Risk and Prevalence of Fatty Liver Assessed in A Scientific Research Institute in Beijing

Shu-Gen Qu (✉ shugenju@wmu.edu.cn)

Wenzhou Medical University

Hui-Qin Chen

School of Radiation Medicine and Protection, Medical College of Soochow University

Dong-Mei Li

Fangshan Branch of Beijing Nuclear Industry Hospital

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Abstract

Background: To investigate the prevalence and distribution of employees with fatty liver disease (FLD) and assess the risk factors associated with diseases and biochemical markers.

Methods: Disease risk markers, and the levels of biochemical markers of 2541 participants from an Institute of Scientific Research in Beijing, were assessed according to standard methods and FLD was diagnosed by abdominal ultrasonography. Chi-square test was used to compare the results between participants with and without FLD.

Results: The prevalence of FLD, based on abdominal ultrasonography examination, was 43.5% (1105/2541) in this population. The overall prevalence increased with age, and it was substantially higher in males (50.0% vs females: 34.6%, $P < 0.001$). The gender and age distributions were significantly different between the two groups ($\chi^2=59.8$ for gender and $t=-15.2$ for age or $\chi^2=205.6$ for age group, $P < 0.05$). Chi-square test results revealed statistically significant differences in the BMI, prehypertension, hypertension, prediabetes, diabetes, hyperlipidemia, mixed type hyperlipidemia, hypertriglyceridemia, and the rise of GGT, ALT, AST, total bilirubin and indirect bilirubin between populations with and without FLD ($P < 0.05$). The risk of disease and biochemical markers contributing to the development of FLD was assessed by calculating the odd ratio (OR) and 95% confidence interval (95% CI), and the results are ordered as follows: overweight and obesity [6.85 (5.54-8.48)], diabetes [6.00 (3.66-9.82)], prediabetes [5.06 (3.10-8.26)], ALT rise [4.67 (3.58-6.10)], GGT rise [4.01 (3.03-5.30)]. Multiple factors analysis was conducted to further compare those identified risk factors of FLD, which showed statistically significant differences in age, overweight and obesity, prediabetes, diabetes, mixed type hyperlipidemia, hypertriglyceridemia and ALT rise by Logistic regression analysis ($P < 0.05$).

Conclusions: Chronic disease, especially FLD, can be easily ignored during health assessment, although it is as important health risk factor as overweight and obesity, hypertension and diabetes. Physical examination is a practical approach to detect FLD in the process of control and prevention.

Background

Fatty liver disease (FLD) has become one of the most common disorders of liver since the improvement of people's living conditions and adoption of a more westernized diet. The prevalence of FLD has consistently risen over the recent years in China, especially for non-alcoholic fatty liver disease (NAFLD) which is associated with a higher energy intake and normal metabolic profile in patients with a genetic predisposition. In western countries, the prevalence of FLD in the adult population is estimated to be 20% – 33% [1], increasing the importance for its clinical diagnosis [2, 3]. FLD is typically diagnosed by imaging and ultrasonography at present, and is highly prevalent (27%) in the urban population in China, with 7.6% – 34.2% being young people. It is mainly related to obesity and metabolic syndrome (MetS) [4, 5]. The hepatitis disease, initially found to be induced by hepatitis virus, is still a leading cause of chronic liver disease in China, even though viral hepatitis infection has decreased from 10–7% between 1992 and 2006 in mainland China [6], and infectious hepatitis is an important factor leading to hepatocellular carcinoma. While as a visible and most frequently diagnosed liver disease in Chinese clinics, FLD represents a particularly alarming threat to human health and public healthcare system, especially because it can readily progress to steatohepatitis, fibrosis or cirrhosis, even liver cancer. Approximately 10% – 25% of patients with silent liver disease develop non-alcoholic steatohepatitis (NASH), and 5% – 8% may develop liver cirrhosis

within 5 years from diagnosis ^[7, 8], as well as having an increased risk to develop cardiovascular diseases and diabetes. Furthermore, 12.8% of patients with liver cirrhosis may develop hepatocellular carcinoma (HCC) within 3 years from diagnosis ^[9, 10]. NASH is considered to be a major inducer of cryptogenic cirrhosis as patients with NASH have 70% risk to develop NAFLD ^[11, 12].

