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Original Article

Effect of evacuation on liver function after the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey

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ABSTRACT

Background: The Great East Japan Earthquake and subsequent Fukushima Daiichi Nuclear Power Plant accident caused residents to switch from their normal lives to lives focused on evacuation. We evaluated liver function before and after this disaster to elucidate the effects of evacuation on liver function.
Methods: This study was a longitudinal survey of 26,006 Japanese men and women living near the Fukushima Daiichi Nuclear Power Plant. This study was undertaken using data from annual health checkups conducted for persons aged 40–90 years between 2008 and 2010. Follow-up examinations were conducted from June 2011 to the end of March 2013, with a mean follow up of 1.6 years. Changes in liver function before and after the disaster were compared among evacuees and non-evacuees. We also assessed groups according to alcohol drinking status.
Results: The prevalence of liver dysfunction significantly increased in all participants from 16.4% before to 19.2% after the disaster. The incidence of liver dysfunction was significantly higher in evacuees than in non-evacuees. Multivariate logistic regression analysis showed that evacuation was significantly associated with liver dysfunction among residents.
Conclusions: This is the first study to show that evacuation due to the Fukushima Daiichi nuclear power plant disaster was associated with an increase in liver dysfunction.
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Introduction

The Great East Japan Earthquake, which occurred on March 11, 2011 in the Pacific coast of the northern area of Japan, registered a magnitude 9.0. The earthquake caused serious damage, including a subsequent tsunami and an accident at the Fukushima Daiichi Nuclear Power Plant. As a result, more than 160,000 residents in Fukushima Prefecture were forced to evacuate.

Health problems subsequent to extensive lifestyle changes are a matter of great concern worldwide. As such, the "Fukushima Health Management Survey (FHMS)" was started after the earthquake.[1] The survey was launched to monitor the long-term health of residents and comprises four detailed surveys, including a comprehensive health check for all residents from evacuation zones. Some reports have shown an increase in cardiovascular disease, stroke, and peptic ulcers after a disaster.[2–7] However, few reports have examined changes in liver function after a disaster.[8] Recently, we reported that liver dysfunction increased after the Great East Japan Earthquake in the 2011–2012 follow-up of the FHMS; however, the causes and risk factors for liver dysfunction are still unknown.[9] The goals of the present study were to elucidate effects of evacuation on changes in liver function among residents in the Fukushima Prefecture in Japan after the Great East Japan Earthquake.

Methods

Study population

We analyzed a subset of participants from FHMS. Participants were Japanese men and women living near the Fukushima Daiichi Nuclear Power Plant in the following areas of Fukushima Prefecture: Tamura City, Minamisoma City, Kawamata-machi, Hirono-machi, Naraha-machi, Tomioka-machi, Kawauchi-mura, Okuma-machi, Futaba-machi, Namie-machi, Katsurao-mura, Iitate-mura, and Date City. In 2010, the Census populations of these communities were 42,085, 71,661, 16,065, 5,495, 7927, 15,854, 3074, 11,553, 7171, 21,551, 1582, 6584, and 67,684 people, respectively (total, 278,276 people). Following the disaster, the government designated the 20-km-radius area around the Fukushima Daiichi Nuclear Power Plant as a "restricted area" with compulsory evacuation. The government subsequently designated a 20- to 30-km-radius area around the plant as an "evacuation-prepared area in case of emergency," and areas near the 30-km-radius area where high-level radiation exposure (>20 mSv/y) was expected were designated as "deliberate evacuation areas". As a result, all residents of Hirono-machi, Naraha-machi, Tomioka-machi, Kawauchi-mura, Okuma-machi, Futaba-machi, Namie-machi, Katsurao-mura, Iitate-mura, and part of Tamura City, Minamisoma City, Kawamata-machi, and Date City were forced to evacuate their homes at the direction of the government, based on increased local radiation levels after the Fukushima Daiichi Nuclear Power Plant accident (Fig. 1). In these communities, residents aged 40–74 years and the elderly aged ≥75 years (the target population for checkups consisted of 91,554 men and women in 2010) have undergone annual health checkups for insured people of the Japan's National Health Care Insures. This study limited all analyses to men and women aged 40–90 years (the census population aged 40–90 years of these communities was 164,714 in 2010). Between 2008 and 2010, 41,633 participants (18,745 men and 22,888 women; mean age, 67 years) in the communities

