Letter to the Editor

Risk of Developing Non-Alcoholic Fatty Liver Disease Over Time in a Cohort of the Elderly in Qingdao, China*

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Nonalcoholic fatty liver disease (NAFLD) is characterized by fat accumulation in the liver in the absence of alcohol consumption and comprises a variety of conditions such as simple steatosis, nonalcoholic steatohepatitis, fibrosis, and cirrhosis[1]. More than one-quarter of the world's population experience NAFLD[2]. The prevalence of NAFLD in China increased from 23.8% in 2001 to 32.9% in 2018, indicating that hepatitis B virus is the primary cause of chronic liver disease[3]. However, NAFLD is considered one of the most important etiologies of chronic liver diseases. The current annual medical and social costs of NAFLD are estimated to be $103 billion in the United States and €35 billion in the European countries. Therefore, it is critical to explore the etiology of NAFLD to prevent its morbidity.

Age, smoking status, physical activity, obesity, hypertension, diabetes, dyslipidemia, and high alanine aminotransferase (ALT) levels are reportedly associated with NAFLD[4-7]. However, these conclusions remain controversial[8-10]. Moreover, no study has investigated the longitudinal relationship between changes in risk factors and the progression of NAFLD in the older adults in China. Therefore, our study aims to clarify the impact of certain factors on the development of NAFLD over time, based on a large Chinese elderly cohort study conducted in Qingdao, China.

Based on the National Basic Public Health Service (BPHS) project, two health examinations for residents aged ≥ 65 years were conducted in 2018 and 2021 in five community centers in Qingdao, Shandong Province, China. All Chinese citizens can use the BPHS project's services in community health centers. The BPHS includes 12 service categories, one of which is the health management of the elderly, which in 2018 and 2021 included: (1) a standard questionnaire including questions about age, sex, marital status, smoking status, alcohol consumption, education, and dietary habits; (2) measurement of height, weight, and blood pressure; and (3) detection of the levels of fasting plasma glucose (FPG), ALT, total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL), and performing ultrasonography of the liver. ALT and TG levels were determined using enzymatic techniques, and HDL was measured using a direct method. FPG levels were determined using the glucose oxidase method. A written informed consent was obtained from all participants. This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of the Qingdao Municipal Center for Disease Control and Prevention.

A total of 57,808 individuals aged ≥ 65 years participated in the health examination in 2018, and 47,862 individuals underwent a health check-up in 2021. Of the 47,862 participants, those with incomplete information on height, weight, and ultrasonography of the liver (n = 6,282), as well as those with ALT levels higher than three times of the upper limit (n = 236) were excluded. An additional 3,101 participants were excluded because of high alcohol consumption (> 140 g/week for men and > 70 g/week for women), the presence of hepatitis B surface antigen, a history of schistosomiasis, viral hepatitis, hepatic cirrhosis, liver carcinoma, and autoimmune liver disease. Finally, the data from 38,243 individuals were included in this study.

A balanced diet was defined as consuming adequate types of food with an appropriate ratio of

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vegetable-to-meat intake. Overweight was defined as body mass index (BMI) ≥ 24.0 kg/m^2, and obesity was defined as BMI ≥ 28.0 kg/m^2. Hypertension was defined as systolic blood pressure of ≥ 140 mmHg and (or) diastolic blood pressure of ≥ 90 mmHg. Moreover, dyslipidemia was defined as presence of at least one of the following: TC levels of ≥ 5.72 mmol/L, TG levels of ≥ 1.70 mmol/L, HDL levels of < 0.91 mmol/L, or lipoprotein cholesterol (LDL) levels of > 3.64 mmol/L. Diabetes was defined as an FPG level of ≥ 7.0 mmol/L or a history of previously diagnosed diabetes.

NAFLD was diagnosed using established ultrasound criteria for fatty liver (at least two of the following abnormal findings: increased echogenicity of the liver relative to that of the kidney and spleen, obliteration of the vascular architecture of the liver, and deep attenuation of the ultrasonic signal), safe alcohol consumption (Asian standards: < 140 g/week for males and < 70 g/week for females), and the absence of HbsAg and anti-HCV. Abnormal ALT levels were defined as levels of > 40 IU/L according to the conventional value.

