BRIEF COMMUNICATION

Blood Pressure Among Public Employees After the Great East Japan Earthquake: The Watari Study

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BACKGROUND
Increases in blood pressure were reported in overworked public workers following the Mid-Niigata earthquake. This study aimed to compare blood pressure changes between public employees and the general population after the Great East Japan Earthquake of March 2011.

METHODS
We analyzed 1,776 individuals from the general population and 240 public employees of the town of Watari who received medical check-ups in 2010 and from July 2011 through November 2011. Anthropometric parameters and sitting blood pressure were compared, and fasting blood samples were taken from all participants. In postdisaster measurements, the degrees of insomnia, depression, fatigue, and life disruption due to the disaster were assessed using a questionnaire. Information on the working hours of public employees was obtained from authorized sources.

RESULTS
After age–sex adjustments, the public employees showed greater increases in systolic (11.3 vs. −1.9 mm Hg, $P < 0.001$) and diastolic (7.8 vs. 1.1 mm Hg, $P < 0.001$) blood pressure than the general population when compared with measurements taken during the previous year. In contrast, the degrees of fatigue, depression, and life disruption were equivalent in the 2 groups. The average monthly overtime hours worked by public employees in March 2011 was 10-fold higher compared with the previous March.

CONCLUSION
Public employees showed greater and more prolonged increases in blood pressure than the general population after the Great East Japan earthquake. Thus blood pressure should be monitored after a great earthquake among public employees, and treatment should be considered if necessary.

Keywords: blood pressure; disaster hypertension; Great East Japan earthquake; hypertension; overtime work; public employees.

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Natural disasters such as earthquakes and hurricanes place great stress on citizens, and several studies have suggested associations between natural disasters and onset or progression of diseases.[1,2] Temporary increases in blood pressure were observed immediately after the Hanshin-Awaji earthquake[3–5] in 1995, with these increases being one of the primary causes of increased incidence of cardiovascular diseases after natural disasters. It has been reported that increases in blood pressure after disasters gradually return to normal levels within several weeks in patients with hypertension[4,5] or chronic kidney disease.[6] An analysis of local government staff members several months after the Mid-Niigata earthquake[7] showed that workers with the highest workload had significantly greater increases in systolic blood pressure than those who performed normal amounts of work, suggesting that overwork by public employees involved in disaster relief operations could result in prolonged blood pressure elevation.

On 11 March 2011, the Great East Japan earthquake struck northeastern Japan with a magnitude of 9.0 on the Richter scale, resulting in 15,879 casualties and 2,712 missing persons as end of 2012.[8] The damage caused by the earthquake was far greater than that caused by the Hanshin-Awaji or Mid-Niigata earthquakes. As a result, work stress of individuals involved in postdisaster relief operations for the Great East Japan earthquake was greater than on previous occasions. In 2008, we started a prospective cohort study in the town of Watari,[9,10] located in the southeastern part of Miyagi prefecture, Japan. This town was struck by the Great East Japan earthquake and the subsequent tsunami. Using a survey, we first compared the blood pressure changes 4–8 months after the Great earthquake between the general population and public employees who were engaged in the disaster relief operation. The objective of this study was to determine if public employees showed greater increases in blood pressure than the general population.

METHODS

The details of the Watari study, which was started in 2008, have been described previously.[9,10] The ethics committee of

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Tohoku Rosai Hospital approved the study protocol, and written informed consent was obtained from all participants.

Participants included 412 public employees and 3,459 individuals from the general population who received annual health check-ups in 2010. Of these, 240 public employees and 1,776 individuals underwent follow-up examinations between July 2011 and November 2011. In Japan's health-management system, general population aged from 40 to 74 years and all working people are strongly encouraged to obtain an annual health check-up. The final decision of participation depends on the individual.

Trained nurses measured height, body weight, and waist circumference, and body mass index (BMI) was calculated as body weight (kg) divided by the square of height (m). Fasting blood samples were collected from study participants to measure the levels of low- and high-density lipoprotein (LDL and HDL) cholesterol, triglycerides, and glycated hemoglobin (HbA1c). Sitting blood pressures were measured once after a 5-minute rest using an automated oscillometric sphygmomanometer (BX-10; Omron Colin, Kyoto, Japan).