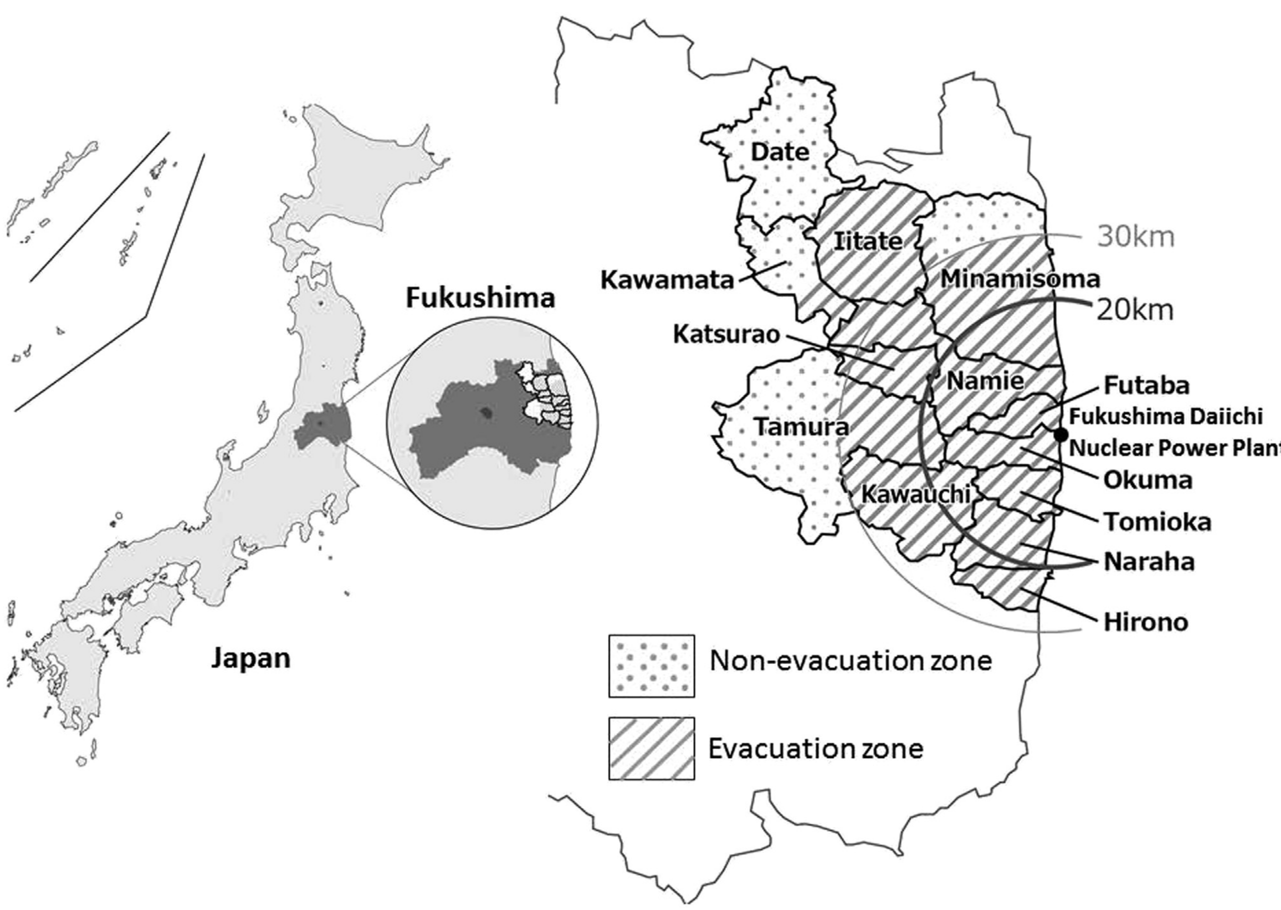

Fig. 1. Map of the evacuee zone, non-evacuee zone, and the Tokyo Daiichi Nuclear Power Plant.

participated in the health checkups. The participation rates for the initial Census population and the target population for checkups were 25.3% and 45.5%, respectively.

