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A vegetarian diet does not protect against nonalcoholic fatty liver disease (NAFLD): A cross-sectional study between Buddhist priests and the general population

LIVER

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Original Article

ABSTRACT

Background/Aims: There is limited data that supports a role for a vegetarian diet in nonalcoholic fatty liver disease (NAFLD). The aim of this study is to evaluate the relationship between vegetarian diets and NAFLD, considering metabolic syndrome and obesity.

Materials and Methods: This is a cross-sectional, retrospective study comparing the prevalence of NAFLD of 615 Buddhist priests and age-, sex-, Body mass index (BMI)-and presence/absence of metabolic syndrome-matched controls who underwent routine health checkups in a health promotion center. Diagnosis and severity of NAFLD was determined based on ultrasonographic findings.

Results: The prevalence of NAFLD was not statistically significantly different between the Buddhist priests and the general population (29.9% vs. 25.05%, p=0.055). The Buddhist priest group had higher serum albumin, serum aspartate aminotransferase (AST), serum alanine aminotransferase (ALT), and serum triglyceride levels and lower serum total bilirubin, serum fasting glucose, and serum high density lipoprotein (HDL) levels than the general population group. In univariate analysis and multivariate analysis, NAFLD was associated with old age, male gender, increased BMI, increased waist circumference, metabolic syndrome, high albumin, high glucose, high AST, high ALT, high gamma glutamyl transpeptidase (GGT), high triglycerides, low HDL, high low density lipoprotein (LDL), and high total cholesterol.

Conclusion: The vegetarian diet does not protect against NAFLD.

Keywords: Vegetarian diet, NAFLD, Buddhist priest

INTRODUCTION

Nonalcoholic fatty liver disease (NAFLD) refers to the presence of hepatic steatosis without heavy alcohol consumption. NAFLD may progress to steatohepatitis or cirrhosis and is likely an important cause of cryptogenic cirrhosis (1). NAFLD is seen worldwide and is also the most common liver disorder in Western industrialized countries (2). In the United States of America, the prevalence of NAFLD has been steadily increasing. This finding may originate from increases in the rates of metabolic syndrome, including obesity, type 2 diabetes, and systemic hypertension (3). The prevalence of NAFLD in Korea is also increasing. A report found that the prevalence of NAFLD disease in Korea was 23.6% in 2010, approximately double the prevalence in 2004 (11.5%), and individuals with abdominal obesity had an approximately five-fold greater obesity rate than the control group (4). NAFLD's known risk factors include age, male gender, obesity, and metabolic syndrome (5).

The pathogenesis of NAFLD has not been fully revealed. The most widely accepted theory implicates insulin resistance as the most important mechanism leading to hepatic steatosis. Others have proposed that an additional oxidative injury or "second hit" is required to result in the necroinflammatory component of steatohepatitis. Meanwhile, with respect to dietary habits, among other theories, there has been work suggesting that fruits, vegetables, and fibrous foods are beneficial for patients with NAFLD (5). Vegetarian diets are antioxidant rich, which may reduce oxidative stress (6). Antioxidant defense mechanisms work against different types of free radicals, which may play a role in the protection of NAFLD. However, there has been little data on the

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relationship between vegetarian diets and NAFLD. This study aimed to investigate the effect of the vegetarian diet on NAFLD by evaluating the differences in the prevalence of NAFLD between Buddhist priests, who are obligatory vegetarians, and the general population.

MATERIALS AND METHODS

Study population

This is a cross-sectional, retrospective study. We screened the subjects who visited the health examination center of the Dongguk University Ilsan Hospital for their health examination during the period from August 2005 to March 2013. Study population selection is illustrated in the flow chart in Figure 1. During the study period, 45,911 subjects underwent abdominal ultrasonography for routine check-ups. Among these subjects, 815 were Buddhist priests. Among the Buddhist priests, 200 met the exclusion criteria, which were presence of potential chronic hepatitis, hepatocellular carcinoma, positive test for HBV surface antigen (HBsAg) or antibody to the hepatitis C virus (Anti-HCV). Therefore, our study included 615 Buddhist priests. The general population group consisted of 615 age- and gender-matched controls selected from 45,911 subjects. To exclude the effect of metabolic syndrome and body mass index (BMI), which are well-known risk factors for NAFLD, BMI and the presence/absence of metabolic syndrome were also matched to each vegetarian. The subjects who answered "yes" to the question "Are you vegetarian?" in our questionnaire were excluded from the controls. This study design was approved by the Institutional Review Board of the Dongguk University Ilsan Hospital.