Because of the youth oriented tendency of FLD and the increased concern of scientific researchers for their health due to the high technology mastering demands in their working environment, it was imperative to assess the health of employees in an institute of scientific research in China. To gain further information on the prevalence and risk of fatty liver, the current study was designed to analyze the retrospective data of adult participants in a research institute in Beijing, based on physical examinations.

Methods

Study participants

A total number of 2760 consecutive adult workers who underwent routine physical examinations at the Fangshan Branch of Beijing Nuclear Industry Hospital from September 1, 2018 to December 31, 2018 were retrospectively enrolled in the study.

Physical examination, biochemical and radiological analysis

The physical examination was performed by a professional personnel doctor who had the title of attending or above. The routine examinations of internal medicine, surgery and ophthalmology were carried out according to the unified standards. Patients were presented to the hospital for blood sampling in the morning after 10 h of fasting. All serological measurements were performed on-site at the certified laboratory. Unicel DxC 800 automatic biochemistry analyzer (Beckman Coulter Laboratories, United States) was used for the determination of plasma concentration of glucose, total cholesterol (TC), triglyceride (TG), low density lipoprotein cholesterol (LDL-C), gamma glutamyl transpeptidase (GGT), alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin (TBIL), direct bilirubin (DBIL), indirect bilirubin (IBIL) and other biochemical markers. Abdominal ultrasonography was conducted to detect FLD with standard imaging criteria ^[13]. Electrocardiography and chest X-ray were performed to rule out serious heart and lung diseases. Hepatitis B test in serum was performed to excludes HBV/HCV chronic infections. All employee were excluded from acute infection during physical examination.

Diagnostic criteria and definitions

The participants were allocated into 4 groups according to their Body mass index (BMI): thin ($\leq 18.4 \text{ kg/m}^2$), normal ($18.5\text{--}23.9 \text{ kg/m}^2$), overweight ($24.0\text{--}27.9 \text{ kg/m}^2$) and obese ($\geq 28.0 \text{ kg/m}^2$) ^[14, 15]. According to the Chinese and national hypertension guidelines for the management of hypertension ^[16, 17], hypertension was diagnosed when the systolic pressure was $\geq 140 \text{ mmHg}$ and/or the diastolic pressure was $\geq 90 \text{ mmHg}$; prehypertension was diagnosed when the systolic pressure was $120\text{--}139 \text{ mmHg}$ and/or the diastolic pressure was $80\text{--}89 \text{ mmHg}$ under no medication and no self-reported hypertension. Hyperglycemia was diagnosed when the fasting plasma glucose levels were $6.1\text{--}6.95 \text{ mmol/L}$ for prediabetes, and $\geq 6.95 \text{ mmol/L}$ for diabetes when patients were receiving medication or had reported diabetes ^[18, 19]. Dyslipidemia was defined when the cholesterol TC levels were $\geq 5.7 \text{ mmol/L}$ and/or TG $\geq 1.8 \text{ mmol/L}$ and/or LDL-C $\geq 3.6 \text{ mmol/L}$ and/or HDL-C $< 0.8 \text{ mmol/L}$

[20]. The various types of hyperlipidemia were diagnosed when TC content was ≥ 5.7 mmol/L and TG ≥ 1.8 mmol/L for mixed type hyperlipidemia, when TC levels were ≥ 5.7 mmol/L and TG < 1.8 mmol/L, and when LDL-C < 3.6 mmol/L and HDL-C ≥ 0.8 mmol/L for hypercholesterolemia, when the TC content was < 5.7 mmol/L and TG ≥ 1.8 mmol/L, and when LDL-C levels were < 3.6 mmol/L and HDL-C ≥ 0.8 mmol/L for hypertriglyceridemia, and when TC concentration was < 5.7 mmol/L and TG ≥ 1.8 mmol/L and LDL-C ≥ 3.6 mmol/L and HDL-C < 0.8 mmol/L for low density lipoprotein cholesterolemia. Abnormal elevation in the levels of gamma glutamyl transpeptidase (GGT), alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin (TBIL), direct bilirubin (DBIL) and indirect bilirubin (IBIL) were defined when these were ≥ 50 U/L, ≥ 40 U/L, ≥ 40 U/L, ≥ 20 μ mol/L, ≥ 6 μ mol/L and ≥ 15 μ mol/L, respectively.

