Evacuation and Risk of Hypertension After the Great East Japan Earthquake
The Fukushima Health Management Survey


Abstract—On March 11, 2011, the Great East Japan Earthquake occurred in Japan, with a nuclear accident subsequently occurring at the Fukushima Daiichi Nuclear Power Plant. The disaster forced many evacuees to change particular aspects of their lifestyles. This study assessed the hypothesis that evacuation may have increased the risk of hypertension among residents in Fukushima. A longitudinal study examined data collected from 31,252 Japanese participants aged 40 to 74 years sourced from general health checkups conducted in 13 communities between 2008 and 2010. Follow-up examinations were conducted from 2011 through 2013. A total of 21,989 participants (follow-up proportion, 70.4%) received follow-up examinations. Mean blood pressure significantly increased in both evacuees and nonevacuees after the disaster, with greater changes in blood pressure among the former. The changes in systolic and diastolic blood pressure among the evacuees and nonevacuees were +5.8/3.4 versus +4.6/2.1 mm Hg (P<0.01/P<0.0001) for men and +4.4/2.8 versus +4.1/1.7 mm Hg (P=0.33/P<0.0001) for women, respectively. evacuation was associated with an increased risk of hypertension among men, and the age-adjusted hazard ratios of evacuation for incidence of hypertension were 1.24 (95% confidence interval, 1.11–1.39; P<0.001) for men and 1.05 (95% confidence interval, 0.94–1.17; P=0.37) for women, respectively. For men, after adjustment for confounding variables, the hazard ratio slightly decreased to 1.20, but the association was essentially unchanged. Blood pressure increased among residents, especially evacuees, in the evacuation zone of Fukushima prefecture after the Great East Japan Earthquake. evacuation may be associated with an increased risk of hypertension among men in the 2 years after the disaster. (Hypertension. 2016;68:558-564. DOI: 10.1161/HYPERTENSIONAHA.116.07499.)

Key Words: blood pressure ■ cardiovascular disease ■ disaster ■ hypertension ■ prospective study

On March 11, 2011, the Great East Japan Earthquake, registering 9.0 on the Richter scale, occurred in Japan. The earthquake provoked the subsequent tsunami that struck the Fukushima Daiichi Nuclear Power Plant (NPP), located on the east coast of Honshu. More than 160,000 residents of the Fukushima prefecture, many living in the areas surrounding the NPP, were forced to evacuate from their homes because of radiation hazards from the nuclear accident. Many epidemiological studies have previously reported that cardiovascular diseases (CVD) and related deaths tend to occur more frequently after large disasters, such as earthquakes,1-3 tsunamis,4 and hurricanes.5 For instance, compared with those in the previous years, the weekly occurrences of CVD, including out-of-hospital cardiac arrest, heart failure, acute coronary syndrome, and stroke, were significantly increased after the Great East Japan Earthquake.2,5 Because hypertension is closely related to the incidence of CVD,6 increased blood pressure (BP) is likely to be one important factor in the increase of CVD occurrences after a disaster. Although the acute effects of a disaster on increased BP have
been established in previous studies, evidence for the long-term effects of a disaster is limited. The disaster forced many evacuees from the government-designated evacuation zone in the Fukushima prefecture to change several aspects of their lifestyles, such as diet, physical exercise, and smoking and alcohol habits. Because these lifestyle changes are associated with hypertension, evacuees may have a higher risk of increased BP and hypertension. However, few longitudinal studies have reported the effect of evacuation after a disaster on the risk of hypertension among a population.

We therefore sought to examine the association of evacuation with changes in BP before and after the disaster and examine the association of evacuation with incidence of hypertension among residents in the evacuation area. Our a priori hypothesis was that BP would increase among residents in the evacuation area after the Great East Japan Earthquake, especially evacuees, and evacuation would be associated with an increased risk of hypertension via lifestyle changes after the disaster.