Postdisaster insomnia, depression, fatigue, and life disruption due to the disaster were assessed using a questionnaire. The degree of insomnia (insomnia score ranging from 0 to 6) was calculated as the sum of 3 items from the Hamilton Depression Rating Scale (insomnia early, insomnia middle, and insomnia late).[11] The degrees of depression (6 items, with scores ranging from 6 to 24) and fatigue (3 items, with scores ranging from 3 to 12) were determined using the Brief Job Stress Questionnaire.[12] The degree of life disruption was determined on the basis of answers (where 1 = greatly, 2 = slightly, 3 = not at all) to the question, "Has your daily life been disrupted by the disaster?"

Information regarding overtime hours worked was obtained from public employees' attendance records.

Statistical analysis

Two-sided χ^2 tests and unpaired *t* tests were used to compare pre- and postdisaster characteristics in the 2 groups. Two-sided unpaired *t* tests were used to compare 1-year changes in clinical data. Age- and sex-adjusted analysis of covariance was also used to compare questionnaire results and 1-year changes in clinical data. Statistical analysis was performed using JMP (version 9.0 for Windows; SAS Institute, NC). A *P* value < 0.05 was considered statistically significant.

RESULTS

Measurements taken prior to the earthquake and tsunami showed that public employees were younger and had lower BMI and blood pressure than the general population (Table 1). The public employees also had lower LDL cholesterol, triglyceride, and HbA1c levels. Baseline characteristics indicate that the public employees primarily comprised young healthy subjects with few cardiovascular risk factors.

Following the disaster, the public employees showed significantly greater increases in systolic (unadjusted, 8.9 vs. −1.6 mm Hg, *P* < 0.001; age–sex adjusted, 11.3 vs. −1.9 mm Hg, *P* < 0.001) and diastolic (unadjusted, 6.2 vs. 1.3 mm Hg, *P* < 0.001; age–sex adjusted, 7.8 vs. 1.1 mm Hg, *P* < 0.001) blood pressure than the general population when compared with measurements taken during the previous year (Table 2). The frequency of hypertension (systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure (DBP) ≥ 90 mm Hg) increased from 5.4% to 11.2% in the public employees, whereas this frequency remained almost unchanged in the general population (17.2%–16.7%). Ten (4.2%) public employees and 475 (26.8%) individuals from the general population were being treated with antihypertensive medications. Further adjustment for antihypertensive treatment provided substantially similar results of adjusted changes in both systolic and diastolic blood pressures.

Adjusted mean changes in BMI and levels of LDL cholesterol and HDL cholesterol were greater in the public employees than in the general population. In contrast, HbA1c levels decreased to a greater extent in the public employees than in the general population (Table 2).

Of 412 public employees who received health check-ups in 2010, 240 were followed in 2011. Compared with the successfully followed public employees, those who were not successfully followed were older, more obese, and demonstrated significantly higher blood pressures and worse glucose and lipid profiles (Supplementary Table S1). The general population who were not followed were younger and showed significantly higher BMI and blood pressures and higher levels of triglyceride and HbA1c than those who were followed.

The insomnia scores were slightly lower (having less symptoms of insomnia) in the public employees than in the general population (adjusted mean, 1.3 vs. 1.5, *P* = 0.048), whereas the degrees of depression (adjusted mean, 8.5 vs. 8.5, *P* = 0.81), fatigue (adjusted mean, 4.6 vs. 4.5, *P* = 0.33), and life disruption (adjusted mean, 2.4 vs. 2.4, *P* = 0.64) due to the disaster did not differ significantly between the 2 groups.

On average, public employees worked 10-fold more overtime hours in March 2011 than in March 2010 (146.8 vs. 14.2 hours/month). The average monthly overtime hours worked from March 2011 to November 2011 was 40.1, whereas that from March 2010 to November 2010 was 14.1 hours, suggesting that most public employees were involved in long-term overwork after the disaster.