Follow-up health checkups were conducted from June 2011 to the end of March 2013 as a part of a comprehensive health check. Detailed methods of the comprehensive health check have been published previously.[1] The FHMS and the follow-up survey was conducted countrywide because the subjects evacuated to various parts of the country.[1] As a result, a total of 27,486 participants (12,432 men and 15,054 women) underwent the follow-up examination after the disaster, with a mean follow up of 1.6 years. If people participated in the checkups more than once during each survey period (before the disaster, 2008–2010, and after the disaster, 2011–2012), we used the data from the latest year in 2008–2010 and from the earliest year in 2011–2012 in order to examine the direct effect of the disaster on health status. We excluded 1480 participants with insufficient data for liver function. Ultimately, 26,006 (11,715 men and 14,291 women) participants were eligible for this study. A total of 8684 (33.4%) were evacuees and 17,322 participants (66.6%) were not.

Informed consent was obtained from community representatives to conduct an epidemiologic study based on the guidelines of the Council for International Organizations of Medical Science.[10] This study was approved by the Ethics Committee of the Fukushima Medical University (#1916).

Biochemical analysis

Laboratory data obtained from participants as follows: aspartate aminotransferase (AST; IU/L); alanine aminotransferase (ALT; IU/L); gamma-glutamyl transpeptidase (γ-GTP; IU/L); high-density lipoprotein cholesterol (HDL-C; mg/dL); low-density lipoprotein cholesterol (LDL-C; mg/dL); triglycerides (TG; mg/dL); fasting plasma glucose (FPG; mg/dL); and HbA1c (%). The values for HbA1c were estimated according to the National Glycohemoglobin Standardization Program, and the equivalent value was calculated using the equation: HbA1c (%) $= 1.019 \times$ HbA1c (Japanese Diabetes Society) (%) $+ 0.4\%$.[11] Liver dysfunction was defined as AST $\geq$40 IU/L, or ALT level $\geq$40 IU/L, or γ-GTP level $\geq$50 IU/L. Diabetes was defined as a fasting plasma glucose level $\geq$126 mg/dL, HbA1c level $\geq$6.5%, or the self-reported use of antihyperglycemic agents. Dyslipidemia was defined as a fasting LDL-C level $\geq$140 mg/dL, fasting TG level $\geq$150 mg/dL, fasting HDL-C level <40 mg/dL, or self-reported use of antidyslipidemic agents.

Assessment for other variables

Height in stocking feet and weight in light clothing were measured, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). Overweight was defined as BMI $\geq$25 kg/m^2. Systolic and diastolic blood pressure (BP) was measured by trained technicians using a standard mercury sphygmomanometer on the right arm of seated participants. Hypertension was defined as a systolic blood pressure of more than 140 mmHg, diastolic blood pressure of more than 90 mmHg, or the self-reported use of antihypertensive agents. An interview was performed to obtain the history of cigarette smoking, weekly alcohol intake, and medication history. Participants were divided into three groups according to alcohol intake: 1) non-drinkers were defined as drinking no alcohol; 2) light drinkers were defined as drinking $\leq$22 g of ethanol per day; and 3) moderate/heavy drinkers were defined as drinking >22 g of ethanol per day.