Statistical analyses were performed using SPSS (version 17.0; SPSS, Chicago, IL), and statistical significance was set at a two-sided *P*-value of < 0.05. Data are presented as mean ± standard deviation for continuous variables and as *n* (%) for categorical variables. The normality of the variables was examined using the Kolmogorov-Smirnov test. Group differences were compared using the Student's *t*-test for continuous variables since data were normally distributed. For categorical variables, we used the χ^2 test to compare differences. Moreover, multivariate logistic regression models were used to calculate the unadjusted and adjusted odds ratios (*OR*s) and 95% confidence intervals (*CI*s) for cross-sectional associations. Longitudinal analyses were conducted on 19,919 participants without NAFLD in 2018, and multinomial logistic regression models were used to examine the association between changes in possible risk factors and NAFLD over time. Supplementary Table S1 (available in www.besjournal.com) displayed different groups defined by variable status over time.

Of the 38,243 individuals aged ≥ 65 years, the prevalence of NAFLD in 2018 and 2021 was 48.96% and 47.91%, respectively (Table 1). The mean values of BMI, TC, TG, LDL, and ALT and the prevalence of hypertension, diabetes, and dyslipidaemia were notably high, while the HDL levels were lower in the participants with NAFLD than that of the participants without NAFLD (*P* < 0.001).

In the cross-sectional analysis, current drinking (*OR*: 1.19, 95% *CI*: 1.11–1.29) and non-balanced dietary habits (*OR*: 1.63, 95% *CI*: 1.50–1.77) increased the risk of NAFLD, and older age (*P* < 0.001) was negatively associated with NAFLD in the adjusted model in 2018. Compared with those with normal weight, individuals with obesity had a 6.98 fold higher odds (95% *CI*: 6.54–7.44) and a 10.34 fold higher odds (95% *CI*: 9.68–11.05) of developing NAFLD in 2018 and 2021, respectively. After adjusting for confounders, abnormal ALT levels, obesity, hypertension, diabetes, and dyslipidemia were all risk factors (*P* < 0.001 for all comparisons) for NAFLD (Table 2).

As shown in Table 3, among the elderly without NAFLD in 2018, 19.90% had developed NAFLD in 3 years (Table 3). In the longitudinal analyses, current drinking [relative risk reduction (RRR): 1.20, 95% *CI*: 1.05–1.38] and unbalanced dietary habits (RRR: 1.45, 95% *CI*: 1.28–1.64) were positively correlated with developing NAFLD, while regular physical activity (RRR: 0.73, 95% *CI*: 0.66–0.81) was negatively associated with NAFLD after adjusting for the confounders. Individuals who remained with overweight or obesity were at an increased risk of developing NAFLD, as the category with the greatest risk for NAFLD was weight gain, which resulted in a change in the BMI status (RRR: 7.99, *P* < 0.001). Remained hypertension (RRR: 1.70, *P* < 0.001), remained diabetes (RRR: 3.87, *P* < 0.001), remained dyslipidemia (RRR: 1.14, *P* < 0.05), developed hypertension (RRR: 1.90, 95% *CI*: 1.70–2.12), developed diabetes (RRR: 4.14, 95% *CI*: 3.78–4.54), and developed dyslipidemia (RRR: 1.46, 95% *CI*: 1.30–1.63) could increase the incidence of NAFLD, while no longer having hypertension or dyslipidemia could minimize the risks of developing NAFLD. No significant association between ALT levels change and NAFLD was detected, as compared to those with normal ALT levels from 2018 to 2021 (*P* > 0.05).

To the best of our knowledge, this is the first study to evaluate how over-time changes in the status of hypertension, diabetes, dyslipidemia, and ALT levels affect the incidence of NAFLD in the older adults in China. Moreover, the current study revealed that regular physical activity reduced the risk of NAFLD, whereas drinking and unbalanced dietary habits increased the risk.