Methods

Study Population and Design

The subjects of this study were Japanese men and women living near the Fukushima Daiichi NPP in the Fukushima prefecture, in communities including Tamura City (2010 Census population, 42085), Minami-Soma City (71661), Kawamata-machi (16065), Hironomachi (5495), Naraha-machi (7927), Tomioka-machi (15854), Kawauchi-mura (3074), Okuma-machi (11553), Futaba-machi (7171), Namie-machi (21551), Katsurao-mura (1582), Itate-mura (6584), and Date City (67684), with a total 2010 population of 278276. After the disaster, the government designated the 20-km radius around the Fukushima Daiichi NPP a restricted area with compulsory evacuation. The government subsequently designated a 20- to 30-km area around the plant as an evacuation-prepared area in case of emergency, and areas near the 30-km radius where high-level radiation exposure was expected (>20 mSv/y) as deliberate evacuation areas. As a result, governmental direction forced all residents of Hirono-machi, Naraha-machi, Tomioka-machi, Kawauchi-mura, Okuma-machi, Futaba-machi, Namie-machi, Katsurao-mura, and Itate-mura to evacuate their homes; this was also the case for some areas of Tamura City, Minami-Soma City, Kawamata-machi, and Date City (Figure, Evacuation zone). The remaining areas in the latter communities were defined as nonevacuation zones in the present study (Figure, nonevacuation zones).

Annual health checkups focusing on metabolic syndrome for people insured by National Health Insurance aged 40 to 74 years (target population, 57552) and for the elderly aged ≥75 years (target population, 34002) have been conducted in these communities since 2008. This study limited all analyses to men and women aged 40 to 74 years (2010 Census population, 127551) because the measurement of lifestyle factors was limited to those ages. Between 2008 and 2010, 31252 subjects (14022 men and 17230 women; mean age: 62.8 years) in these communities participated in health checkups. The participation rates for the initial Census population and the target population for checkups were 24.5% and 54.3%.

Follow-up examinations were conducted from June 2011 through March 2013 as a part of the Comprehensive Health Check in the Fukushima Health Management Survey; methods are detailed in a previous report. The follow-up survey was conducted countrywide because the subjects had been evacuated to various parts of the country. As a result, 21989 participants (9730 men and 12259 women; 70.4%) received follow-up examinations after the disaster, with an average follow-up period of 2.2 years. There were some differences in baseline characteristics between individuals who received follow-up examinations and those who did not, such as mean age (61.9 versus 63.2 years), proportion of women (55.8% versus 53.7%), excessive drinkers (5.2% versus 6.7%), and prevalence of diabetes mellitus (9.1% versus 11.6%), while there were few baseline differences in mean body mass index (BMI; 23.5 versus 23.7 kg/m²) and prevalence of hypertension (49.8% versus 50.9%).

This study obtained informed consent from community representatives to conduct an epidemiological study based on the guidelines of the Council for International Organizations of Medical Science and was approved by the Ethics Committee of the Fukushima Medical University.

Measures and Definitions

At the baseline and follow-up, height in stocking feet and weight in light clothing were measured, and BMI was calculated as weight (kg)/height (m²). Overweight was defined as a BMI ≥25 kg/m². Systolic and diastolic BPs (SBP/DBP) were measured by trained technicians using a standard mercury sphygmomanometer on the right arm of seated participants. Readings were made to the nearest 2 mm Hg, and DBP was taken at the phase V Korotkoff sound. Hypertension was defined as a SBP ≥140 mm Hg, a DBP ≥90 mm Hg, or the use of antihypertensive medication. An interviewer also obtained histories for cigarette smoking and weekly alcohol intake in units of “go,” a traditional Japanese unit of volume corresponding to 22 g of ethanol, which was subsequently converted to g/d. One go equates 180 mL of sake and corresponds to 1 bottle (500 mL) of beer, 2 single shots (60 mL) of whiskey, or 2 glasses (240 mL) of wine. Participants who consumed ≥2 go (≥44 g ethanol) per day were classified as being current excessive drinkers.