Statistical analysis

Changes in data before and after the disaster were compared using the paired Student's t test, Wilcoxon's test, or McNemar's test. The difference in prevalence of liver dysfunction after the disaster between evacuees and non-evacuees was compared using χ^2 test. For participants without liver dysfunction at baseline (before the disaster), we tested associations between evacuation and other potential confounders with the incidence of liver dysfunction after the disaster using multivariate logistic regression analysis. The following variables were considered potential confounding factors: age (continuous), sex, BMI (continuous), current smoking (yes or no), and evacuation (yes or no). Moreover, multiple regression analysis was used to examine the association of changes in serum AST, ALT, or γ-GTP and the potential confounding factors. Analysis was stratified by drinking status (non-drinkers, light drinkers, or moderate/heavy drinkers) because alcohol intake is one of major causes of liver dysfunction. SAS version 9.3 (SAS Institute, Cary, NC, USA) was used for all statistical analyses. All probability values for statistical tests were two-tailed, and p values <0.05 were considered statistically significant.

Results

Overall, the prevalence of liver dysfunction significantly increased from 16.4% to 19.2% ($p < 0.001$) after the disaster. Moreover, the prevalence of liver dysfunction significantly increased in all three groups (non-drinkers, light drinkers, and moderate/heavy drinkers). The prevalence of liver dysfunction in non-, light, and moderate/heavy drinkers significantly increased from 9.0% to 11.7%, 12.9% to 15.5%, and 41.2% to 44.6%, respectively, after the disaster (Table 1). In all three groups, the prevalence of overweight, hypertension, dyslipidemia, and diabetes also increased.

The change in prevalence of liver dysfunction was greater in evacuees than in non-evacuees ($p < 0.001$ for all comparisons) (Table 2). In non-drinkers, the prevalence of liver dysfunction significantly increased from 9.8% to 14.2% in evacuees ($p < 0.001$) and from 8.7% to 10.4% in non-evacuees ($p < 0.001$). In light drinkers, the prevalence of liver dysfunction significantly increased from 12.5% to 18.9% in evacuees ($p < 0.001$), and from 13.1% to 13.9% in non-evacuees ($p < 0.001$). In moderate/heavy drinkers, the prevalence of liver dysfunction significantly increased from 44.0% to 48.8% ($p < 0.001$) in evacuees and from 39.7% to 42.5% in non-evacuees ($p < 0.001$).

AST, ALT, and γ-GTP levels were significantly increased in both evacuees and non-evacuees after the disaster, regardless of drinking group. In non- and light drinkers, changes in AST, ALT, and γ-GTP level were significantly greater in the evacuee group than in the non-evacuee group ($p < 0.01$). In moderate/heavy drinkers, only changes in AST levels were significantly greater in the evacuee group than in the non-evacuee group ($p < 0.01$).

After the disaster, 884 participants (12.3%) in the evacuee group were defined as having liver dysfunction, while 1076 participants (7.4%) had liver dysfunction in the non-evacuee group. Multivariate logistic regression was used to explore risk factors associated with liver dysfunction after the disaster. After adjusting for age, sex, baseline BMI and smoking status at baseline, evacuation was significantly associated with liver dysfunction in non-drinkers. Furthermore, age, sex, and baseline BMI were also significantly associated with liver dysfunction in non-drinkers. After adjusting for age, sex, baseline BMI, alcohol intake, and smoking status at baseline, evacuation was also significantly associated with liver dysfunction in both light and moderate/heavy drinkers.

Table 1
Clinical and biochemical characteristics of 26,006 participants classified according to alcohol intake status before and after the Great East Japan Earthquake.