Statistical analysis

The participants' physical examination results were stored in the database of the health center management system (Peking University Medical Information Technology Co., Ltd), and exported as an excel spreadsheet to extract the relevant data. All statistical analyses were performed using the SPSS statistical software suite (version 20.0, Chicago, IL, United States). Measurement data were expressed as mean $\pm$ SD. Comparisons between quantitative data and categorical variables were carried out by Student's *t*-test and χ^2 test, respectively.

Odds ratio (OR) was used to express ratio between positive to negative in FLD group and positive to negative in Non-FLD group. i.e. $OR = (\text{positive/negative in FLD group}) / (\text{positive/negative in Non-FLD group})$. Regression models was used to evaluate the relations between risk factors and FLD morbidity from specific causes by adjusting the confounding factors. In this study, multivariate analysis with statistically significant risk factors by Chi-square test at univariate model was performed by Logistic regression analysis. All reported *P*-values were two-sided, and differences with *P* < 0.05 were considered statistically significant.

Results

Demographics and distribution of fatty liver

The study population of physical examination of employees in the institute of scientific research of Beijing comprised 1466 males and 1075 females besides 19 of having HBV/HCV inflections, 12 of lung shadow, 32 of fibroid, 9 of influenza and 147 of missing. The average age of participants was 39.4 ± 9.4 years old (range: 19–60 years) and they were divided to four groups, each with a ten years coverage. The percentage of FLD was 43.5% based on abdominal ultrasonography (1105/2541), with an obvious higher prevalence in males than in females (50.0% vs 34.6%, *P* < 0.001). As presented in Table 1, the prevalence of FLD was much higher in males than in females (65.7% vs 34.3% in the 30 to 39 year-old group, and 57.1% vs 41.7% in the 40 to 49 year-old group), and this trend did not exist in the other two age groups (for both *P* < 0.001, $\chi^2 = 205.6$) (shown in Table 1).

Table 1
Age and gender distribution of overall fatty liver prevalence and total populations (%)

Age	Total Populations	Positive in populations	In males	In females	χ^2	<i>P</i>
19–29	429	89(20.7)	51(57.3)	38(42.7)	2.2	0.141
30–39	953	367(38.5)	241(65.7)	126(34.3)	18.4	< 0.001
40–49	751	375(49.9)	230(61.3)	145(38.7)	17.7	< 0.001
50–60	408	274(67.2)	211(77.0)	63(23.0)	2.7	0.098
Total	2541	1105(43.5)	733(66.3)	372(33.7)	59.8	< 0.001

Characteristics and prevalence in the total populations and FLD

1105 participants were diagnosed with FLD by physical examination. The incidence of all the markers basically showed an obvious increase in the FLD group when compared with the non-FLD and total study population. The top five strongest markers consisted of four disease and six biochemical markers and its morbidity rate are listed in order as follows in total and FLD populations: overweight and obesity (47.5% vs 27.7% vs 72.4%), prehypertension (47.1% vs 49.1% vs 44.7%), hyperlipidemia (33.3% vs 20.7% vs 49.8%), hypertension (27.2% vs 17.8% vs 39.1%), hypertriglyceridemia (14.2% vs 7.1% vs 23.5%)(shown in Table 2).

Table 2
Prevalence and categorization in the total study population (%)