Clinical and laboratory evaluations

All enrolled subjects were questioned about their medical history, including diabetes, hypertension, drinking history, alcohol consumption, smoking, medication history, dietary pattern, and chronic disease history, with a questionnaire. This study was conducted in accordance with the Helsinki Declaration.

All subjects underwent physical examinations by well-trained nurses to use a systematic protocol by means of standardized machines. Subjects' weight and height were measured using Inbody 720 (Biospace, Seoul, South Korea), and their BMI was calculated by dividing the weight by the square of the height. With respect to their waist size, the middle site between the lowest point of the ribs and the highest point of the pelvis was measured with a tapeline (7). Blood tests and blood pressure measurement were performed. The subjects fasted for 12 h to undergo venous blood sampling to measure hemoglobin, total cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL), triglycerides, glucose, serum aspartate aminotransferase (AST), serum alanine aminotransferase (ALT), gamma glutamyl transpeptidase (GGT), albumin, and total bilirubin levels. All the other biochemical tests were conducted in the laboratory medicine department at the Dongguk University Ilsan Hospital.

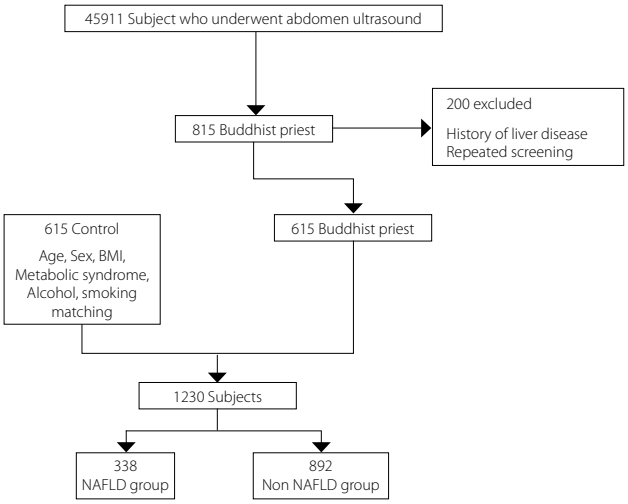

Figure 1. Study Population. In total, 45,911 subjects were screened with abdominal ultrasonography during the study period. Of 815 Buddhist priests, 200 were excluded by exclusion criteria. The remaining 615 Buddhists were assigned as a group, and a control group containing the same number of age-, gender-, BMI-, and metabolic syndrome-matched non-vegetarians was created from the original group of subjects. Across the groups, there were 338 subjects with NAFLD and 892 without NAFLD.

Definition of NAFLD by abdominal ultrasonography

Nonalcoholic fatty liver disease was defined as the presence of fatty liver by ultrasonography (US) in the absence of the following: (i) excessive alcohol intake (>30 g/day for men and >20 g/day for women), (ii) positive test for HBsAg or an Anti-HCV, (iii) known etiologies of liver disease, and (iv) medications known to produce fatty liver. NAFLD is defined as the condition in which a person has signs of liver tissue damage, although the patient does not have alcoholic fatty liver disease (AFLD) because he or she has no history of excessive drinking. This study applied the US guidelines for NAFLD, which consider 21 standard cups a week for males and 14 standard cups a week for females during the past 2 years to be a significant amount of drinking. Twelve grams of alcohol is considered a standard cup. Regular prescription medication was defined as medication taken for 3 months during the preceding year. Hypertension was defined as blood pressure of at least 140/90 mmHg or having an antihypertensive prescription. Diabetes mellitus was defined as fasting glucose levels greater than 126 mg/dL or as a previous diagnosis of diabetes. Subjects were deemed to have metabolic syndrome by the presence of three or more criteria in the Regional Office for the Western Pacific Region of the World Health Organization (WPRO) waist circumference criteria of the National Cholesterol Education Program Adult Treatment Panel III: (a) abdominal obesity (waist circumference >90 cm for males and 80 cm for females), (b) blood pressure >130/85 mmHg, (c) fasting glucose >110 mg/dL females). Buddhist priests do not eat meat and fish but eat vegetarian meals following the Buddhist lessons and eat fruits, vegetables, nuts, and soybean protein foods instead (8).