Statistical Analysis

We excluded participants who had hypertension before the disaster (n=10952). The remaining 11037 participants (4515 men and 6522 women) were used in the present analyses of hypertension. The participants were divided into 2 groups: evacuees (n=3831) and nonevacuees (n=7206). Differences between the participants with incident hypertension and those without hypertension in age- and sex-adjusted mean values or proportions of potential risk factors at baseline were tested for statistical significance using ANCOVA for continuous variables and logistic regression for dichotomous variables. A paired t test was used to compare the mean values of BP and BMI before and after the disaster, and the McNemar test was used to compare the proportion of lifestyle-related variables before and after the disaster, stratified by sex. The differences in changes in BP and BMI or the proportion of lifestyle-related variables before and after the disaster between the evacuees and nonevacuees were calculated using ANCOVA or logistic regression models, with adjustments for age. The associations between changes in BP and lifestyle-related variables were analyzed with adjustments for age using linear regression or logistic regression models. The hazard ratios of incidence of hypertension after the disaster and 95% confidence intervals for evacuation were calculated with adjustments for age and other potential confounding factors using the Cox proportional hazards model. The potential confounding factors were BMI, excess ethanol intake, smoking status, and SBP at baseline for model 1 and dietary factors, physical exercise, physical activity, and sleep quality at baseline for model 2. SAS version 9.3 was used for analyses. All probability values for statistical tests were 2-tailed, with P values <0.05 regarded as statistically significant.

Results

Among the 11037 men and women followed up for an average of 2.2 years, 2604 incidents of hypertension were confirmed after the disaster. The number of cases (incidence rate per 1000 person-years) for men and women were 1242 (128) and 1362 (96). Mean values of BMI and SBP and DBP,
proportion of overweight people, people having late-night dinners at baseline, and experiences of evacuation were higher among subjects with than those without hypertension for both men and women, and proportion of excess drinkers was higher among subjects with hypertension for men (Table 1).

Table 2 shows changes in body weight, SBP and DBP, and the proportion of lifestyle-related variables among evacuees and nonevacuees before and after the disaster. Mean body weight and BP significantly increased in both evacuee and nonevacuee groups after the disaster, although changes were greater in the evacuee group. The changes in body weight and SBP and DBP among the evacuees and nonevacuees were +2.2 versus +0.6 kg (P<0.0001) and +5.8/3.4 versus +4.6/2.1 mm Hg (P<0.01/P<0.0001) for men and +1.1 versus +0.4 kg (P<0.0001) and +4.4/2.8 versus +4.1/1.7 mm Hg (P=0.33/P<0.0001) for women, respectively. Furthermore, changes in body weight and BMI among evacuees were greater in men than in women (P<0.0001). In the evacuee group, the proportion of overweight men and women increased after the disaster from 23.7% to 36.1% and from 21.9% to 29.2%, respectively, whereas proportions in the nonevacuee group increased from 19.8% to 23.1% and 18.2% to 20.7%, respectively. These change rates were significantly different between the evacuee and nonevacuee groups for both men and women. Changes in BP were greater in the evacuees than in the nonevacuees, regardless of age group. Changes in SBP/DBP among evacuees were 4.5/3.0 mm Hg for those aged <65 years and 5.7/3.3 mm Hg for those aged ≥65 years, and among nonevacuees were 3.9/1.9 mm Hg for those aged <65 years and 4.8/1.7 mm Hg for those aged ≥65 years. For lifestyle-related variables, the proportion of subjects with sufficient sleep for men and women decreased after the disaster from 75.8% to 67.5% and 69.9% to 57.4%, respectively, whereas the proportions in the nonevacuee group decreased from 77.5% to 75.0% and 71.7% to 69.7%, respectively. Age-adjusted changes in BP before and after the disaster were significantly associated with changes in BMI for both men and women. Increments in SBP and DBP per one increment of BMI (kg/m²) were 2.5 mm Hg (P<0.0001) and 1.8 mm Hg (P<0.0001) for men and 1.7 mm Hg (P<0.0001) and 1.1 mm Hg (P<0.001) for women, respectively. Furthermore, the associations were essentially unchanged after further adjustment for baseline levels of BMI. There were no significant associations between changes in BP and changes in other lifestyle factors.

As shown in Table 3, evacuation was associated with an increased risk of hypertension among men. The age-adjusted hazard ratios of evacuation for the incidence of hypertension were 1.24 (95% confidence interval, 1.11–1.39; P<0.001) for men and 1.05 (95% confidence interval, 0.94–1.17; P=0.37) for women, respectively. For men, after adjustment for age, sex, BMI, excess ethanol intake, smoking status, SBP, dietary factors, physical exercise, physical activity, and sleep quality at baseline, the hazard ratio slightly decreased to 1.20, but the association was essentially unchanged.