Obesity was identified as the most important risk factor for NAFLD, as its prevalence increased in proportion to obesity. Overweight and weight gain could predict the development of NAFLD[5,6]. Consistent with these studies, our findings revealed

Table 1. Demographic characteristics of the individuals in 2018 and 2021 (in our study)

Characteristics	In 2018			In 2021		
	NAFLD (*n* = 18,725)	No NAFLD (*n* = 19,518)	*P* value*	NAFLD (*n* = 18,324)	No NAFLD (*n* = 19,919)	*P* value*
Sex						
Male	7,697 (41.10)	8,004 (41.00)		7,421 (40.50)	8,280 (41.60)	
Female	11,028 (58.90)	11,514 (59.00)	0.847	10,903 (59.50)	1,1639 (58.40)	0.034
Age (years)						
65–	9,724 (51.90)	9,262 (47.50)		5,050 (27.60)	4,838 (24.30)	
70–	7,461 (39.80)	7,825 (40.10)		10,952 (59.80)	10,977 (55.10)	
≥ 75	1,540 (8.30)	2,431 (12.50)	< 0.001	2,322 (12.70)	4,104 (20.60)	< 0.001
Education						
Low	4,371 (23.30)	4,786 (24.50)		4,458 (24.30)	4,699 (23.60)	
Intermediate	13,309 (71.10)	13,551 (69.40)		12,814 (69.90)	14,046 (70.50)	
High	1,045 (5.60)	1,181 (6.10)	0.002	1,052 (5.70)	1,174 (5.90)	0.221
Current smoking						
No	16,807 (89.80)	16,799 (86.10)		16,422 (89.60)	1,6916 (84.90)	
Yes	2,603 (13.90)	1,991 (10.20)	< 0.001	2767 (15.10)	2,072 (10.40)	< 0.001
Current drinking						
No	16,524 (88.20)	17,054 (87.40)		16,115 (87.90)	1,7551 (88.10)	
Yes	2,359 (12.60)	2,303 (11.80)	0.009	2,209 (12.10)	2,368 (11.90)	0.615
BMI (kg/m^2)	26.90 ± 3.40	24.27 ± 3.12	< 0.001	27.40 ± 3.30	24.29 ± 3.19	< 0.001
Systolic blood pressure (mmHg)	149.47 ± 21.69	144.21 ± 21.43	< 0.001	151.92 ± 19.99	147.31 ± 20.90	< 0.001
Diastolic blood pressure (mmHg)	82.71 ± 11.69	80.42 ± 11.60	< 0.001	82.81 ± 11.24	80.80 ± 11.31	< 0.001
FPG (mmol/L)	6.52 ± 2.07	5.90 ± 1.67	< 0.001	6.86 ± 2.17	6.21 ± 1.76	< 0.001
TC (mmol/L)	5.64 ± 3.68	5.50 ± 6.21	0.005	5.66 ± 1.20	5.48 ± 1.34	< 0.001
TG (mmol/L)	1.78 ± 1.11	1.33 ± 0.71	< 0.001	1.86 ± 1.28	1.29 ± 0.71	< 0.001
HDL (mmol/L)	1.44 ± 0.31	1.53 ± 0.59	< 0.001	1.44 ± 2.29	1.54 ± 0.34	< 0.001
LDL (mmol/L)	3.14 ± 0.82	3.05 ± 2.42	< 0.001	3.34 ± 0.96	3.19 ± 0.97	< 0.001
ALT (IU/L)	24.51 ± 14.94	19.94 ± 11.19	< 0.001	25.55 ± 14.60	20.56 ± 14.52	< 0.001
Marital status						
Single or widowed	2,773 (14.80)	2,973 (15.20)		2,788 (15.20)	2,958 (14.90)	
Married	15,952 (85.20)	16,545 (84.80)	0.247	15,536 (84.80)	16,961 (85.10)	0.323
Regular physical activity						
Yes	13,005 (69.50)	13,437 (68.80)		11,909 (65.00)	13,386 (67.20)	
No	5,720 (30.50)	6,081 (31.20)	0.198	6,415 (35.00)	6,533 (32.80)	< 0.001
Dietary habits						
Balanced	17,536 (93.70)	17,574 (90.00)		16,745 (91.40)	1,8365 (92.20)	
Unbalanced	1,873 (10.00)	1,230 (6.30)	< 0.001	1,579 (8.60)	1,554 (7.80)	0.041
ALT levels						
Normal	17,070 (91.20)	18,899 (96.80)		16,487 (90.00)	19,171 (96.20)	
Abnormal	1,655 (8.80)	619 (3.20)	< 0.001	1,837 (10.00)	748 (3.80)	< 0.001