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The abdominal US was performed by trained radiologists who had no information about the experiment and its details at the time of the procedure. The diagnosis of fatty liver was made by US (Acuson, Sequoia 512; Siemens, Mountain View, CA, USA) using the previously described standardized criteria (9). The ultrasonographic diagnoses of fatty liver were assigned grades in accordance with the degree of liver parenchymal echo, acoustic attenuation, and identification of the diaphragm and the boundaries of blood vessels within the liver. Liver parenchymal echogenicity is generally equivalent or less than that of the renal cortex. The fatty liver disease is mild when the liver parenchyma echo is slightly increased and the boundaries with other organs are clear, moderate when the liver parenchyma echo is increased and the boundaries with other organs are unclear, and severe when the liver parenchyma echo is significantly increased and the boundaries with other organs are unclear.

Statistical analysis

The continuous variables were expressed by calculating averages and standard deviations. To compare the two groups, the Student's t-test study for all continuous variables and chi-square test for categorical variables were used. Odds ratio (OR) and 95% confidence interval (CI) were established for each variable, and p values <0.05 were considered statistically significant. Risk factors that were significant in univariate analysis were subjected to multivariate analysis. All data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 18.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

Baseline characteristics of the subjects

The characteristics of the study population are shown in Table 1. The mean age was 48.3 years and 61.2% were men. Each group included 19.2% of the subjects with metabolic syndrome. There were no statistically significant differences between the Buddhist priest group and the general population group with respect to BMI, waist circumference, prevalence of metabolic syndrome, diabetes, and hypertension. There were no significant differences between the two groups with respect to GGT, triglycerides, LDL cholesterol, and total cholesterol. Albumin, AST, and ALT levels were statistically higher in the Buddhist priest group, whereas the total bilirubin, fasting glucose, and HDL cholesterol levels were statistically lower in the same group than those in the general population group.

Vegetarianism and NAFLD

We examined the effect of a vegetarian diet on NAFLD. The prevalence of fatty liver as measured ultrasonographically was 29.9% in the Buddhist priest group, while it was 25.0% in the control group; however, there was no statistically significant difference between the two groups (95% CI, p=0.055) (Table 2).

We performed subgroup analysis after classifying NAFLD into three grades: mild, moderate, and severe. Mild NAFLD included 19.2% of the vegetarians and 15.1% of the meat eaters, moderate NAFLD was present in 9.6% of the vegetarians and 8.3% of the meat eaters, and severe NAFLD was present in 1.1% of the vegetarians and 1.6% of the meat eaters. However, there was no relationship between diet and NAFLD grade (p=0.184) (Table 3).

Table 1. Baseline characteristics of the Buddhist priests and the general population

Factor	Buddhist (n=615)	General (n=615)	p value
Age, mean±SD	48.3±9.9	48.3±9.8	0.965
Male	239 (38.8%)	239 (38.8%)	1.000
Female	376 (61.2%)	376 (61.2%)	1.000
Metabolic syndrome	118 (19.2%)	118 (19.2%)	1.000
Body mass index (kg/m^2)	23.89±3.18	23.85±3.1	0.839
Waist circumference (cm)	79.5±10.7	79.1±11.6	0.595
Albumin (g/dL)	4.66±0.25	4.60±0.24	<0.001
Total bilirubin (mg/dL)	0.88±0.53	0.95±0.43	0.013
Glucose (mg/dL)	91.2±17.2	96.0±20.1	<0.001
AST (IU/L)	29.1±12.3	22.9±10.4	0.004
ALT (IU/L)	29.9±15.4	22.6±14.5	0.031
GGT (IU/L)	29.2±41.6	29.8±34.8	0.781
Triglyceride (mg/dL)	135.1±89.7	126.0±74.5	0.055
HDL (mg/dL)	54.5±16.8	58.7±14.5	<0.001
LDL (mg/dL)	125.1±36.6	125.4±33.1	0.891
Total cholesterol (mg/dL)	196.1±41.4	192.9±35.4	0.149