	Non-drinkers			Light drinkers			Moderate/Heavy drinkers		
	Before	After	*p*-Value	Before	After	*p*-Value	Before	After	*p*-Value
Number	8914			12,644			4448		
Sex, male/female	1894/7020			5623/7021			4198/250		
Age, years	68.1 (9.1)	69.6 (9.1)		65.7 (9.4)	67.2 (9.4)		64.6 (8.9)	66.1 (8.8)	
Body weight, kg	53.9 (9.7)	54.4 (9.9)	<0.001	57.2 (9.9)	57.8 (10.1)	<0.001	62.7 (9.4)	63.7 (9.7)	<0.001
BMI, kg/m^2	23.4 (3.4)	23.7 (3.5)	<0.001	23.4 (3.2)	23.7 (3.3)	<0.001	23.6 (2.9)	24.0 (3.0)	<0.001
Overweight: BMI ≥25, %	30.1	33.3	<0.001	28.4	32.6	<0.001	30.13	35.25	<0.001
Hypertension, %	55.4	60.8	<0.001	50.6	56.3	<0.001	60.81	67.65	<0.001
Smoking, %	6.5	5.5	<0.001	10.8	9.4	<0.001	31.4	27.5	<0.001
Dyslipidemia, %	28.9	32.7	<0.001	23.6	27.45	<0.001	14.0	17.6	<0.001
Diabetes, %	9.4	10.4	<0.001	8.0	9.29	<0.001	8.8	11.0	<0.001
AST, IU/L[a]	23 (19–26)	23 (19–27)	<0.001	23 (19–27)	23 (20–27)	<0.001	25 (22–30)	26 (22–31)	<0.001
ALT, IU/L[a]	17 (13–22)	17 (13–23)	<0.001	17 (14–23)	18 (14–24)	<0.001	20 (15–27)	21 (16–29)	<0.001
γ-GTP, IU/L[a]	18 (14–25)	18 (14–27)	<0.001	21 (16–31)	22 (16–33)	<0.001	40 (27–67)	42 (27–71)	<0.001
Liver dysfunction, %	9.0	11.7	<0.001	12.9	15.5	<0.001	41.2	44.6	<0.001

AST, aspartate aminotransferase; ALT, alanine aminotransferase; BMI, body mass index; γ-GTP, gamma-glutamyl transpeptidase.
Data are mean values (standard deviation) for continuous variables and percentage values for categorical variables, unless otherwise noted.
[a] Reported as median (interquartile range).

Table 2
Changes in clinical and biochemical characteristics between non-evacuees (n = 17,322) and evacuees (n = 8684) after the Great East Japan Earthquake.