DISCUSSION

We have shown that public employees experienced marked blood pressure elevation after the Great East Japan earthquake compared with the general population (11.3 vs. −1.9 mm Hg for systolic and 7.8 vs. 1.1 mm Hg for diastolic, *P* < 0.001 for both). In the Mid-Niigata earthquake,[7] blood pressure elevation 3 to 4 months after the disaster among overworked male government workers (mean age, 39.4 ± 8.9 years) was reported to be 4.4 mm Hg for systolic and 2.5 mm Hg for diastolic compared with the previous year. Moreover, the blood pressure elevation in the present study was found to be prolonged for 4 to 8 months after the

Table 1. Pre- and post-disaster characteristics of subjects

Variables	Public employees (n = 240)	General population (n = 1,776)	*P* value
2010 (predisaster)			
Age, years	39.6 ± 11.3	62.7 ± 10.1	<0.001
Men, %	36.7	43.1	0.06
Body weight, kg	59.2 ± 10.3	58.1 ± 10.3	0.12
Waist circumference, cm	79.8 ± 8.7	84.4 ± 9.0	<0.001
BMI, kg/m^2	22.4 ± 3.3	23.3 ± 3.2	<0.001
Systolic blood pressure, mm Hg	115.8 ± 14.0	125.0 ± 16.4	<0.001
Diastolic blood pressure, mm Hg	67.4 ± 11.5	73.2 ± 11.0	<0.001
LDL cholesterol, mg/dl	106.9 ± 28.0	118.0 ± 28.6	<0.001
HDL cholesterol, mg/dl	66.6 ± 15.8	61.9 ± 15.3	<0.001
Triglyceride, mg/dl	84.4 ± 55.1	109.1 ± 64.1	<0.001
HbA1c, %	5.59 ± 0.78	5.94 ± 0.59	<0.001
2011 (postdisaster)			
Body weight, kg	59.2 ± 10.3	58.1 ± 10.3	0.13
Waist circumference, cm	79.8 ± 8.7	84.4 ± 8.8	<0.001
BMI, kg/m^2	22.6 ± 3.4	23.2 ± 3.2	0.01
Systolic blood pressure, mm Hg	124.8 ± 13.7	123.3 ± 16.9	0.21
Diastolic blood pressure, mm Hg	73.7 ± 11.3	74.5 ± 10.6	0.24
LDL cholesterol, mg/dl	117.5 ± 32.5	123.8 ± 30.9	0.003
HDL cholesterol, mg/dl	69.0 ± 16.8	62.8 ± 15.4	<0.001
Triglyceride, mg/dl	83.5 ± 52.9	108.7 ± 68.7	<0.001
HbA1c, %	5.45 ± 0.52	5.91 ± 0.59	<0.001

Data are shown as mean ± standard deviation or percentage. *P* values are for unpaired *t* test or χ^2 test.
Abbreviations: BMI, body mass index. LDL, low-density lipoprotein. HDL, high-density lipoprotein.

disaster. Therefore, the blood pressure elevation observed among the public employees of the town of Watari was larger and its duration was longer than that after the Mid-Niigata[7] or other previous studies conducted in patients with treated hypertension[3–5] or diabetes.[13]

Recent publications have reported increased cardiovascular morbidities after the Great East Japan earthquake[14] and the Abruzzo earthquake.[15] A 10-mm Hg increase in systolic blood pressure has been reported to increase the risks of stroke and ischemic heart disease by approximately 20% and 15%, respectively.[16]

The mechanisms underlying disaster-associated hypertension are very complex, but both psychological stress and environmental factors are likely involved.[17] The degree of life disruption due to the disaster, which was previously reported to be correlated with cardiovascular mortality,[17] did not differ between public employees and the general population. The degrees of depression and fatigue did not differ between the 2 groups, whereas sleep quality was poorer in the general population. Thus, public employee–specific stress, which was not evaluated using the questionnaire, may be involved in the marked and prolonged blood pressure increase observed in this study.

Immediately after the earthquake, more than 6,000 residents of the town (one fifth of the town's total population) were evacuated to a shelter. The public employees cared for these evacuees throughout the day and were involved in the recovery of lifelines such as water, electricity, and gas. A couple of months later, the public employees were further charged with reconstruction of the town including disposing of large amounts of tsunami rubble, preventing epidemics, and providing life support for the victims, including distribution of disaster-relief donations, in addition to their usual duties. Indeed, mean overtime of public employees was 10-fold greater in March 2011 than in March 2010, and mean overtime was 2.8-fold greater from March 2011 to November 2011 than from March 2010 to November 2010. Working for 50 hours or more per week (equivalent to more than 10 hours per week of overtime) has been reported to be associated with increases in adverse health outcomes.[18] Taken together, the prolonged blood pressure increase seen in public employees may have been due to overwork related to disaster management.