SD: Standard deviation, AST: serum aspartate aminotransferase, ALT: serum alanine aminotransferase
GGT: gamma glutamyl transpeptidase, HDL: high density lipoprotein, LDL: lower density lipoprotein

Table 2. Comparison of prevalence of NAFLD between the Buddhist priests and the general population

Fatty liver	Buddhist (n=615)		General (n=615)	p value 0.055
No	431	70.1%	461	75.0%
Yes	184	29.9%	154	25.0%

Table 3. Comparison of NAFLD severity grade between the Buddhist priests and the general population

NAFLD	Buddhist priests (%) (n=615)	General population (%) (n=615)	p value 0.184
None	431 (70.1%)	461 (75%)	
Mild	118 (19.2%)	93 (15.1%)	
Moderate	59 (9.6%)	51 (8.3%)	
Severe	7 (1.1%)	10 (1.6%)	

Other factors having effects on NAFLD

Other risk factors of NAFLD are shown in Table 4. In univariate analysis, age (OR 1.035, 95% CI, p=0.072), male gender (OR 2.087,

Table 4. Effect of characteristics on NAFLD in univariate analysis

	Number of person (%)		Univariate analysis		
	Normal (n=892)	NAFLD (n=338)	OR (95% CI)	p value	*P_{trend}
Age					<0.0001
~30	32 (3.6%)	4 (1.2%)	1	1	
30–40	181 (20.3%)	36 (10.7%)	1.591 (0.530–4.777)	0.408	
40–50	376 (42.2%)	137 (40.5%)	2.915 (1.012–8.394)	0.047	
50–60	216 (24.2%)	115 (34.0%)	4.259 (1.470–12.340)	0.008	
60~	87 (9.8%)	46 (13.6%)	4.230 (1.409–12.696)	0.01	
Gender					<0.0001
Male	303 (34.0%)	175 (51.8%)	2.087 (1.618–2.692)	<0.001	
Female	589 (66.0%)	163 (48.2%)	1	1	
Vegetarianism					0.0553
No	461 (51.7%)	154 (45.6%)	1	1	
Yes	431 (48.3%)	184 (54.4%)	1.278 (0.994–1.643)	0.056	
BMI					<0.0001
<18.5 kg/m^2	45 (5.0%)	0 (0%)	0	0.997	
18.5–24.9 kg/m^2	636 (71.3%)	118 (34.9%)	1	1	
>24.9 kg/m^2	211 (23.7%)	220 (65.1%)	5.620 (4.279–7.380)	<0.001	
Waist circumference (cm)					<0.0001
Man <90, Woman <90	733 (82.2%)	160 (47.3%)	1	1	
Man ≥90, Woman ≥80	159 (17.8%)	178 (52.7%)	5.110 (3.879–6.731)	<0.001	
Metabolic syndrome					<0.0001
No	788 (88.3%)	206 (60.9%)	1	1	
Yes	104 (11.7%)	132 (39.1%)	4.855 (3.599–6.549)	<0.001	
Albumin (g/dL)					<0.0001
1st quartile (<4.5)	375 (42.0%)	92 (27.2%)	1	1	
2nd quartile (4.5–4.6)	143 (16.0%)	56 (16.6%)	1.596 (1.087–2.344)	0.017	
3rd quartile (4.6–4.8)	234 (26.2%)	98 (29.0%)	1.707 (1.230–2.370)	0.001	
4th quartile (>4.8)	140 (15.7%)	92 (27.2%)	2.679 (1.891–3.794)	<0.001	
Total bilirubin (mg/dL)					0.1307
≤1.3	776 (87.0%)	283 (83.7%)	1	1	
>1.3	116 (13.0%)	55 (16.3%)	1.308 (0.923–1.854)	0.132	
Glucose (mg/dL)					<0.0001
<100	775 (86.9%)	226 (66.9%)	1	1	
100–125	96 (10.8%)	80 (23.7%)	2.858 (2.051–3.981)	<0.001	
>125	21 (2.4%)	32 (9.5%)	5.225 (2.955–9.240)	<0.001	
AST (IU/L)					<0.0001
≤37	831 (93.2%)	286 (84.6%)	1	1	
>37	61 (6.8%)	52 (15.4%)	2.477 (1.671–3.671)	<0.001	
ALT (IU/L)					<0.0001
≤40	833 (93.4%)	254 (75.1%)	1	1	
>40	59 (6.6%)	84 (24.9%)	4.669 (3.253–6.702)	<0.001	
GGT (IU/L)					<0.0001
Man ≤61, Woman ≤36	803 (90.0%)	268 (79.3%)	1	1	
Man >61, Woman >36	89 (10.0%)	70 (20.7%)	2.357 (1.674–3.318)	<0.001	

