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# Higher Incidence of Sleep Disturbance among Survivors with Musculoskeletal Pain after the Great East Japan Earthquake: A Prospective Study

**Yutaka Yabe,[1] Yoshihiro Hagiwara,[1] Takuya Sekiguchi,[1] Yumi Sugawara,[2] Masahiro Tsuchiya,[3] Masashi Koide,[1] Nobuyuki Itaya,[1] Shinichiro Yoshida,[1] Yasuhito Sogi,[1] Toshihisa Yano,[1] Ichiro Tsuji[2] and Eiji Itoi[1]**

[1]Department of Orthopaedic Surgery, Tohoku University School of Medicine, Sendai, Miyagi, Japan
[2]Division of Epidemiology, Department of Health Informatics and Public Health, Tohoku University, Graduate School of Public Health, Sendai, Miyagi, Japan
[3]Tohoku Fukushi University, Sendai, Miyagi, Japan

Sleep disturbance is a common symptom after natural disasters. Although musculoskeletal pain also increases after natural disasters, its relation to sleep disturbance is not clear. The purpose of this study was to determine the influence of musculoskeletal pain on new-onset sleep disturbance among survivors after the Great East Japan Earthquake (GEJE). A prospective cohort study was conducted with the survivors of the GEJE at two and three years after the earthquake. New-onset sleep disturbance was defined as sleep disturbance absent at two years and present at three years after the earthquake. The sites of musculoskeletal pain included low back, shoulder, knee, and hand or foot. The number of musculoskeletal pain sites at two years after the earthquake was divided into three categories (0, 1, and 2 or more). Univariate and multivariate logistic regression models were used to calculate the odds ratio (OR) and 95% confidence interval (95%CI) for new-onset sleep disturbance according to the number of musculoskeletal pain sites. A total of 1,102 survivors were included in this study and 14.6% of the participants reported new-onset sleep disturbance. Using "0" as a reference, the adjusted ORs (95% CI) for new-onset sleep disturbance were 2.43 (1.55-3.80) in "1" and 2.96 (1.88-4.64) in "2 or more", respectively (P for trends < 0.001). In conclusion, this is the first study showing higher incidence of sleep disturbance among survivors with musculoskeletal pain after the GEJE. Care for musculoskeletal pain is important to prevent sleep disturbance after natural disasters.

**Keywords:** disaster; Great East Japan Earthquake; musculoskeletal pain; sleep disturbance; survivor
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## Introduction

Natural disasters have negative effects on physical and mental health in survivors (Marres et al. 2011). People suffer from various health disturbances in the short term after a natural disaster, but also in the middle and long term (van der Velden et al. 2013). The Great East Japan Earthquake (GEJE), which was followed by a devastating tsunami, hit the northeastern coastal area of Japan on 11th March, 2011 and left approximately 18,500 people dead or missing (Ishigaki et al. 2013). Although six years have passed, 119,000 survivors have still had to evacuate from their hometowns because of their dwelling environments and accidents of the Fukushima Daiichi Nuclear Power Plant (Hagiwara et al. 2017a). Various factors related to the earthquake, such as life-threatening stress, unhealthy conditions, social isolation, uncertainty over the future, and dwelling environments, have been reported to relate to the onset or worsening of some diseases (Matsumoto et al. 2014; Yabuki et al. 2015; Sone et al. 2016; Yabe et al. 2017). Sleep disturbance and musculoskeletal pain are particularly common symptoms after natural disasters (Yabuki et al. 2015; Kawano et al. 2016).