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Characteristics	In 2018			In 2021		
	NAFLD (*n* = 18,725)	No NAFLD (*n* = 19,518)	*P* value*	NAFLD (*n* = 18,324)	No NAFLD (*n* = 19,919)	*P* value*
BMI status						
Normal	3,462 (18.50)	9,391 (48.10)		2,563 (14.00)	9,694 (48.70)	
Overweight	8,759 (46.80)	7,950 (40.70)		8,614 (47.00)	7,920 (39.80)	
Obesity	6,504 (34.70)	2,177 (11.20)	< 0.001	7,147 (39.00)	2,305 (11.60)	< 0.001
Diabetes						
No	14,015 (74.80)	16,976 (87.00)		12,594 (68.70)	16,615 (83.40)	
Yes	4,710 (25.20)	2,542 (13.00)	< 0.001	5,730 (31.30)	3,304 (16.60)	< 0.001
Hypertension						
No	5,951 (31.80)	8,107 (41.50)		4,842 (26.40)	7,017 (35.20)	
Yes	12,774 (68.20)	11,411 (58.50)	< 0.001	13,482 (73.60)	12,902 (64.80)	< 0.001
Dyslipidemia						
No	6,190 (33.10)	9,953 (51.00)		5,528 (30.20)	9,245 (46.40)	
Yes	12,535 (66.90)	9,565 (49.00)	< 0.001	12,796 (69.80)	10,674 (53.60)	< 0.001

Note. BMI, body mass index; FPG, fasting plasma glucose; TC, total cholesterol; TG, triglycerides; HDL, high-density lipoprotein cholesterol; LDL, lipoprotein cholesterol; ALT, alanine aminotransferase; NAFLD, nonalcoholic fatty liver disease. Data are presented as mean ± SD for continuous variables, and *n* (%) for categorical variables. **P* values in the *t*-tests for differences in means or in the Chi-square tests for differences in proportions.

that overweight and obesity were associated with NAFLD. Further comparisons revealed that compared with those who maintained a normal weight, participants with long-term overweight and obesity had a 3.76 and 4.49 increased risk of developing NAFLD, respectively. Moreover, our study suggested that the category with the greatest risk for NAFLD was weight gain, which resulted in changes in the BMI status (RRR: 7.99, $P < 0.001$).

Our study showed that diabetes was significantly associated with an increased risk of NAFLD, which was consistent with the findings of the American study[4]. Furthermore, patients who remained with diabetes or developed it during the study period had a higher risk of NAFLD than those who did not. However, an Indian cohort study did not reveal a significant association between diabetes and NAFLD[9]. The discrepancy between our study and the Indian study might be related to the sample size. Individuals in the Indian study were from a clinical cohort, thus, the conclusion might not apply to the general population.

Many studies reported that higher TG levels (*OR*: 5.03, $P < 0.001$) and lower HDL levels (*OR*: 3.99, $P < 0.001$) are risk factors for NAFLD[7]. Our study not only revealed that dyslipidemia was associated with NAFLD, but also suggested that the presence of dyslipidemia was a more important risk factor. Consistent with other studies' findings, our results supported a positive association between hypertension and incident NAFLD[7]. Moreover, no longer having hypertension or dyslipidemia was a protective factor for the development of NAFLD, indicating that NAFLD could be reversed when patients with hypertension or hyperlipidemia control their blood pressure and lipids to the normal levels.