The LDL cholesterol level was increased in both groups compared with the previous year, although the increase was larger among public employees than among the general population. This increase may be associated with the metabolic response to prolonged stress[19] or dietary changes after the disaster.

Our study had several limitations. First, the subjects were requested to obtain annual health check-ups on a voluntary basis, and the participation rate during postdisaster measurements was relatively low (58.3% for public employees and

Table 2. Unadjusted and age–sex-adjusted changes from 2010 to 2011

Variable	Public employees (n = 240)	General population (n = 1,776)	*P* value
Unadjusted changes from 2010 to 2011			
Body weight, kg	0.7 ± 2.9	–0.4 ± 2.1	<0.001
Waist circumference, cm	0.3 ± 3.7	–0.2 ± 3.7	0.06
BMI, kg/m^2	0.2 ± 1.1	–0.1 ± 0.8	<0.001
Systolic blood pressure, mm Hg	8.9 ± 10.8	–1.6 ± 13.2	<0.001
Diastolic blood pressure, mm Hg	6.2 ± 7.9	1.3 ± 8.5	<0.001
LDL cholesterol, mg/dl	10.5 ± 18.9	5.9 ± 20.5	<0.001
HDL cholesterol, mg/dl	2.4 ± 8.7	0.9 ± 7.5	0.006
Triglyceride, mg/dl	–0.9 ± 44.8	–0.4 ± 55.1	0.89
HbA1c, %	–0.1 ± 0.6	0.0 ± 0.3	<0.001
Age–sex-adjusted changes from 2010 to 2011			
Body weight, kg	0.61 (0.28, 0.95)	–0.37 (–0.47, –0.26)	<0.001
Waist circumference, cm	0.37 (–0.25, 1.00)	–0.21 (–0.41, –0.02)	0.09
BMI, kg/m^2	0.25 (0.11, 0.38)	–0.09 (–0.13, –0.05)	<0.001
Systolic blood pressure, mm Hg	11.3 (9.3, 13.2)	–1.9 (–2.5, –1.3)	<0.001
Diastolic blood pressure, mm Hg	7.8 (6.5, 9.1)	1.1 (0.7, 1.5)	<0.001
LDL cholesterol, mg/dl	12.4 (9.2, 15.5)	5.6 (4.6, 6.6)	<0.001
HDL cholesterol, mg/dl	2.7 (1.5, 3.9)	0.8 (0.5, 1.2)	0.004
Triglyceride, mg/dl	–3.7 (–12.0, 4.6)	–0.2 (–2.9, 2.4)	0.47
HbA1c, %	–0.20 (–0.26, –0.15)	–0.02 (–0.04, 0.0)	<0.001

Data are shown as mean ± standard deviation or adjusted mean values (95% confidence interval). *P* values are for unpaired *t* test or analysis of covariance.

Abbreviations: BMI, body mass index; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

51.3% for the general population). In general, people who participate in annual health check-ups tend to have better health status than those who do not, which may lead to a self-selection bias. A possible reason for low participation rates was the evacuation from the affected areas, and those who evacuated could have greater damage due to the disaster. Indeed, in the Great East Japan earthquake, most of the damage was caused by the tsunami, rather than the earthquake per se, and more people may have evacuated from the coastal area than from inland. On the other hand, the public employees had to continue working irrespective of the damage caused by the disaster. Therefore, the changes in blood pressure after the disaster may be underestimated in the general population. Second, blood pressure was measured only once during annual health check-ups during this study, which may lower the accuracy of blood pressure measurement and statistical power. Third, we were not able to obtain information on overtime hours worked by the general population, and information on the level of job stress, such as job strain, was not directly evaluated in both groups. Finally, as this study was observational, we cannot establish a causal relationship between the disaster and blood pressure changes.

In conclusion, public employees of the town of Watari showed marked and prolonged blood pressure elevation after the Great East Japan earthquake compared with the general population. We failed to clarify the mechanisms, but overwork during disaster relief operations may have been related. Thus blood pressure should be monitored after a great earthquake among public employees and treatment should be considered if necessary.

SUPPLEMENTARY MATERIAL

Supplementary materials are available at *American Journal of Hypertension* (http://ajh.oxfordjournals.org).

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DISCLOSURE

The authors declared no conflict of interest.

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