	Non-evacuees			Evacuees			*p*-Value[b]
	Before	After	*p*-Value	Before	After	*p*-Value	
Non-drinkers							
Number	5880			3034			
Sex, male/female	1254/4626			640/2394			
Age, years	68.0 (8.9)	69.5 (8.9)		68.2 (9.6)	69.9 (9.6)		
Body weight, kg	53.6 (9.6)	53.9 (9.8)	<0.001	54.5 (10.0)	55.4 (10.2)	<0.001	<0.001
BMI, kg/m^2	23.3 (3.4)	23.5 (3.5)	<0.001	23.7 (3.5)	24.2 (3.6)	<0.001	<0.001
Overweight: BMI ≥25, %	28.7	30.4	<0.001	32.9	38.9	<0.001	<0.001
Hypertension, %	54.8	60.4	<0.001	56.5	61.6	<0.001	0.004
Smoking, %	6.4	5.4	<0.001	6.6	5.8	0.008	0.263
Dyslipidemia, %	29.2	32.8	<0.001	28.4	32.6	<0.001	0.006
Diabetes, %	8.7	9.7	<0.001	10.8	11.7	0.0227	<0.001
AST, IU/L[a]	22 (19–26)	23 (19–27)	<0.001	23 (19–27)	23 (19–27)	<0.001	0.003
ALT, IU/L[a]	17 (13–21)	17 (13–22)	<0.001	17 (13–22)	17 (13–24)	<0.001	<0.001
γ-GTP, IU/L[a]	18 (14–25)	18 (14–26)	<0.001	18 (14–25)	19 (14–29)	<0.001	<0.001
Liver dysfunction, %	8.7	10.4	<0.001	9.8	14.2	<0.001	<0.001
Light drinkers							
Number	8498			4146			
Sex, male/female	3823/4675			1800/2346			
Age, years	65.7 (9.2)	67.2 (9.2)		65.7 (9.7)	67.3 (9.7)		
Body weight, kg	57.0 (9.8)	57.3 (10.0)	<0.001	57.6 (10.1)	58.8 (10.3)	<0.001	<0.001
BMI, kg/m^2	23.4 (3.2)	23.5 (3.3)	<0.001	23.6 (3.2)	24.2 (3.3)	<0.001	<0.001
Overweight: BMI ≥25, %	27.4	29.9	<0.001	30.5	38.0	<0.001	<0.001
Hypertension, %	50.5	56.3	<0.001	51.0	56.2	<0.001	0.101
Smoking, %	10.7	9.1	<0.001	11.2	10.1	<0.001	0.569
Dyslipidemia, %	23.7	26.7	<0.001	23.4	29.1	<0.001	<0.001
Diabetes, %	7.8	9.0	<0.001	8.4	9.9	<0.001	<0.001
AST, IU/L[a]	23 (19–27)	23 (20–27)	<0.001	23 (19–27)	23 (20–28)	<0.001	<0.001
ALT, IU/L[a]	17 (14–23)	18 (14–24)	<0.001	18 (14–23)	19 (14–26)	<0.001	<0.001
γ-GTP, IU/L[a]	21 (16–31)	21 (16–32)	<0.001	21 (16–31)	23 (16–35)	<0.001	<0.001
Liver dysfunction, %	13.1	13.9	0.025	12.5	18.9	<0.001	<0.001
Moderate/Heavy drinkers							
Number	2944			1504			
Sex, male/female	2802/142			1396/108			
Age, years	65.0 (8.8)	66.4 (8.8)		63.8 (8.9)	65.5 (8.8)		
Body weight, kg	62.5 (9.3)	63.0 (9.5)	<0.001	63.1 (9.6)	65.1 (9.9)	<0.001	<0.001
BMI, kg/m^2	23.5 (2.8)	23.7 (2.8)	<0.001	23.7 (3.0)	24.5 (3.1)	<0.001	<0.001
Overweight: BMI ≥25, %	28.8	31.3	<0.001	32.8	43.0	<0.001	<0.001
Hypertension, %	61.2	67.1	<0.001	60.1	68.8	<0.001	0.120
Smoking, %	30.2	26.2	<0.001	33.8	30.1	<0.001	0.297
Dyslipidemia, %	14.3	17.0	<0.001	13.4	18.7	<0.001	0.021
Diabetes, %	8.7	10.5	<0.001	9.0	12.0	<0.001	0.046
AST, IU/L[a]	25 (21–30)	25 (22–31)	<0.001	26 (22–31)	26 (22–32)	<0.001	0.005
ALT, IU/L[a]	19 (15–26)	20 (15–27)	<0.001	21 (16–28)	22 (16–32)	<0.001	0.091
γ-GTP, IU/L[a]	40 (27–65)	41 (26–67)	<0.001	42 (27–72)	45 (29–77)	<0.001	0.877
Liver dysfunction, %	39.7	42.5	<0.001	44.0	48.8	<0.001	<0.001

AST, aspartate aminotransferase; ALT, alanine aminotransferase; BMI, body mass index; γ-GTP, gamma-glutamyl transpeptidase.
Data are mean values (standard deviation) or percentage values for categorical variables, unless otherwise noted.
[a] Reported as median (interquartile range).
[b] *p* Value for comparing the changes in evacuees to the changes in non-evacuees between before and after the earthquake.

Table 3
Multivariate logistic regression analysis of factors influencing the incidence of liver dysfunction (n = 1960) after the Great East Japan Earthquake among 14,519 participants without liver dysfunction before the disaster.