Markers	Total populations		FLD populations		Non-FLD population	
	No.	Positive No.	No.	Positive No.	No.	Positive No.
Fatty liver	2541	1105(43.5)	1105	1105(100)	1436	0(0.00)
Overweight and above	1718	816(47.5)	761	551(72.4)	957	265(27.7)
Prehypertension	2346	1106(47.1)	1030	460(44.7)	1316	646(49.1)
Hypertension	2346	637(27.2)	1030	403(39.1)	1316	234(17.8)
Prediabetes	2498	98(3.9)	1085	77(7.1)	1413	21(1.5)
Diabetes	2498	106(4.2)	1085	86(7.9)	1413	20(1.5)
Hyperlipidemia	2497	831(33.3)	1083	539(49.8)	1414	292(20.7)
Mixed type hyperlipidemia	2497	179(7.2)	1083	141(13.0)	1414	38(2.7)
Hypercholesterolemia	2497	45(1.8)	1083	16(1.5)	1414	29(2.1)
Hypertriglyceridemia	2497	355(14.2)	1083	255(23.5)	1414	100(7.1)
LDL cholesterolemia	2497	33(1.3)	1083	13(1.2)	1414	20(1.4)
GGT rise	2501	274(11.0)	1086	199(18.3)	1415	75(5.3)
ALT rise	2501	321(12.8)	1086	240(22.1)	1415	81(5.7)
AST rise	2501	99(4.0)	1086	66(6.1)	1415	33(2.3)
Total bilirubin	2501	336(13.4)	1086	129(11.9)	1415	207(14.6)
Direct bilirubin	2499	285(11.4)	1084	111(10.2)	1415	174(12.3)
Indirect bilirubin	1468	177(12.1)	658	63(9.6)	810	114(14.1)
Note: The missing number of less than 2541 or 1105 was due to employee failing to attend physical examination. LDL cholesterolemia: Low density lipoprotein cholesterolemia. GGT: Gamma glutamyl transpeptidase. ALT: Alanine aminotransferase. AST: Aspartate aminotransferase.						

Gender and age distribution of participants diagnosed with fatty liver

The gender distribution of prevalence and categorization of the 1105 participants with FLD is listed in Table 3. The prevalence of FLD was relatively higher in males than females for most of the markers apart from prehypertension and hypercholesterolemia (overweight and obesity: 81.4% vs 54.2%; hypertension: 46.2% vs 23.9%; hyperlipidemia: 57.7% vs 34.0%; hypertriglyceridemia: 29.1% vs 12.4%; GGT rise: 24.6% vs 5.8%; ALT rise: 28.9% vs 8.5%; TBIL: 15.8% vs 4.1%; DBIL: 13.6% vs 3.6%; IBIL: 13.3% vs 2.3%; prediabetes: 8.6% vs 4.1%; diabetes: 9.8% vs 4.1%). However, the incidence was lower for prehypertension and hypercholesterolemia in males than in females (prehypertension: 42.9% vs 48.5%; hypercholesterolemia: 1.0% vs 2.5%) in the FLD group. The first top five ranking markers were overweight and obesity, hyperlipidemia, hypertension, prehypertension and hypertriglyceridemia for

males, and overweight and obesity, prehypertension, hyperlipidemia, hypertension and hypertriglyceridemia for females.

Table 3
Gender distribution of prevalence and categorization in the 1105 fatty liver populations (%)

Markers	Populations in males		Populations in females		χ^2	<i>P</i>
	Examined Positive		Examined Positive			
Overweight and above	510	415(81.4)	251	136(54.2)	62.2	< 0.001
Prehypertension	704	302(42.9)	326	158(48.5)	2.8	0.095
Hypertension	704	325(46.2)	326	78(23.9)	46.3	< 0.001
Prediabetes	722	62(8.6)	363	15(4.1)	7.3	0.007
Diabetes	722	71(9.8)	363	15(4.1)	10.8	0.001
Hyperlipidemia	721	416(57.7)	362	123(34.0)	54.2	< 0.001
Mixed type hyperlipidemia	721	59(8.2)	362	18(5.0)	3.8	0.052
Hypercholesterolemia	721	7(1.0)	362	9(2.5)	3.8	0.051
Hypertriglyceridemia	721	210(29.1)	362	45(12.4)	37.3	< 0.001
LDL cholesterolemia	721	10(1.4)	362	3(0.8)	0.3	0.617
GGT rise	723	178(24.6)	363	21(5.8)	57.3	< 0.001
ALT rise	723	209(28.9)	363	31(8.5)	58.2	< 0.001
AST rise	723	48(6.6)	363	18(5.0)	1.2	0.274
Total bilirubin	723	114(15.8)	363	15(4.1)	31.3	< 0.001
Direct bilirubin	722	98(13.6)	362	13(3.6)	26.1	< 0.001
Indirect bilirubin	437	58(13.3)	221	5(2.3)	20.6	< 0.001

The age prevalence distribution of diseases and biochemical markers in the 1105 participants with FLD is displayed in Table 4. The overall prevalence increased with age, which was statistically significant different for all disease markers and for two of the biochemical markers (hyperlipidemia and ALT rise), and there was no age bias. However, the prevalence of ALT rise decreased prominently with age (28.4–28.3% to 20.5–13.8%, $P < 0.05$).