Table 4. Continued

Triglyceride (mg/dL)					<0.0001
Triglyceride <150	707 (79.3%)	172 (50.9%)	1	1	
Triglyceride ≥150	185 (20.7%)	166 (49.1%)	3.710 (2.838–4.850)	<0.001	
HDL (mg/dL)					<0.0001
Man ≥40, Woman ≥50	716 (80.3%)	209 (61.8%)	1	1	
Man <40, Woman <50	176 (19.7%)	129 (38.2%)	2.511 (1.908–3.304)	<0.001	
LDL (mg/dL)					<0.0001
<130	573 (64.2%)	142 (42.0%)	1	1	
≥130	319 (35.8%)	196 (58.0%)	2.448 (1.894–3.162)	<0.001	
Total cholesterol (mg/dL)					<0.0001
<200	578 (64.8%)	156 (46.2%)	1	1	
≥200	314 (35.2%)	182 (53.8%)	2.148 (1.666–2.769)	<0.001	

CI: confidence interval, BMI: body mass index; AST: serum aspartate aminotransferase; ALT: serum alanine aminotransferase; GGT: gamma glutamyl transpeptidase; HDL: high density lipoprotein; LDL: lower density lipoprotein
*Ptrend derived from Cochran-Armitage trend test

95% CI, p<0.001), increased BMI (OR 5.620, 95% CI, p<0.001), increased waist circumference (OR 5.110, 95% CI, p<0.001), metabolic syndrome (OR 4.855, 95% CI, p<0.001), high albumin (OR 2.679, 95% CI, p<0.001), high glucose (OR 5.225, 95% CI, p<0.001), elevated AST (OR 2.477, 95% CI, p<0.001), elevated ALT (OR 4.669, 95% CI, p<0.001), elevated GGT (OR 2.357, 95% CI, p<0.001), high triglycerides (OR 3.710, 95% CI, p<0.001), low HDL (OR 2.511, 95% CI, p<0.001), high LDL (OR 2.448, 95% CI, p<0.001), and high total cholesterol (OR 2.148, 95% CI, p<0.001) were significant risk factors for NAFLD (Table 4).

In multivariate analysis, male gender (OR 1.975, 95% CI, p<0.001), increased BMI (OR 2.736, 95% CI, p<0.001), increased waist circumference (OR 2.385, 95% CI, p<0.001), high albumin (OR 2.618, 95% CI, p<0.001), high glucose (OR 2.032, 95% CI, p=0.044), high ALT (OR 3.793, 95% CI, p<0.001), high triglycerides (OR 1.819, 95% CI, p<0.001), low HDL (OR 2.237, 95% CI, p<0.001), and high LDL (OR 1.676, 95% CI, p<0.001) were significant risk factors for NAFLD (Table 5).

DISCUSSION

In this study, we found that a vegetarian diet does not protect against NAFLD, contrary to our hypothesis. Conversely, the prevalence tends to be higher in the Buddhist priests than that in the general population. NAFLD was significantly associated with male gender, BMI, waist circumference, albumin, glucose, ALT, triglycerides, HDL, and high LDL.