Variable	Non-drinkers		Light drinkers		Moderate/Heavy drinkers	
	Odds ratio (95% CI)	*p*-Value	Odds ratio (95% CI)	*p*-Value	Odds ratio (95% CI)	*p*-Value
Age, per 1-year	0.96 (0.96–0.97)	<0.001	0.97 (0.97–0.98)	<0.001	0.98 (0.97–0.98)	<0.001
Women vs. men	0.45 (0.39–0.53)	<0.001	0.46 (0.41–0.52)	<0.001	0.41 (0.30–0.56)	<0.001
Body mass index, per 1 kg/m^2	1.15 (1.14–1.17)	<0.001	1.13 (1.12–1.15)	<0.001	1.14 (1.11–1.17)	<0.001
Smoking, yes	1.00 (0.78–1.28)	0.981	0.97 (0.83–1.13)	0.654	1.45 (1.26–1.67)	<0.001
Evacuation, yes	1.38 (1.20–1.58)	<0.001	1.43 (1.29–1.59)	<0.001	1.24 (1.09–1.42)	0.001

CI, confidence interval.

Furthermore, age, sex, and baseline BMI were also significantly associated with liver dysfunction in these groups (Table 3).

Multiple regression analyses were also performed in all subjects using changes in serum AST, ALT, and γ-GTP as dependent variables and evacuation age, sex, baseline BMI, alcohol intake, and smoking status at baseline as independent variables. Evacuation was significantly associated with changes in serum AST, ALT, and γ-GTP in both non- and light drinkers. Furthermore, evacuation was significantly associated with changes in serum ALT in moderate/heavy drinkers (Table 4).

Discussion

In the present study, we showed an increase in the prevalence of liver dysfunction after the Great East Japan Earthquake and subsequent Fukushima Daiichi nuclear power plant accident. Although many studies have examined the effects of this disaster on cardiovascular disease, mental health, and peptic ulcers,[2–7] there are few reports about liver function, despite the fact that it is an important issue for evacuees. Only one study reported elevations of AST and ALT levels after the Great Hanshin-Awaji Earthquake on January 17, 1997.[8] That study reported elevations of AST and ALT levels that were independent of drinking or obesity; however, risk factors for liver dysfunction were not evaluated and γ-GTP levels did not significantly change after the disaster. Recently, we reported that the prevalence of liver dysfunction increased after a disaster, although the causes and risk factors for liver dysfunction were not evaluated.[9] Therefore, the present study is the first report about the effects of a disaster on liver dysfunction and the first to elucidate the risk factors for liver dysfunction after a disaster using a longitudinal analysis.

The disaster has dramatically changed the lifestyle of residents. Many evacuees were subject to restricted physical activity after the Fukushima Daiichi Nuclear Power Plant accident because outside activity was restricted by the government. Reduced physical activity induces obesity, and we confirmed a significant increase in obesity after the disaster in the present study. Non-alcoholic fatty liver disease (NAFLD) is a hepatic form of metabolic syndrome; thus, obesity is strongly associated with onset of NAFLD or nonalcoholic steatohepatitis (NASH). Low physical activity is an important risk factor for NASH.[12] In the present study, being an evacuee and having an increased BMI were independent risk factors for liver dysfunction after the disaster in both non-drinkers and drinkers. Therefore, these findings may indicate that the increase in liver dysfunction after this disaster was due to an increase in fatty liver disease via increased BMI.

Alcohol intake is one of the major causes of liver dysfunction. In this study, however, the prevalence of moderate/heavy drinking significantly decreased from 17.1% to 12.1% after the disaster. Other studies have also reported a decrease in alcohol consumption after disasters or social stress.[13–16] In the present study, the prevalence of liver dysfunction significantly increased in moderate/heavy drinkers as well as in non- and light drinkers. Furthermore, changes in body weight after the disaster were positively associated with changes in liver enzymes in the participants, while changes in weekly alcohol intake were not. Therefore, increased body weight, but not alcohol intake, may have lead to the onset of liver dysfunction after the disaster in this study.

Table 4
Associations of changes in AST, ALT, or γ-GTP and factors among 26,006 participants after the Great East Japan Earthquake.