Discussion
The main findings of this longitudinal study were an overall increase in mean BP after the Great East Japan Earthquake among residents surrounding the Fukushima Daiichi NPP in the Fukushima prefecture, and a male-specific significant association between evacuation and an increased risk of hypertension after adjusting for confounding variables. As of 2015, almost 100 000 people in the Fukushima prefecture were still in evacuation 4 years after the disaster. Because hypertension is one of the most important risk factors for CVD, a long-term effect of evacuation on BPs may increase the future risk of CVD among the evacuees.

Although previous studies have shown that BP control deteriorates among hypertensive patients after a natural
disaster such as an earthquake or hurricane, there are few longitudinal studies examining the associations between a disaster and risk of hypertension within a population. After the Hanshin-Awaji earthquake, SBP and DBP increased by 18 and 8 mm Hg 1 to 2 weeks after the disaster in hypertensive patients who lived around the epicenter. Although many studies have reported acute effects of a disaster on BP, chronic effects remain to be elucidated. In a population-based study conducted among immigrants to Israel from the contaminated zone after the Chernobyl NPP accident, 21% of the subjects from the high-exposure areas had high SBP (>140 mm Hg) 3 years after the accident, compared with 16% from less exposed areas. Although that study did not use data before the nuclear accident, the results after the accident were consistent with the present study. In Fukushima, the disaster of the Great East Japan Earthquake was the complex disaster consisted of the 3 effects of major earthquake, tsunami, and nuclear accident. The fears of earthquake and tsunami might gradually decrease over several years. However, the fear regarding exposed radiation at the time of the nuclear accidents would fast longer, resulting in long-lasting psychological stress, which may increase body weight and related components of metabolic syndrome. Furthermore, in addition to increasing hypertension, the prevalence of obesity, diabetes mellitus, and dyslipidemia increased among the evacuees after the disaster, which may lead to future incidence of CVD. Although the mechanisms by which evacuation increases the risk of hypertension are not yet fully understood, there may be an association with an excessive increase in body weight among the evacuees, especially for male evacuees. In the present study, the proportion of overweight people (an important risk factor for hypertension) among the evacuees increased after the disaster from 23.7% to 36.1% for men and from 21.9% to 29.2% for women, a change that was significantly higher than that for non-evacuees and significantly higher for men than for women. Furthermore, this effect was specifically observed among the evacuees in the Fukushima prefecture. The National Health and Nutrition Survey reported that the proportion of overweight people was unchanged from 2003 to 2012 among men aged 20 to 69 years and had decreased among women aged 40 to 69 years; the proportions of overweight people in 2003 and 2012 were 29.5% and 29.6% for men and 25.0% to 20.5% for women, respectively. Moreover, changes in BMI were significantly associated with changes in mean levels of SBP and DBP in the present study. These findings may support that evacuees, especially men, have a higher risk of hypertension via increased body weight.

Second, changes in job status of the evacuees may affect the changes in body weight and BPs. Because the target population in the present study consisted of people insured by National Health Insurance (mainly intended for farmers, fisherpersons, the self-employed, and retired employees), almost all evacuees who worked before the disaster lost their jobs after the disaster. This may lead to increase body weight and BPs among the evacuees via decreased physical activity. In the present study, the changes in body weight before and after the disaster were