Table 4
Age distribution of prevalence and categorization in the 1105 fatty liver populations (%)

Markers	Populations examined	19–29	30–39	40–49	50–60	χ^2	<i>P</i>
Overweight and above	48:245:274:194	28(58.3)	188(76.7)	187(68.2)	148(76.3)	10.9	0.012
Prehypertension	76:341:352:261	38(50.0)	159(46.6)	167(47.4)	96(36.8)	9.1	0.028
Hypertension	76:341:352:261	23(30.3)	108(31.7)	140(39.8)	132(50.6)	24.9	< 0.001
Prediabetes	88:364:365:268	2(2.3)	14(3.8)	29(7.9)	32(11.9)	18.9	< 0.001
Diabetes	88:364:365:268	4(4.5)	11(3.0)	34(9.3)	37(13.8)	27.0	< 0.001
Hyperlipidemia	88:364:363:268	32(36.4)	162(44.5)	184(50.7)	161(60.1)	21.9	< 0.001
Mixed type hyperlipidemia	88:364:363:268	9(10.2)	39(10.7)	48(13.2)	45(16.7)	5.6	0.133
Hypercholesterolemia	88:364:363:268	2(2.3)	4(1.1)	3(0.8)	7(2.6)	3.9	0.271
Hypertriglyceridemia	88:364:363:268	13(14.8)	80(22.0)	93(25.6)	69(25.7)	5.8	0.119
LDL cholesterolemia	88:364:363:268	1(1.1)	4(1.1)	5(1.4)	3(1.1)	0.1	0.986
GGT rise	88:364:365:269	13(14.8)	59(16.2)	75(20.5)	52(19.3)	3.2	0.359
ALT rise	88:364:365:269	25(28.4)	103(28.3)	75(20.5)	37(13.8)	21.5	< 0.001
AST rise	88:364:365:269	7(8.0)	26(7.1)	23(6.3)	10(3.7)	3.9	0.270
Total bilirubin	88:364:365:269	12(13.6)	38(10.4)	43(11.8)	36(13.4)	1.6	0.667
Direct bilirubin	88:364:365:269	11(12.5)	33(9.1)	39(10.7)	28(10.4)	1.1	0.767
Indirect bilirubin	47:191:235:185	5(10.6)	14(7.3)	28(11.9)	16(8.6)	2.8	0.416

Comparison of prevalence between populations with fatty liver and non-fatty liver

Comparison of the fatty liver to the non-fatty liver control group revealed gender and age distribution differences ($\chi^2 = 59.8$ for gender and $t = -15.2$ for age or $\chi^2 = 205.6$ for age group, $P < 0.05$), therefore we analyzed the odds ratio (OR) to identify the risk factors associated with FLD. The Chi-square test was performed to assess factors such as BMI, prehypertension, hypertension, prediabetes, diabetes, hyperlipidemia, mixed type hyperlipidemia, hypertriglyceridemia, and the rise of GGT, ALT, AST, total bilirubin and indirect bilirubin between populations with and without FLD ($P < 0.05$). The values of OR and 95% confidence interval (95% CI) are listed in a descending order in Table 5, starting with overweight and obesity, diabetes, prediabetes, ALT rise, GGT rise and so on.

Table 5
Comparison of prevalence of risk factors between with and without fatty liver (%).