	Variable	Non-drinkers		Light drinkers		Moderate/Heavy drinkers	
		β	*p*-Value	β	*p*-Value	β	*p*-Value
ΔAST	Age, per 1 year	−0.007	0.491	−0.018	0.017	−0.020	0.386
	Women vs. men	−0.79	<0.001	−1.00	<0.001	−2.43	0.005
	Body mass index, per 1 kg/m^2	0.19	<0.001	0.13	<0.001	0.13	0.063
	Smoking, yes	−0.98	0.012	−0.35	0.138	0.87	0.047
	Evacuation, yes	0.69	<0.001	0.91	<0.001	−0.60	0.148
ΔALT	Age, per 1 year	−0.18	<0.001	−0.15	<0.001	−0.18	<0.001
	Women vs. men	−3.18	<0.001	−2.39	<0.001	−3.48	<0.001
	Body mass index, per 1 kg/m^2	0.54	<0.001	0.47	<0.001	0.49	<0.001
	Smoking, yes	−1.23	0.03	−0.13	0.695	1.08	0.028
	Evacuation, yes	1.49	<0.001	2.17	<0.001	1.39	0.003
Δγ-GTP	Age, per 1 year	−0.11	<0.001	−0.10	<0.001	−0.37	<0.001
	Women vs. men	−2.66	<0.001	−1.85	<0.001	−16.7	<0.001
	Body mass index, per 1 kg/m^2	0.26	<0.001	0.04	0.580	0.48	0.111
	Smoking, yes	0.04	0.962	1.67	0.017	9.03	<0.001
	Evacuation, yes	1.79	<0.001	2.53	<0.001	1.38	0.437

Δ, change in variable before and after the Great East Japan Earthquake; AST, aspartate aminotransferase; ALT, alanine aminotransferase; γ-GTP, gamma-glutamyl transpeptidase, β; standardized coefficients beta.
Multiple regression model included changes of AST, ALT, or γ-GTP as dependent variables and the combination of age, sex, body mass index, smoking status, and evacuation as independent variables.

This study is the first to report that being an evacuee is a risk factor for liver dysfunction, regardless of alcohol intake. Moreover, we previously confirmed that being an evacuee is an independent risk factor for obesity in the FHMS.[17] Evacuee status affects mental health as well as physical activity and daily customs. Results of a mental health and lifestyle survey through the FHMS showed that evacuees tended to feel more psychological stress and had more trouble sleeping, in addition to undertaking less physical activity.[18] Previous studies reported that depression was higher in patients with NAFLD and was associated with the histologic severity of NAFLD.[19] Kim et al indicated that there was a significant association between an increased risk of NAFLD and short sleep duration or poor sleep quality in middle-aged Koreans.[20] Recently, we also reported that short sleep duration tended to be associated with NAFLD in Japanese women within a wide age range.[21] Therefore, being an evacuee after a disaster could be associated with liver dysfunction or the onset of NAFLD not only due to changes in physical activity but also due to mental health or sleep disorders.

The present study had several limitations. First, it was based only on an analysis of routine health checkups, so we did not confirm the precise cause of liver dysfunction (e.g., viral hepatitis or medication) and we did not perform an ultrasonography. The identification of the precise cause of liver dysfunction is essential in future studies. Second, significant increases in liver dysfunction were observed among both evacuees and non-evacuees in the present study. Future research is needed to compare the changes in liver dysfunction between residents living in the evacuation area and those living in an area far from the Fukushima Daiichi Nuclear Power plant. Third, this study did not evaluate food intake, mental status, or sleep disorders, all of which can affect obesity. It is important to elucidate the lifestyle factor that are most affected by evacuation, as this could help in the development of novel strategies for protecting against the onset of liver dysfunction after a disaster.

In conclusion, this is the first report to show that being an evacuee was associated with liver dysfunction. This information could be important in periodic health checkups and lifestyle recommendations for people who are evacuated from their homes. In addition, because even non-evacuees showed an increase in liver dysfunction, periodic health checkups and lifestyle recommendations are important for all people, regardless of evacuation status.

Conflicts of interest

None declared.

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