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Men</th>
<th></th>
<th>Women</th>
<th></th>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td>N</td>
<td>1242</td>
<td>3273</td>
<td>…</td>
<td>1362</td>
<td>5160</td>
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<td>Age, y</td>
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<td>…</td>
<td>63.6</td>
<td>60.1</td>
<td>…</td>
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<td>BMI, kg/m²</td>
<td>23.6</td>
<td>22.7</td>
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<td>23.4</td>
<td>22.3</td>
<td>&lt;0.0001</td>
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<td>Overweight (BMI ≥25 kg/m²), %</td>
<td>27.6</td>
<td>18.7</td>
<td>&lt;0.0001</td>
<td>28.6</td>
<td>17.1</td>
<td>&lt;0.0001</td>
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<td>Systolic blood pressure, mm Hg</td>
<td>126.7</td>
<td>119.5</td>
<td>&lt;0.0001</td>
<td>126.0</td>
<td>118.1</td>
<td>&lt;0.0001</td>
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<td>Diastolic blood pressure, mm Hg</td>
<td>77.3</td>
<td>73.5</td>
<td>&lt;0.0001</td>
<td>76.2</td>
<td>71.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Current smokers, %</td>
<td>33.1</td>
<td>32.1</td>
<td>0.50</td>
<td>4.1</td>
<td>5.3</td>
<td>0.03</td>
</tr>
<tr>
<td>Current excessive drinkers*, %</td>
<td>14.1</td>
<td>7.9</td>
<td>&lt;0.0001</td>
<td>0.5</td>
<td>0.3</td>
<td>0.16</td>
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<tr>
<td>Regular physical exercise† (yes), %</td>
<td>31.7</td>
<td>30.4</td>
<td>0.45</td>
<td>29.4</td>
<td>28.3</td>
<td>0.50</td>
</tr>
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<td>Daily walking or physical activity‡ (yes), %</td>
<td>39.4</td>
<td>38.0</td>
<td>0.42</td>
<td>33.6</td>
<td>32.0</td>
<td>0.38</td>
</tr>
<tr>
<td>Subjective sufficient sleep (yes), %</td>
<td>78.3</td>
<td>76.7</td>
<td>0.25</td>
<td>71.3</td>
<td>70.3</td>
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<td>Skipping breakfast ≥3 times/wk (yes), %</td>
<td>7.6</td>
<td>8.0</td>
<td>0.58</td>
<td>5.7</td>
<td>5.6</td>
<td>0.96</td>
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<tr>
<td>Late-night dinners ≥3 times/wk (yes), %</td>
<td>29.0</td>
<td>25.2</td>
<td>0.01</td>
<td>18.8</td>
<td>16.3</td>
<td>0.05</td>
</tr>
<tr>
<td>Between-meal or bedtime snacks ≥3 times/ wk (yes), %</td>
<td>9.2</td>
<td>11.6</td>
<td>0.02</td>
<td>10.8</td>
<td>11.6</td>
<td>0.43</td>
</tr>
<tr>
<td>Eating quickly (yes), %</td>
<td>26.4</td>
<td>24.4</td>
<td>0.16</td>
<td>22.8</td>
<td>21.2</td>
<td>0.21</td>
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<tr>
<td>Evacuation (yes), %</td>
<td>39.4</td>
<td>32.0</td>
<td>&lt;0.0001</td>
<td>38.0</td>
<td>34.4</td>
<td>0.01</td>
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</table>

BMI indicates body mass index.
*Ethanol intake ≥44 g/d.
†At least ≥30 min/d and ≥2 times/wk for a year.
‡At least ≥1 h/d or equivalent physical activity.
greater for men than for women, and the association between evacuation and incidence of hypertension was confined to men. These findings may support our hypothesis because jobs insured by National Health Insurance were male dominated.

In addition to changes in lifestyle and job status, psychological stress may be associated with the risk of hypertension among the evacuees, as chronic stress and insufficient sleep could lead to increased BP levels. In the present study, the proportion of subjects with sufficient sleep significantly decreased after the disaster, from 75.8% to 67.5% for men and from 69.9% to 57.4% for women, although no significant association was observed between sufficient sleep and changes in BPs. Moreover, results of a mental health and lifestyle survey by the Fukushima Health Management Survey

Table 2. Changes in Mean Blood Pressure Levels and Lifestyle-Related Variables Among Evacuees and Nonevacuees After the Great East Japan Earthquake