Markers	Populations with fatty liver		Populations without fatty liver		OR	95%CI	χ^2	P
	Examined	Positive	Examined	Positive				
Overweight and above	761	551(72.4)	957	265(27.7)	6.85	5.54 ~ 8.48	339.9	< 0.001
Prehypertension	1030	460(44.7)	1316	646(49.1)	0.84	0.71 ~ 0.99	4.5	0.033
Hypertension	1030	403(39.1)	1316	234(17.8)	2.97	2.46 ~ 3.59	133.1	< 0.001
Prediabetes	1085	77(7.1)	1413	21(1.5)	5.06	3.10 ~ 8.26	51.3	< 0.001
Diabetes	1085	86(7.9)	1413	20(1.4)	6.00	3.66 ~ 9.82	64.0	< 0.001
Hyperlipidemia	1083	539(49.8)	1414	292(20.7)	3.81	3.20 ~ 4.54	234.2	< 0.001
Mixed type hyperlipidemia	1083	141(13.0)	1414	38(2.7)	5.41	3.74 ~ 7.81	98.1	< 0.001
Hypercholesterolemia	1083	16(1.5)	1414	29(2.1)	0.72	0.39 ~ 1.33	1.1	0.286
Hypertriglyceridemia	1083	255(23.5)	1414	100(7.1)	4.05	3.16 ~ 5.18	136.5	< 0.001
LDL cholesterolemia	1083	13(1.2)	1414	20(1.4)	0.85	0.42 ~ 1.71	0.2	0.643
GGT rise	1086	199(18.3)	1415	75(5.3)	4.01	3.03 ~ 5.30	106.8	< 0.001
ALT rise	1086	240(22.1)	1415	81(5.7)	4.67	3.58 ~ 6.10	147.3	< 0.001
AST rise	1086	66(6.1)	1415	33(2.3)	2.71	1.77 ~ 4.15	22.7	< 0.001
Total bilirubin	1086	129(11.9)	1415	207(14.6)	0.79	0.62 ~ 1.00	4.0	0.046

Markers	Populations with fatty liver		Populations without fatty liver		OR	95%CI	χ^2	<i>P</i>
	Examined	Positive	Examined	Positive				
Direct bilirubin	1084	111(10.2)	1415	174(12.3)	0.81	0.63 ~ 1.05	2.6	0.109
Indirect bilirubin	658	63(9.6)	810	114(14.1)	0.65	0.47 ~ 0.90	6.9	0.008

Multiple factors regression analysis was carried out to compare the risk factors of FLD which displayed significant difference by single factor Chi-square test analysis, and the corresponding results are shown in Table 6. Logistic regression analysis revealed that there were statistically significant differences in age, overweight and obesity, prediabetes, diabetes, mixed type hyperlipidemia, hypertriglyceridemia and ALT rise ($P < 0.05$).

Table 6
Multiple Logistics regression analysis of risk factors for fatty liver

Markers	B	Std. Error	Wald	Sig.	Exp(B)	95% CI for Exp(B)
Gender	-0.309	0.186	2.775	0.096	0.734	0.510 ~ 1.056
Age	0.066	0.010	46.101	0.000	1.069	1.048 ~ 1.089
Overweight and above	-1.579	0.178	78.440	0.000	0.206	0.145 ~ 0.292
Prehypertension	-0.013	0.207	0.004	0.949	0.987	0.658 ~ 1.480
Hypertension	-0.396	0.233	2.878	0.090	0.673	0.426 ~ 1.063
Prediabetes	-1.596	0.557	8.213	0.004	0.203	0.068 ~ 0.604
Diabetes	-1.161	0.501	5.366	0.021	0.313	0.117 ~ 0.836
Hyperlipidemia	-0.029	0.242	0.014	0.906	0.972	0.605 ~ 1.562
Mixed type hyperlipidemia	-1.209	0.411	8.656	0.003	0.298	0.133 ~ 0.668
Hypertriglyceridemia	10.759	0.300	6.398	0.011	0.468	0.260 ~ 0.843
GGT rise	0.192	0.279	0.470	0.493	1.211	0.700 ~ 2.094
ALT rise	-0.968	0.288	11.296	0.001	0.380	0.216 ~ 0.668
AST rise	-0.674	0.450	2.245	0.134	0.510	0.211 ~ 1.231
Total bilirubin	-0.765	0.664	1.328	0.249	0.465	0.127 ~ 1.710
Indirect bilirubin	1.216	0.688	3.126	0.077	3.374	0.876 ~ 12.995
Constant	3.732	1.133	10.852	0.001	41.752	–