The purpose of this paper was to clarify the relationship between vegetarian dietary habits and NAFLD. NAFLD has shown various clinical outcomes ranging from simple fat deposition to fatty hepatitis and can develop into cirrhosis when it persists. Although the current prevalence of NAFLD has not been clearly determined, reports have ranged from 6% to 50%. Autopsy results from one report found that 20% of the bodies from traffic accidents had NAFLD (10). It is one of the most frequent liver diseases in America and Western Europe, and it has been reported that Korea also has a similar prevalence to that of the Western world. The prevalence is steadily increasing. The prevalence that we found in our study of NAFLD (25%) was similar to those of other studies.

For NAFLD, insulin resistance is known as the most important mechanism, and diabetes and metabolic syndrome are proven risk factors (11). This study looked at the inter-relationship between vegetarian diets and fatty liver as an extension. Generally, it has been reported that populations in which fast food consumption is high, exercise is insufficient, and with a high meat intake have a high fatty liver prevalence (12,13). Studies suggest that the prevalence of NAFLD is high in populations that consume many carbohydrates, highly saturated fatty acids and other fats, and have a low protein intake (14). In this study, the prevalence of NAFLD was 29.9% in the Buddhist priest group and 25.0% in the general population; however, statistically significant differences were not present. The relatively higher prevalence of fatty liver in the Buddhist priest subjects may be due to the fact that the subjects of this study were those who visited the health examination center because they may have already had some health problems. The results of this study suggest that the high carbohydrate diet is more dangerous than non-vegetarianism in NAFLD.

The average energy content of a temple meal in Korea is 1633.8 kcal, of which 67.3% is carbohydrates, 14.8% protein, and 17.9% fat. There has been research suggesting that temple meals are balanced healthy diets (15,16). Modern Korean priests frequently eat eggs, butter containing milk, yogurt, cheese, bread, cookies, and cakes. These snacks are important sources of fat and cholesterol for the priest population. The diet habit of consuming such types of refreshments and lack of exercise may contribute to the increase of obesity and fatty liver in priests (15).

Table 5. Effect of characteristics on NAFD in multivariate analysis

	Number of person (%)		Multivariate analysis*	
	Normal (n=892)	NAFLD (n=338)	OR (95% CI)	p value
Age				
~30	32 (3.6%)	4 (1.2%)	1	1
30–40	181 (20.3%	36 (10.7%)	2.404 (0.573–10.081)	0.23
40–50	376 (42.2%)	137 (40.5%)	3.380 (0.845–13.522)	0.085
50–60	216 (24.2%)	115 (34.0%)	4.020 (0.992–16.292)	0.051
60~	87 (9.8%)	46 (13.6%)	2.841 (0.667–12.096)	0.158
Gender				
Male	303 (34.0%)	175 (51.8%)	2.026 (1.432–2.867)	<0.001
Female	589 (66.0%)	163 (48.2%)	1	1
BMI				
<18.5 kg/m^2	45 (5.0%)	0 (0%)	0	0.997
18.5–24.9 kg/m^2	636 (71.3%)	118 (34.9%)	1	1
>24.9 kg/m^2	211 (23.7%)	220 (65.1%)	2.730 (1.918–3.887)	<0.001
Waist circumference (cm)				
Man <90, Woman <90	733 (82.2%)	160 (47.3%)	1	1
Man ≥90, Woman ≥80	159 (17.8%)	178 (52.7%)	2.506 (1.688–3.720)	<0.001
Metabolic syndrome				
No	788 (88.3%)	206 (60.9%)	1	1
Yes	104 (11.7%)	132 (39.1%)	1.016 (0.629–1.642)	0.949
Albumin (g/dL)				
1st quartile (<4.5)	375 (42.0%)	92 (27.2%)	1	1
2nd quartile (4.5–4.6)	143 (16.0%)	56 (16.6%)	1.481 (0.937–2.340)	0.093
3rd quartile (4.6–4.8)	234 (26.2%)	98 (29.0%)	1.545 (1.034–2.308)	0.034
4th quartile (>4.8)	140 (15.7%)	92 (27.2%)	2.506 (1.604–3.916)	<0.001
Glucose (mg/dL)				
<100	775 (86.9%)	226 (66.9%)	1	1
100–125	96 (10.8%)	80 (23.7%)	1.322 (0.886–1.972)	0.172
>125	21 (2.4%)	32 (9.5%)	2.183 (1.090–4.374)	0.028
AST (IU/L)				
≤37	831 (93.2%)	286 (84.6%)		
>37	61 (6.8%)	52 (15.4%)	0.523 (0.271–1.007)	0.053
ALT (IU/L)				
≤40	833 (93.4%)	254 (75.1%)		
>40	59 (6.6%)	84 (24.9%)	3.707 (2.076–6.618)	<0.001
GGT (IU/L)				
Man ≤61, Woman ≤36	803 (90.0%)	268 (79.3%)		
Man >61, Woman >36	89 (10.0%)	70 (20.7%)	0.728 (0.451–1.176)	0.194
Triglyceride (mg/dL)				
Triglyceride <150	707 (79.3%)	172 (50.9%)	1	1
Triglyceride ≥150	185 (20.7%)	166 (49.1%)	1.819 (1.318–2.512)	<0.001