ALT levels are positively associated with NAFLD and to some extent, can be used as a diagnostic marker for NAFLD. However, 25% of patients with NAFLD showed normal ALT levels clinically; however, the elevation of ALT levels is a non-invasive indicator of NAFLD[8,10]. A positive association between ALT levels and NAFLD was observed in the cross-sectional analysis of our study; however, this relationship was not detected in the longitudinal analysis. Therefore, further studies are required to verify the impact of ALT levels on NAFLD.

Our study had several strengths, as it is the first study to examine how changes in the status of hypertension, diabetes, dyslipidaemia, and ALT levels over time impact incident NAFLD in the elderly in China. Moreover, the sample size was large enough, increasing the statistical power to detect the association between relative factors and NAFLD.

Table 2. A cross-sectional analysis of relative risk factors for NAFLD in 2018 and 2021

Characteristics	In 2018 (*n* = 38,243)		In 2021 (*n* = 38,243)	
	Unadjusted *OR* (95% *CI*)[a]	Adjusted *OR* (95% *CI*)[b]	Unadjusted *OR* (95% *CI*)[a]	Adjusted *OR* (95% *CI*)[b]
Sex				
Male	1.00	1.00	1.00	1.00
Female	0.99 (0.96–1.04)	1.04 (0.99–1.09)	1.05 (1.01–1.09)	1.03 (0.99–1.08)
Age (years)				
65–	1.00	1.00	1.00	1.00
70–	0.91 (0.87–0.95)*	0.95 (0.91–0.99)	0.96 (0.91–1.01)	0.95 (0.90–1.01)
≥ 75	0.60 (0.56–0.65)*	0.71 (0.66–0.77)*	0.54 (0.51–0.58)*	0.64 (0.60–0.69)*
Education				
Low	1.00	1.00	1.00	1.00
Intermediate	1.03 (0.94–1.13)	0.88 (0.79–0.97)**	0.96 (0.92–1.01)	0.97 (0.92–1.03)
High	1.11 (1.02–1.21)***	0.97 (0.88–1.06)	0.95 (0.86–1.04)	0.93 (0.83–1.03)
Current smoking				
No	1.00	1.00	1.00	1.00
Yes	1.42 (1.33–1.51)*	1.06 (0.98–1.14)	1.03 (0.97–1.09)	1.02 (0.94–1.10)
Current drinking				
No	1.00	1.00	1.00	1.00
Yes	1.08 (1.02–1.15)*	1.19 (1.11–1.29)***	1.02 (0.96–1.08)	1.00 (0.93–1.08)
Marital status				
Single or widowed	1.00	1.00	1.00	1.00
Married	0.98 (0.91–1.12)	1.01 (0.95–1.08)	0.97 (0.92–1.03)	0.98 (0.92–1.04)
Regular physical activity				
No	1.00	1.00	1.00	1.00
Yes	0.97 (0.93–1.02)	0.93 (0.89–0.98)**	1.03 (0.98–1.07)	1.04 (0.99–1.10)
Dietary habits				
Balanced	1.00	1.00	1.00	1.00
Unbalanced	1.63 (1.51–1.76)*	1.63 (1.50–1.77)*	1.11 (1.04–1.20)	0.93 (0.86–1.01)
ALT levels				
Normal	1.00	1.00	1.00	1.00
Abnormal	2.96 (2.69–3.25)*	2.22 (2.00–2.46)*	2.86 (2.62–3.12)*	2.17 (1.97–2.39)*
BMI status				
Normal	1.00	1.00	1.00	1.00
Overweight	2.99 (2.84–3.14)*	2.70 (2.56–2.84)*	4.11 (3.90–4.34)*	3.77 (3.57–3.98)*
Obesity	8.10 (7.61–8.63)*	6.98 (6.54–7.44)*	11.73 (11.00–12.50)*	10.34 (9.68–11.05)*
Diabetes				
No	1.00	1.00	1.00	1.00
Yes	2.24 (2.13–2.37)*	1.87 (1.77–1.99)*	2.29 (2.18–2.40)*	2.03 (1.93–2.15)*
Hypertension				
No	1.00	1.00	1.00	1.00
Yes	1.53 (1.46–1.59)*	1.20 (1.15–1.26)*	1.51 (1.45–1.58)*	1.18 (1.12–1.24)*
Dyslipidemia				
No	1.00	1.00	1.00	1.00
Yes	2.11 (2.02–2.20)*	1.81 (1.73–1.89)*	2.00 (1.92–2.09)*	1.81 (1.73–1.90)*