Discussion

FLD is a common clinical pathologic syndrome that manifests from hepatic steatosis and excessive fat accumulation induced by a variety of factors. Despite the increase in alcohol sales in China, the intake of alcohol in public institutions has been significantly reduced by government policies. However, NAFLD is still prevalent and is strongly associated with metabolic disorders. Not surprisingly, FLD has been frequently reported in patients with type 2 diabetes mellitus (T2DM) and obesity, accounting for 40–80% and 30–90%, respectively^[21]. Thus it is necessary to track FLD progress as it may develop to steatohepatitis, fatty liver cirrhosis, and associated virus hepatocellular carcinoma. Although liver biopsy is the gold standard for the diagnosis of FLD, abdomen ultrasonography is still a general approach to screen FLD especially in adult populations. The prevalence of NAFLD has increased globally and recently became the predominant cause of chronic liver disease around the world. The epidemiology and demographic characteristics vary worldwide^[3]. The incidence rate of FLD, diagnosed by ultrasonography, was reported to be more than 46% in developed countries^[7, 22, 23] and 39.5% in developing countries^[4, 24], and it is still on the rise.

In the current study in Fangshan Branch of the Beijing Nuclear Industry Hospital, the prevalence of FLD was 43.5%, which was higher than the results reported by another survey study in Beijing^[24]. However, only 19 to 60-year-old subjects were employed in the research and 17.9% of patients below 40-year-old were diagnosed with FLD (16.1% is the standard). The prevalence increased with age, which was dramatically higher than previously estimated values in other Chinese cities^[25, 26]. Overall, the age group with the highest FLD prevalence was the over 50-year-old group^[27], at which age the adiponectin levels in women also generally decreased. According to the results shown in Table 1, there was a negative correlation between FLD prevalence and adiponectin levels, which could explain the lower incidence of FLD in women over 50-year-old as at this age they undergo menopause and as a result have lower estrogen and higher androgen levels. As a whole, the prevalence of FLD, overweight and above, prehypertension (hypertension) and hyperlipidemia was relatively high in the total population (Table 2). Actually, age comes with experience and higher responsibility in the working environment. Intense competition for title assessment and promotion and the prolonged working hours in this institute has resulted in the personnel to decrease physical activity time, leading to the prevalence of overweight and obesity and hypertension, which are risk factors for developing FLD with diabetes^[3, 11, 20, 24]. The westernized diet, irregular diet, reduced physical exercise, hypertension and diabetes are major determinants of FLD among Chinese scientific researchers. The incidence of overweight and obesity, hypertension and diabetes was considerably high in the 1105 participants diagnosed with FLD. As seen in the Table 2, the prevalence of the other biochemical markers was consistent with that of disease markers, and both resembled that of hyperlipidemia and FLD.

Previous reports have indicated that males have more risk to develop FLD than females after the age of 50^[28]. However, alcohol-related FLD (AFLD) in males is more prominent than in females under excessive alcohol consumption. In this research, AFLD and NAFLD were not separately investigated. The rate of rise of the levels of biochemical markers for MetS in males exceeded that of females, with the exception of AST. The prevalence of FLD was 50% in males and 34.6% in females, which was relatively higher than what has been reported in a previous Chinese study^[29]. The results of gender distribution of prevalence and categorization in the 1105 participants with FLD (Table 3), were in agreement with the findings of a Japanese study^[30]. Besides, males usually consume high fat diet and as a consequence store fat in their abdomen, whereas females that look after their weight tend to utilize fat in the subcutaneous tissue by weight loss plans such as physical exercise. The reason why the prevalence of overweight and above was still high remains uncertain. The differential fat accumulation in males and females may be a consequence of their different lipid metabolism pathways. The

comparative values and distribution of different genders are listed in Table 3. Briefly, our study, along with previously published findings, highlights the importance of prevention and screening of FLD in specific age populations. It has been reported that a high protein and hypocaloric diet are associated with improved lipid profile, glucose homeostasis and liver enzymes function in NAFLD, independent to BMI decrease or body fat mass reduction ^[31]. However, our results showed statistically significant differences in all disease markers and two of the biochemical markers (hyperlipidemia and ALT rise) between the age groups in the FLD group. As shown in Table 4, the prevalence of prehypertension and ALT rise decreased by aging, and this rise was surprisingly higher in the 19 to 29 year-old group than in the other three groups. On the other hand, although the prevalence of other markers increased with age, there were no significant differences between the age groups.