Sleep disturbance is a common symptom and the prevalence in the general adult population of Japan is reported to be approximately 20% (Liu et al. 2000). Several factors such as age, sex, psychological factors, and socioeconomic factors (including income and employment) are considered to be associated with sleep disturbance (Morin et al. 2009; Matsumoto et al. 2014). Furthermore, some pain has also been related to sleep disturbance (Ashburn and Staats 1999; Doufas et al. 2012). In the acute phase of natural disasters,

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Correspondence: Yoshihiro Hagiwara, Department of Orthopaedic Surgery, Tohoku University School of Medicine, 2-1 Seiryo-machi, Aoba-ku, Sendai, Miyagi 980-8574, Japan.
e-mail: hagi@med.tohoku.ac.jp

sleep disturbance occurs frequently and mainly as a stress reaction (Kawano et al. 2016). Matsumoto et al. (2014) reported that sleep disturbance was also common among the survivors in the 6-12 months following the GEJE and associated with socioeconomic factors. Although the prevalence of musculoskeletal pain increases after natural disasters (Angeletti et al. 2014; Yabuki et al. 2015) and careful attention has been paid to psychological and socioeconomic factors, there are no reports examining the influence of musculoskeletal pain on sleep disturbance after natural disasters.

The purpose of this study was to determine influential factors of musculoskeletal pain on new-onset sleep disturbance among survivors in the chronic phase of the GEJE.

## Methods

*Participants*

This is a prospective cohort study. A panel study was conducted with survivors of the GEJE (18 years old or over) living in the severely damaged coastal regions, such as Ogatsu and Oshika areas in Ishinomaki city and Wakabayashi ward in Sendai city, in Miyagi prefecture. Questionnaire surveys were conducted from November 2012 to February 2013, two years after the earthquake, and from November 2013 to February 2014, three years after the earthquake. The study population comprised residents who were included in the Residential Registry for Ogatsu and Oshika areas and residents who have lived in prefabricated housing after the earthquake in Wakabayashi ward. A self-reported questionnaire and documented informed consent were mailed to all participants. This study was approved by the institutional review board of Tohoku University School of Medicine (approval number: 201192)

*Outcome variable*

The outcome of interest was new-onset sleep disturbance which was defined as sleep disturbance absent at the 1st period (two years after the earthquake) and present at the 2nd period (three years after the earthquake). Sleep condition was assessed through the self-report questionnaire using the Athens Insomnia Scale (AIS), which is a self-assessment instrument for sleep disturbance based on the ICD-10 criteria. Sleep disturbance was defined as a score of ≥ 6/24 on the AIS (Soldatos et al. 2000).

*Exposures*

Musculoskeletal pain in the 1st period was determined through the self-report questionnaires based upon the Comprehensive Survey of Living Conditions (Ministry of Health, Labour and Welfare 2017). The question was: "Have you had anything wrong within the last few days? If yes, please indicate your symptoms" (multiple symptoms could be chosen). There were 28 items and examples of the possible responses were "irritation," "palpitation," "dizziness," "diarrhea," "headache," "low back pain," "shoulder pain," "knee pain," "hand or foot pain," and "katakori" (a Japanese term, similar to neck pain in western countries) (Cerezo-Tellez et al. 2016). Among the answer options, low back pain, shoulder pain, knee pain, hand or foot pain, and katakori were included in musculoskeletal pain. Musculoskeletal pain was categorized into three groups according to the number of painful sites (0, 1, and 2 or more).

*Covariates*

The following variables were included in this analysis as covariates because they were potential cofounding factors: sex, age, body mass index (BMI; calculated from self-reported height and weight values), living area, working status, smoking habits, drinking habits, walking time, living status, complications (hypertension [HT], diabetes mellitus [DM], myocardial infarction [MI], and cerebral stroke), subjective economic hardship, psychological distress (Kessler Psychological Distress Scale [K6]) (Kessler et al. 2002), and social isolation (Lubben Social Network Scale [LSNS-6]) (Sone et al. 2016) in the 1st period. Following the previous studies, psychological distress and social isolation were defined as a score of ≥ 10/24 on the K6 (Suzuki et al. 2014) and < 12/30 on the LSNS-6 (Sone et al. 2016), respectively.