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Nonevacues</th>
<th>Evacuees</th>
<th>Δ</th>
<th>P Value</th>
<th>Nonevacues</th>
<th>Evacuees</th>
<th>Δ</th>
<th>P Value</th>
<th>P value*</th>
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<td>Before</td>
<td>After</td>
<td></td>
<td></td>
<td>Before</td>
<td>After</td>
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<tr>
<td>Age, y</td>
<td>62.1</td>
<td>64.2</td>
<td>2.1</td>
<td>&lt;0.0001</td>
<td>61.0</td>
<td>63.1</td>
<td>2.1</td>
<td>&lt;0.0001</td>
<td>&lt;0.01</td>
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<tr>
<td>Systolic blood pressure, mmHg</td>
<td>121.5</td>
<td>126.1</td>
<td>4.6</td>
<td>&lt;0.0001</td>
<td>121.5</td>
<td>127.3</td>
<td>5.8</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
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<tr>
<td>Diastolic blood pressure, mmHg</td>
<td>74.6</td>
<td>76.7</td>
<td>2.1</td>
<td>&lt;0.0001</td>
<td>74.4</td>
<td>77.8</td>
<td>3.4</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Body weight, kg</td>
<td>61.6</td>
<td>62.2</td>
<td>0.6</td>
<td>&lt;0.0001</td>
<td>62.8</td>
<td>65.0</td>
<td>2.2</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
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<td>Overweight (BMI ≥25 kg/m²), %</td>
<td>19.8</td>
<td>23.1</td>
<td>3.3</td>
<td>&lt;0.0001</td>
<td>23.7</td>
<td>36.1</td>
<td>12.4</td>
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<td>Current smokers, %</td>
<td>32.2</td>
<td>27.5</td>
<td>−4.7</td>
<td>&lt;0.0001</td>
<td>32.6</td>
<td>29.5</td>
<td>−3.1</td>
<td>&lt;0.0001</td>
<td>0.06</td>
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<td>Current excessive drinkers†, %</td>
<td>9.3</td>
<td>7.2</td>
<td>−2.1</td>
<td>&lt;0.0001</td>
<td>10.1</td>
<td>7.7</td>
<td>−2.4</td>
<td>&lt;0.0001</td>
<td>0.75</td>
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<td>Regular physical exercise‡ (yes), %</td>
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<td>29.8</td>
<td>0.4</td>
<td>0.66</td>
<td>30.2</td>
<td>32.1</td>
<td>1.9</td>
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<td>0.39</td>
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<td>Daily walking or physical activity§ (yes), %</td>
<td>37.3</td>
<td>35.9</td>
<td>−1.4</td>
<td>0.19</td>
<td>40.3</td>
<td>36.5</td>
<td>−3.8</td>
<td>0.03</td>
<td>0.22</td>
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<td>Subjective sufficient sleep (yes), %</td>
<td>77.5</td>
<td>75.0</td>
<td>−2.5</td>
<td>0.01</td>
<td>75.8</td>
<td>67.5</td>
<td>−8.3</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
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<td>Skipping breakfast ≥3 times/wk (yes), %</td>
<td>6.9</td>
<td>6.3</td>
<td>−0.6</td>
<td>0.21</td>
<td>8.9</td>
<td>8.4</td>
<td>−0.5</td>
<td>0.69</td>
<td>0.84</td>
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<td>Late-night dinners ≥3 times/wk (yes), %</td>
<td>25.3</td>
<td>23.1</td>
<td>−2.2</td>
<td>0.02</td>
<td>27.7</td>
<td>25.0</td>
<td>−2.7</td>
<td>0.10</td>
<td>0.70</td>
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<td>Between-meal snacks ≥3 times/wk (yes), %</td>
<td>10.0</td>
<td>9.1</td>
<td>−0.9</td>
<td>0.20</td>
<td>12.9</td>
<td>9.9</td>
<td>−3.0</td>
<td>0.01</td>
<td>0.08</td>
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<td>Eating quickly (yes), %</td>
<td>23.7</td>
<td>22.1</td>
<td>−1.6</td>
<td>0.04</td>
<td>26.8</td>
<td>25.8</td>
<td>−1.0</td>
<td>0.41</td>
<td>0.78</td>
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</table>

Values are represented as means. BMI indicates body mass index.
†Ethanol intake ≥44 g/d.
‡At least ≥30 min/d and ≥2 times/wk for a year.
§At least ≥1 h/d or equivalent physical activity.
*Age-adjusted P value for comparing the changes in the evacuee group to the changes in the nonevacuee group before and after the earthquake.
showed that those who evacuated in response to governmental direction tended to experience greater psychological stress and had difficulty sleeping after the disaster.22,23 Stressful conditions and insufficient sleep might diminish nocturnal melatonin production and disrupt circadian rhythmicity and autonomic balance. In the acute phase, a sympathetic nervous system stimulated by psychological stress and insufficient sleep could directly increase BP and in a chronic state could increase levels of catecholamine and glucocorticoid, leading to increased salt sensitivity, which is closely related to hypertension.7 Unfortunately, because we did not measure perceived stress of the participants, we could not evaluate the association between individual psychological stress and hypertension in the present study. Further research is needed to demonstrate the associations between psychological stress and future incidence of hypertension among evacuees.