Note. BMI, body mass index; ALT, alanine aminotransferase. [a]Model 1: Unadjusted. [b]Model 2: Adjusted for age, sex, education, current smoking, current drinking, regular physical activity, dietary habits, ALT levels, BMI status, diabetes, hypertension, and dyslipidemia. *$P < 0.001$ for testing the null hypothesis that the odds ratio is equal to the odds ratio in the reference category. **$P < 0.01$ for testing the null hypothesis that the odds ratio is equal to the odds ratio in the reference category. ***$P < 0.05$ for testing the null hypothesis that the odds ratio is equal to the odds ratio in the reference category.

Table 3. Change in risk factors from 2018 to 2021 and the risk of developing NAFLD among participants without NAFLD in 2018 (*n* = 19,518)

Characteristics	No (%) of NAFLD	No (%) of not NAFLD	Model 1	Model 2
			RRR (95% *CI*)[a]	RRR (95% *CI*)[b]
Sex				
Male	1,583 (40.80)	6,421 (41.10)	1.00	1.00
Female	2,299 (59.20)	9,215 (58.90)	1.01 (0.94–1.09)	0.97 (0.90–1.06)
Age (years)				
65–	1,845 (47.50)	7,417 (47.40)	1.00	1.00
70–	1,553 (40.00)	6,272 (40.10)	0.99 (0.92–1.08)	0.98 (0.90–1.07)
≥ 75	484 (12.50)	1,947 (12.50)	0.99 (0.89–1.18)	0.97 (0.85–1.10)
Education				
Low	975 (25.10)	3,811 (24.40)	1.00	1.00
Intermediate	2,680 (69.00)	10,871 (69.50)	0.96 (0.89–1.05)	0.94 (0.86–1.04)
High	227 (5.80)	954 (6.10)	0.93 (0.79–1.09)	0.91 (0.76–1.09)
Current smoking				
No	3,363 (86.60)	13,436 (85.90)	1.00	1.00
Yes	519 (13.40)	2,200 (14.10)	0.94 (0.85–1.05)	0.97 (0.84–1.11)
Current drinking				
No	3,401 (88.20)	13,791 (88.20)	1.00	1.00
Yes	481 (11.80)	1,845 (11.80)	0.94 (0.84–1.05)	1.20 (1.05–1.38)**
Marital status				
Single or widowed	609 (15.70)	2,364 (15.10)	1.00	1.00
Married	3,273 (84.30)	13,272 (84.90)	0.96 (0.87–1.06)	0.95 (0.85–1.06)
Regular physical activity				
No	2,983 (76.80)	8,329 (53.90)	1.00	1.00
Yes	899 (23.20)	7,307 (46.70)	0.34 (0.32–0.37)*	0.73 (0.66–0.81)*
Dietary habits in 2018				
Balanced	3,349 (86.30)	14,225 (91.00)	1.00	1.00
Unbalanced	533 (13.70)	1,411 (9.00)	1.60 (1.44–1.79)*	1.45 (1.28–1.64)*
BMI status				
Remained normal	538 (13.90)	6,298 (40.30)	1.00	1.00
Weight loss	238 (6.10)	2,877 (18.40)	0.97 (0.83–1.14)	1.10 (0.93–1.30)
Remained overweight	728 (18.80)	2,640 (16.90)	3.23 (2.86–3.64)*	3.76 (3.30–4.29)*
Remained obesity	146 (3.80)	442 (2.80)	3.87 (3.15–4.76)*	4.49 (3.59–5.62)*
Weight gain	2,232 (57.50)	3,379 (21.60)	7.73 (6.98–8.57)*	7.99 (7.02–9.09)*
Hypertension				
Never hypertensive	1,136 (29.30)	4,249 (27.20)	1.00	1.00
Remained hypertension	999 (25.70)	4,268 (27.30)	1.57 (1.32–1.78)**	1.70 (1.53–1.89)*
Developed hypertension	1,345 (34.60)	3,992 (25.50)	1.26 (1.15–1.38)*	1.90 (1.70–2.12)*
No longer having hypertension	402 (10.40)	3,127 (20.00)	0.48 (0.42–0.54)**	0.72 (0.63–0.83)*