*Statistical analysis*

Categorical variables are presented as numbers and percentages (%). Univariate and multivariate logistic regression models were used to calculate odds ratio (OR) and 95% confidence interval (95% CI) for new-onset sleep disturbance according to the number of musculoskeletal pain sites in the 1st period. Variables considered in the models were sex (male or female), age (< 65 or ≥ 65 years), BMI (< 18.5, 18.5 to < 25, ≥ 25, or unknown), living area (Ogatsu, Oshika, or Wakabayashi), working status (unemployed, employed, or unknown), smoking habits (non-smoker, smoker, or unknown), drinking habits (non-drinker, < 45.6 g of alcohol/day, ≥ 45.6 g of alcohol/day, or unknown), walking time/day (≥ 1 h, 30 min to < 1 h, < 30 min, or unknown), living status (living in the same house as before the earthquake, prefabricated house, new house, others, or unknown), complications (HT absence or presence, DM absence or presence, MI absence or presence, and cerebral stroke absence or presence), subjective economic status (normal, a little bit hard, hard, very hard, or unknown), K6 (< 10, ≥ 10, or unknown), LSNS-6 (≥ 12, < 12, or unknown). OR and 95% CI for new-onset sleep disturbance according to each musculoskeletal pain in the 1st period was also evaluated. Furthermore, we stratified the participants into two subgroups (< 65 [n = 551], or ≥ 65 [n = 551] years) and OR and 95% CI for new onset of sleep disturbance according to the number of musculoskeletal pain sites was calculated in the same manner. All statistical analyses were performed with SPSS version 24.0 (SPSS Japan Inc., Tokyo, Japan). A P value of < 0.05 was considered statistically significant.

## Results

The response rate of the 1st period was 38.4% (2,412/6,283) and 2,286 participants consented to this study. The participants who had invalid response (missing data for sleep disturbance, n = 37) or sleep disturbance at the 1st period (n = 829) were excluded and the follow-up rate at the 2nd period was 78.1% (1,109/1,420). After excluding the participants with invalid response (missing data for sleep disturbance, n = 7) at the 2nd period, 1,102 individuals were included in the analysis (Fig. 1). Baseline characteristics of the participants are shown in Table 1. In terms of the number of musculoskeletal pain sites, 68.1% of participants had 0, 16.7% had 1, and 15.2% had 2 or more (Table 1).

The rate of new onset of sleep disturbance was 14.6% (161/1,102). The crude and adjusted ORs (95% CI) for