The strengths of the present study were the inclusion of a relatively large number of residents from the evacuation zone, as well as the assessment of BP and hypertension status before and after the disaster, which allowed longitudinal analyses for an association between evacuation and risk of hypertension. Some potential limitations of this study should however be considered. First, although significant increases in BPs were observed among both evacuees and nonevacuees, aging may have affected the results. However, analysis of the changes in BPs between 2008 and 2010 among evacuees and nonevacees (n=24965) in the target populations who received health checkups ≥2 times between 2008 and 2010 did not show a significant increase in SBP and DBP during the 3 years before the disaster. The mean levels of SBP/DBP for the evacuees and nonevacees were 131.0/77.1 and 131.0/78.3 mm Hg on the first examination and 131.5/76.9 and 131.2/77.5 mm Hg on the second examination, with an average follow-up of 1.7 years. Aging can therefore be expected to have had a limited effect on the results of this study. Second, the study did not evaluate socioeconomic factors other than evacuation. Other environmental or socioeconomic factors, such as changes in living condition, job status, and marital status, may have influenced the association between evacuation and risk of hypertension. In the mental health and lifestyle survey by the Fukushima Health Management Survey, 54% of survey responders changed their job status and 21% lost their job22,23; these changes may affect the incidence of hypertension. Finally, because the target population consisted of people insured by National Health Insurance (mainly intended for farmers, fisherpersons, the self-employed, and retired employees), the authors did not include people insured by social insurance (mainly intended for employees) to analyze the associations. Because 45% of the Census population aged 40 to 74 years of these communities enrolled in National Health Insurance, there is some doubt as to whether the participants in the present study are representative of the community populations, and this may modify the results.

### Perspectives
Mean BP levels and the prevalence of hypertension may have increased among community residents, especially the male evacuees, in the evacuation zone of the Fukushima prefecture after the Great East Japan Earthquake. Furthermore, for men, evacuation may be associated with an increased risk of hypertension in the 2 years after the disaster. As of 2015, almost 100000 residents from Fukushima remain evacuated. Because hypertension is the risk factor most attributable to CVD, the prevention of future CVD among evacuees in Fukushima requires continuous hypertension-preventive programs, in collaboration with local governments and communities.

### Appendix

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Disclosures

None.

References


Novelty and Significance

What Is New?

- Although previous studies have shown an acute effect of a natural disaster, such as an earthquake or hurricane, on blood pressure control, there are few longitudinal studies examining the associations between a disaster and risk of hypertension within a population. This is the first longitudinal study showing that evacuation after the complex disaster is associated with a greater incidence of hypertension among men in a middle-aged general adult population.

What Is Relevant?

- The major strengths of the study are the prospective design, which avoids reverse causation bias, and the inclusion of a relatively large number of residents from the evacuation zone. This study provides evidence that evacuation after a disaster may be associated with an increased risk of hypertension. A major mechanism seems to be an increase in body weight. The results can be used for an intervention study to decrease cardiovascular disease risks among evacuees.

Summary

After the Great East Japan Earthquake on March 11, 2011, with a nuclear accident subsequently occurring at the Fukushima Daiichi Nuclear Power Plant, the government ordered a mandatory evacuation from the high radioactive concentration area in Fukushima. This longitudinal study demonstrated an overall increase in mean blood pressure after the disaster among residents surrounding the nuclear power plant, and a male-specific significant association between evacuation and an increased risk of hypertension after adjusting for confounding variables. Because hypertension is one of the most important risk factors for cardiovascular diseases, a long-term effect of evacuation on blood pressure may increase the future risk of cardiovascular diseases among the evacuees.
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