was significantly different between the groups. In Younossi et al. (27) study, food items, micronutrients and macronutrients among lean NAFLD subjects and lean healthy controls were investigated, but then again, no differences were found in macronutrients intake (carbohydrate, fat, and protein), vitamins, and minerals between these groups. Only copper, beta-tocopherol, galactose, pectin, and phytic acid were different between the groups and the authors suggested that these results may be an indication that NAFLD in lean patients has occurred due to other metabolic abnormalities. Others have postulated that the cause of their NAFLD could be due to genetic characteristics, impaired intestinal motility, and some other metabolic disturbances that are not related to weight status (27).

Given the rising prevalence of obesity and NAFLD and the importance of a multi-sectorial approach toward correction of poor nutritional behaviors in the community, as

its necessity has been regarded in other community-based problems (28), the integration of these interventions in primary health care (PHC) and recently established family physician program (29) of Iran should not be overlooked. Besides studying NAFLD in obese patients, lean NAFLD patients should not be neglected. We suggest more studies with adequate sample size assessing dietary intakes, dietary pattern, and diet quality in lean-NAFLD people to find if there is any association between NAFLD and diet.

Due to the significant association between fat and refined starches and fatty liver, and because of ever increasing consumption of processed and high fat foods, it seems these items should be given greater attention than ever before. Most cereals are almost completely refined in Iran; thus, increasing supply of whole grains and paying attention to training and health promotion programs in this area can be a priority for policy-makers in Iran to prevent the rising trend of NAFLD in population.

4.1. Implication for Health Policy Makers/Practice/Research/Medical Education

The pathophysiology of NAFLD can be impressed by diet and nutrients, and assessing the impact of dietary nutrients can help prevent or treat the disease. Refined carbohydrates and starch intake especially potato, in both lean and non-lean groups with NAFLD, should be also taken into consideration.

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Footnotes

Authors’ Contribution: Study concept and design: Behnam Honarvar, Kamran Bagheri Lankarani; acquisition of data: Behnam Honarvar, Tayebe Rafiee; analysis and interpretation of data: Parisa Keshani, Behnam Honarvar; drafting of the manuscript: Behnam Honarvar, Parisa Keshani; critical revision of the manuscript for important intellectual content: Behnam Honarvar, Kamran Bagheri Lankarani, Parisa Keshani, Tayebe Rafiee; statistical analysis: Behnam Honarvar, Parisa Keshani; administrative, technical, and material support: Behnam Honarvar, Kamran Bagheri Lankarani; study supervision: Behnam Honarvar, Kamran Bagheri Lankarani

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