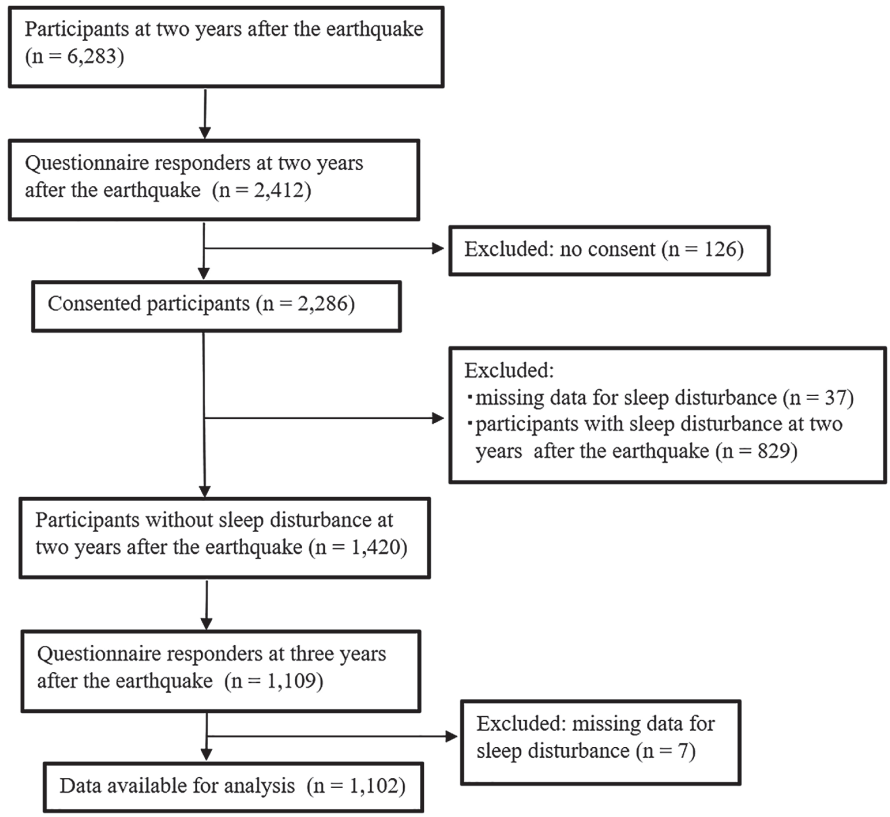


Fig. 1. Flowchart of the present analysis.

new-onset sleep disturbance according to the number of musculoskeletal pain sites are shown in Table 2. The presence of musculoskeletal pain was significantly associated with new-onset sleep disturbance. Using "0" as a reference for the number of musculoskeletal pain sites, the adjusted ORs (95% CI) for new-onset sleep disturbance were 2.43 (1.55-3.80) in "1" and 2.96 (1.88-4.64) in "2 or more", respectively (P for trend < 0.001; Table 2). In each musculoskeletal pain, the adjusted ORs (95%CI) for new-onset sleep disturbance were 2.22 (1.48-3.33) in low back pain, 3.43 (1.90-6.20) in shoulder pain, 1.67 (0.97-2.86) in knee pain, 2.20 (1.26-3.85) in hand or foot pain, and 2.10 (1.36-3.23) in katakori (Table 3).

In the stratified analyses, the presence of musculoskeletal pain was significantly associated with new-onset sleep disturbance in both younger and older groups. Using "0" as a reference for the number of musculoskeletal pain sites, the adjusted ORs (95% CI) for new-onset sleep disturbance were 1.88 (1.02-3.46) in "1" and 2.08 (1.11-3.91) in "2 or more" in the younger group (P for trend = 0.027), and 3.18 (1.48-6.83) in "1" and 5.06 (2.39-10.69) in "2 or more" in the older group (P for trend < 0.001), respectively (Table 4).

## Discussion

The present study has shown the higher incidence of sleep disturbance among survivors with musculoskeletal pain in the chronic phase of the GEJE. Sleep disturbance is thought to be the most common symptom after natural disasters (Brown et al. 2011). Kato et al. (1996) reported that the prevalence of sleep disturbance was 63% at 3 weeks after the 1995 Hanshin-Awaji earthquake in Japan. Many survivors experienced life-threatening fear, death of family or friends, and loss of houses, and experienced strong psychological stress as a result of the GEJE (Ishigaki et al. 2013). This stress is robustly associated with sleep disturbance among survivors in the acute phase of natural disasters (Kawano et al. 2016). On the other hand, sleep disturbance was reported to occur even in the chronic phase of natural disasters (van der Velden et al. 2013). Varela et al. (2008) reported that as many as 55% of survivors of an earthquake in Greece which occurred in 1999 had sleep disorders even one year after the disaster. In the present study, the prevalence of sleep disturbance was 36.9% (829/2,249) at two years after the GEJE and 14.6% of survivors had new-onset sleep disturbance at three years after the GEJE. A higher rate of psychological distress and social isolation among the survivors was reported even in the chronic phase after the GEJE (Niitsu et al. 2014; Sone et al. 2016). Further, many survivors had to live in shelters or unfamiliar places because they lost their homes due to the tsunami after the earthquake or needed to flee to safe places (Hagiwara et al. 2016). These conditions have been considered as associated factors of sleep disturbance after the natural disasters (Kawano et al. 2016). Many survivors suffered from sleep disturbance in the chronic phase of the GEJE, and it is important to know which factors are related

Table 1. Baseline characteristics of the participants according to the number of musculoskeletal pain sites.