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Characteristics	No (%) of NAFLD	No (%) of not NAFLD	Model 1	Model 2
			RRR (95% *CI*)[a]	RRR (95% *CI*)[b]
Diabetes				
Never diabetic	1,870 (48.20)	11,163 (71.40)	1.00	1.00
Remained diabetes	207 (5.30)	376 (2.40)	3.29 (2.76–3.92)[*]	3.87 (3.18–4.71)[*]
Developed diabetes	1,523 (39.20)	2,420 (15.50)	3.76 (3.47–4.07)[*]	4.14 (3.78–4.54)[*]
No longer having diabetes	282 (7.30)	1,677 (10.70)	1.00 (0.88–1.15)[***]	1.08 (0.93–1.25)
Dyslipidemia				
Never dyslipidemic	1,074 (27.70)	4,570 (29.20)	1.00	1.00
Remained dyslipidemia	1,246 (32.10)	4,304 (27.50)	1.23 (1.12–1.35)[*]	1.14 (1.02–1.26)[***]
Developed dyslipidemia	1,032 (26.60)	3,577 (22.90)	1.23 (1.12–1.35)[*]	1.46 (1.30–1.63)[*]
No longer having dyslipidemia	530 (13.70)	3,185 (20.40)	0.71 (0.63–0.79)[*]	0.72 (0.63–0.82)[*]
ALT levels				
Never abnormal	3,430 (88.40)	14,202 (90.80)	1.00	1.00
Remained abnormal	9 (0.20)	34 (0.20)	1.10 (0.53–2.29)	0.63 (0.27–1.42)
Developed abnormal	331 (8.50)	936 (6.00)	1.47 (1.29–1.67)[*]	1.12 (0.97–1.30)
No longer abnormal	112 (2.90)	464 (3.00)	0.99 (0.81–1.23)	1.01 (0.80–1.27)

Note. BMI, body mass index; ALT, alanine aminotransferase. [a]Model 1: Unadjusted. [b]Model 2: Adjusted for age (2018), sex, education, smoking status (2018), marital status (2018), drinking status (2018), regular physical activity (2018), dietary habits (2018), BMI status, diabetes status, hypertension status, dyslipidemia status, and ALT levels over time. [*]$P < 0.001$ for testing the null hypothesis that the odds ratio is equal to the odds ratio in the reference category. [**]$P < 0.01$ for testing the null hypothesis that the odds ratio is equal to the odds ratio in the reference category. [***]$P < 0.05$ for testing the null hypothesis that the odds ratio is equal to the odds ratio in the reference category.

However, this study had some limitations. First, the participants were not from a population-based sample and might not be representative of the entire population. Second, residual confounders might have been ignored in the analysis, although some confounders were controlled in the current study. Third, the diagnostic criteria for NAFLD were based on ultrasonography, which might not be sensitive to mild NAFLD and could not clarify its severity. However, ultrasonography, as a non-invasive method, has been widely used in population-based studies because of its high diagnostic value in detecting NAFLD.

In conclusion, our study revealed that alcohol drinking, unbalanced dietary habits, long-term overweight or obesity, over-time weight gain that results in a BMI category, and the presence of diabetes, hypertension, or dyslipidemia, can increase the risk of developing NAFLD, while regular physical activity and no longer having dyslipidemia or hypertension are protective factors against incident NAFLD. Therefore, the elderly individuals should control their weight, blood pressure, and blood glucose and lipid levels to normal levels to prevent the development of NAFLD.

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Conflict of Interest No potential conflicts of interest.

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