Table 5. Continued

HDL (mg/dL)				
Man ≥40, Woman ≥50	716 (80.3%)	209 (61.8%)	1	1
Man <40, Woman <50	176 (19.7%)	129 (38.2%)	2.209 (1.558–3.133)	<0.001
LDL (mg/dL)				
<130	573 (64.2%)	142 (42.0%)	1	1
≥130	319 (35.8%)	196 (58.0%)	1.639 (1.198–2.243)	0.002
Total cholesterol (mg/dL)				
<200	578 (64.8%)	156 (46.2%)	1	1
≥200	314 (35.2%)	182 (53.8%)	1.220 (0.764–1.949)	0.405

CI: confidence interval, BMI: body mass index, AST: serum aspartate aminotransferase; ALT: serum alanine aminotransferase, GGT: gamma glutamyl transpeptidase, HDL: high density lipoprotein; LDL: lower density lipoprotein
*Adjusted for age, gender, BMI, waist circumference, and the individual components

The factors that are believed to be related to NAFLD with respect to the multivariate analysis in this study include gender, BMI, waist circumference, serum albumin, glucose, ALT, triglyceride, HDL, and LDL. We can say that they are reasonable factors because they are related to other well-known risk factors of fatty liver, such as diabetes and dyslipidemia. Low levels of albumin are known to increase the risk of NAFLD; hence, the results of this study contradict this finding (17). Because the averages show statistically significant differences but the values do not greatly differ, we may have to consider whether they are clinically significant. However, it is believed that further studies are necessary because the results of this study correspond to a study that reported high serum albumin in vegetarians.

This study has several strong points. First, we evaluated obligatory, pure vegetarians, as represented by Buddhist priests. This study design enabled an accurate assessment of the effect of vegetarianism on NALFD. Second, the data collected were of high quality, i.e., measurements were made by trained nurses using a standardized protocol. Finally, to the best of our knowledge, this is the first case control study about this subject.

Nevertheless, there are also several limitations to this study. First, it was a cross-sectional study; therefore, determination of a temporal association between vegetarianism and the prevention of NAFLD could not be made. Furthermore, case control studies typically suffer from selection bias, recall, and reporting bias. Second, the diagnosis of NAFLD was performed only by US. Though expert radiologists conducted abdominal US following objective guidelines, there could have been differences even if it had been performed by a single expert. In addition, the determination of NAFLD should be performed with a biopsy, but we were not able to perform the procedure for every patient. Thus, we used US, which is convenient but has a lower precision than liver biopsies. Third, this study, retrospective in nature, was based on a ready-made questionnaire. Thus, we were unable to analyze the dietary habits and caloric intakes of the subjects.

In summary, the Buddhist priest group had higher serum albumin, serum AST, serum ALT, serum triglyceride levels and lower serum total bilirubin, serum fasting glucose, and serum HDL levels than the general population. The risk factors of NAFLD include the following: male gender, increased BMI, increased waist circumference, high fasting glucose, high triglyceride, low HDL, and low LDL. In conclusion, a vegetarian diet does not protect against NAFLD.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Dongguk University Ilsan Hospital.

Peer-review: Externally peer-reviewed.

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