| | | | Number of musculoskeletal pain sites | | |
|---|---|---|---|---|---|
| | | n (%) | 0 | 1 | ≥ 2 |
| | | 1,102 | 751 | 184 | 167 |
| Sex | Male | 523 (47.5) | 381 (50.7) | 74 (40.2) | 68 (40.7) |
| | Female | 579 (52.5) | 370 (49.3) | 110 (59.8) | 99 (59.3) |
| Age | < 65 | 551 (50.0) | 379 (50.5) | 94 (51.1) | 78 (46.7) |
| | ≥ 65 | 551 (50.0) | 372 (49.5) | 90 (48.9) | 89 (53.3) |
| BMI* | 18.5 to < 25 | 619 (56.2) | 419 (55.8) | 102 (55.4) | 98 (58.7) |
| | < 18.5 | 32 (2.9) | 27 (3.6) | 3 (1.7) | 2 (1.2) |
| | ≥ 25 | 388 (35.2) | 266 (35.4) | 65 (35.3) | 57 (34.1) |
| Living area | Ogatsu | 459 (41.7) | 312 (41.5) | 77 (41.8) | 70 (41.9) |
| | Oshika | 423 (38.4) | 284 (37.8) | 73 (39.7) | 66 (39.5) |
| | Wakabayashi | 220 (20.0) | 155 (20.6) | 34 (18.5) | 31 (18.6) |
| Smoking habits* | Non-smoker | 848 (77.0) | 576 (76.7) | 146 (79.3) | 126 (75.4) |
| | Smoker | 209 (19.0) | 146 (19.4) | 29 (15.8) | 34 (20.4) |
| Drinking habits* | Non-drinker | 661 (60.0) | 445 (59.3) | 116 (63.0) | 100 (59.9) |
| | < 45.6g of alcohol/day** | 227 (20.6) | 163 (21.7) | 32 (17.4) | 32 (19.2) |
| | ≥ 45.6g of alcohol/day** | 107 (9.7) | 73 (9.7) | 18 (9.8) | 16 (9.6) |
| Complication | HT | 444 (40.3) | 288 (38.3) | 78 (42.4) | 78 (46.7) |
| | DM | 99 (9.0) | 62 (8.3) | 22 (12.0) | 15 (9.0) |
| | MI | 62 (5.6) | 37 (4.9) | 11 (6.0) | 14 (8.4) |
| | Cerebral stroke | 18 (1.6) | 13 (1.7) | 1 (0.5) | 4 (2.4) |
| Working status* | Unemployed | 609 (55.3) | 418 (55.7) | 93 (50.5) | 98 (58.7) |
| | Employed | 460 (41.7) | 314 (41.8) | 81 (44.0) | 65 (38.9) |
| Walking time/day* | ≥ 1h | 307 (27.9) | 211 (28.1) | 50 (27.2) | 46 (27.5) |
| | 30min to < 1h | 410 (37.2) | 301 (40.1) | 59 (32.1) | 50 (29.9) |
| | < 30m | 369 (33.5) | 229 (30.5) | 73 (39.7) | 67 (40.1) |
| Living status* | Same house as before the GEJE | 285 (25.9) | 200 (26.6) | 43 (23.4) | 42 (25.1) |
| | Prefabricated house | 514 (46.6) | 346 (46.1) | 87 (47.3) | 81 (48.5) |
| | new house | 39 (3.5) | 26 (3.5) | 8 (4.3) | 5 (3.0) |
| | Others | 232 (21.1) | 155 (20.6) | 43 (23.4) | 34 (20.4) |
| Subjective economic condition* | Normal | 546 (49.5) | 406 (54.1) | 77 (41.8) | 63 (37.7) |
| | A little hard | 291 (26.4) | 182 (24.2) | 51 (27.7) | 58 (34.7) |
| | Hard | 163 (14.8) | 106 (14.1) | 35 (19.2) | 22 (13.2) |
| | Very hard | 84 (7.6) | 46 (6.1) | 16 (8.7) | 22 (13.2) |
| K6* | < 10 | 992 (90.0) | 684 (91.1) | 168 (91.3) | 140 (83.8) |
| | ≥ 10 | 62 (5.6) | 32 (4.3) | 9 (4.9) | 21(12.6) |
| LSNS-6* | ≥ 12 | 829 (75.2) | 563 (75.0) | 141 (76.6) | 125 (74.9) |
| | < 12 | 271 (24.6) | 186 (24.8) | 43 (23.4) | 42 (25.1) |