In the current study most FLDs were diagnosed in participants without any clinical symptoms. Over 50% of cases with FLD had mildly increased contents of biochemical markers, most of which were also accompanied by a rise in cholesterol, triglyceride, LDL cholesterol, GGT, AST levels. There were significant differences in hyperlipidemia, mixed type hyperlipidemia, hypertriglyceridemia, GGT, AST and AST between the FLD and non-FLD group (Table 5). These alterations were found to be associated with certain disease markers. However, in this cohort study analysis of risk factors contributing to the prevalence of FLD was not performed. These results suggest that FLD, with NAFLD being the most common type, may be correlated with those disorders. Additionally, age and gender are basic risk factors as they play important roles in the development of NAFLD ^[32]. Multiple Logistic analysis was carried out to identify risk factors for the analysis of the prevalence of FLD. The vital risk factors determined in this study were: age, overweight and obesity, prediabetes, diabetes, mixed type hyperlipidemia, hypertriglyceridemia and ALT (Table 6). However, our study included a single-site population and diagnosis of FLD was based on ordinary physical examination, which may limit the application of the identified markers for screening larger populations. Therefore, further studies with higher number of participants from various institutes of scientific research, including more demographic and biochemical data, are required in the future.

Recently, FLD has also been attributed to NAFLD, which is characterized by a heightened systemic pro-inflammatory state. NAFLD accelerates the risks of arteriosclerosis and other cardiovascular diseases or associated events ^[33]. However, the previously reported correlation relationship between total cholesterol levels and cancer risk ^[34] is controversial because in the current study we found that FLD prevalence was associated with other risk factors (*e.g.*, gender, age, overweight and obesity, hypertension, diabetes and MetS), and NAFLD was closely related to the incidence of cardiovascular disease, a clear risk factor for hyperlipidemia ^[35]. The incidence and mortality rates of cardiovascular diseases were the highest amongst chronic diseases worldwide ^[36]. The most common causes of death by NAFLD are atherosclerotic cardiovascular diseases and hepatic cirrhosis ^[37], hence it is important to regularly screen for FLD to prevent development of disease. The screening and prevention of obesity and hypertension are also of great importance, as they are risk factors of cardiovascular diseases and their prevalence was 39.1% and 7.9%, respectively, in the FLD group. Therefore, more attention should be paid to systemic diseases of the cardiovascular, urinary, digestive and respiratory system during physical examination, instead of the incidence of overweight and above, diabetes, hypertension and dyslipidemia.

Conclusion

high prevalence of FLD was discovered in employees of the institute of scientific research by physical examination, thus targeted intervention should be carried out as soon as possible. However, this study also has some shortcomings. First, the demographic information was relatively small; second, the diagnosed FLD had not

regarding severity with mild, moderate and severe; besides, the level of AST and ALT is parallel, while in this study, the rise of ALT and AST was not similar; lastly, the incidence of pre-hypertension was too high in this study, more relative studies are needed to gain more detailed information for FLD in the general populations from other graduate schools and colleges to determine the contribution of the above risk factors to FLD development and to set up better guidelines for prevention and control of chronic diseases.

Abbreviations

gamma glutamyl transpeptidase (GGT), alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin (TBIL), direct bilirubin (DBIL), indirect bilirubin (IBIL), total cholesterol (TC), triglyceride (TG), low density lipoprotein cholesterol (LDL-C), fatty liver disease (FLD), non-alcoholic fatty liver disease (NAFLD).

Declarations

There study was approved by the ethics committee of Soochow University.

Ethics approval and consent to participate

Not applicable.

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Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Author contributions

SGQ conceived and designed the study. SGQ and HQC performed this study, HQC and DML extracted the data, SGQ analyzed the data. SGQ, HQC and DML participated in the writing of this paper. All authors have read and approved this manuscript.

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Competing interests

The authors declare that that they have no competing interests.

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