*Because each item has a limited number of respondents, the actual number is not necessarily in accordance with the total.
**22.8 g of alcohol amount to 1 go or traditional unit of sake (180 ml), which also approximates to two glasses of wine (200 ml), or beer (500 ml) in terms of alcohol content.
Categorical variables are presented as numbers and percentage (%).
BMI, body mass index; HT, hypertension; DM, diabetes mellitus; MI, myocardial infarction; LSNS, Lubben Social Network Scale.

Table 2. Influence of the number of musculoskeletal pain sites on new-onset sleep disturbance.

| | Number of musculoskeletal pain sites | | | | |
|---|---|---|---|---|---|
| | total | 0 | 1 | ≥ 2 | P for trend |
| Participants | 1,102 | 751 | 184 | 167 | |
| Sleep disturbance, n (%) | 161 (14.6) | 75 (10.0) | 41 (22.3) | 45 (26.9) | |
| Crude OR (95% CI) | | 1 | 2.58 (1.70-3.94) | 3.33 (2.19-5.04) | < 0.001 |
| Adjusted OR (95% CI) | | 1 | 2.43 (1.55-3.80) | 2.96 (1.88-4.64) | < 0.001 |

Adjusted for sex, age, BMI, living area, smoking habits, drinking habits, complications, working status, walking time, living status, subjective economic condition, K6, and LSNS-6.
OR, odds ratio; CI, confidence interval; LSNS, Lubben Social Network Scale.

Table 3. Influence of each musculoskeletal pain on new-onset sleep disturbance.

| | | Absence | Presence | P value |
|---|---|---|---|---|
| Low back pain | Participants | 906 | 196 | |
| | Crude OR (95% CI) | 1 | 2.64 (1.82-3.84) | < 0.001 |
| | Adjusted OR (95% CI) | 1 | 2.22 (1.48-3.33) | < 0.001 |
| Shoulder pain | Participants | 1,038 | 64 | |
| | Crude OR (95% CI) | 1 | 3.39 (1.96-5.85) | < 0.001 |
| | Adjusted OR (95% CI) | 1 | 3.43 (1.90-6.20) | < 0.001 |
| Knee pain | Participants | 990 | 112 | |
| | Crude OR (95% CI) | 1 | 1.70 (1.04-2.76) | 0.033 |
| | Adjusted OR (95% CI) | 1 | 1.67 (0.97-2.86) | 0.064 |
| Hand or foot pain | Participants | 1,001 | 101 | |
| | Crude OR (95% CI) | 1 | 1.84 (1.12-3.04) | 0.016 |
| | Adjusted OR (95% CI) | 1 | 2.20 (1.26-3.85) | 0.006 |
| Katakori | Participants | 942 | 160 | |
| | Crude OR (95% CI) | 1 | 2.57 (1.72-3.83) | < 0.001 |
| | Adjusted OR (95% CI) | 1 | 2.10 (1.36-3.23) | 0.001 |

Adjusted for sex, age, BMI, living area, smoking habits, drinking habits, complications, working status, walking time, living status, subjective economic condition, K6, and LSNS-6.
OR, odds ratio; CI, confidence interval; LSNS, Lubben Social Network Scale.

to this and to support or reduce survivors' sleep disturbance in the chronic phase.

Natural disasters cause musculoskeletal pain mainly associated with traumatic events in the acute phase (Angeletti et al. 2012). However, its prevalence has been reported at high level even in the chronic phase (Yabuki et al. 2015). Evacuation of life after natural disasters induce conditions for an increase in musculoskeletal pain, such as bad posture, heavy physical efforts, and immobility due to unfamiliar circumstances (Yabuki et al. 2015; Yabe et al. 2017). Furthermore, natural disasters changed working status (Angeletti et al. 2014) and subjective economic hardship was associated with low back and shoulder pain after the GEJE (Hagiwara et al. 2017b; Yabe et al. 2017). Psychological distress under natural disasters was considered to affect peoples' perception of pain (Angeletti et al. 2014), and a reduced pain threshold and elevated sympathetic nervous system activity were considered as candidate reasons (Angeletti et al. 2012, 2014). Musculoskeletal pain after natural disasters disturbed activities of daily living of survivors (Hagiwara et al. 2017a). Furthermore, in this study, that pain was associated with the onset of sleep disturbance, which was also major problem after natural disasters.

It is well known that pain is associated with sleep disturbance (Diaz-Piedra et al. 2015). Chronic pain is found in more than 50% of individuals with sleep disturbance (McBeth et al. 2015). Further, sleep disturbance is present in 50-88% of patients with chronic pain conditions (Kelly et al. 2011; Finan et al. 2013). Although pain and sleep disturbance are considered to have bi-directional relationships (McBeth et al. 2015), there have been only a few reports

Table 4. Stratified analysis for each age group.

| | Number of musculoskeletal pain sites | | | | |
|---|---|---|---|---|---|
| | total | 0 | 1 | ≥ 2 | P for trend |
| Younger (age < 65) | | | | | |
| Participants | 551 | 379 | 94 | 78 | |
| Sleep disturbance, n | 94 (17.1) | 48 (12.7) | 24 (25.5) | 22 (28.2) | |
| Crude OR (95% CI) | | 1 | 2.36 (1.36-4.11) | 2.71 (1.52-4.83) | < 0.001 |
| Adjusted OR (95% CI) | | 1 | 1.88 (1.02-3.46) | 2.08 (1.11-3.91) | 0.027 |
| Older (age ≥ 65) | | | | | |
| Participants | 551 | 372 | 90 | 89 | |
| Sleep disturbance, n | 67 (12.2) | 27 (7.3) | 17 (18.9) | 23 (25.8) | |
| Crude OR (95% CI) | | 1 | 2.98 (1.54-5.74) | 4.45 (2.41-8.24) | < 0.001 |
| Adjusted OR (95% CI) | | 1 | 3.18 (1.48-6.83) | 5.06 (2.39-10.69) | < 0.001 |

Adjusted for sex, BMI, living area, smoking habits, drinking habits, complications, working status, walking time, living status, subjective economic condition, K6, and LSNS-6.
OR, odds ratio; CI, confidence interval; LSNS, Lubben Social Network Scale.

showing an effect of pain on onset of sleep disturbance (Finan et al. 2013). Nicassio and Wallston (1992) reported that prior pain predicted subsequent sleep problem in rheumatoid arthritis patients. Riley et al. (2001) showed that initial pain had negative effects on sleep condition in orofacial pain patients. These results are consistent with our results. Pain leads to arousal and prevents the initiation or continuation of sleep (Roehrs 2009). In addition, brain structures related to pain modulation are also implicated in the generation and maintenance of sleep, which indicates that pain and sleep disturbance are comorbid with common neurobiological dysfunction (Smith and Haythornthwaite 2004). Survivors with multiple pain sites were more likely to have new-onset sleep disturbance than those with only one. The suggested effects might be stronger when there are multiple pain sites. Further, the effect of musculoskeletal pain on new-onset sleep disturbance was strongest in shoulder pain. Although the reason is not clarified, night pain is a common symptom in patients with shoulder disorders (Cho et al. 2013), leading to arousal or discontinuation of sleep. The association of musculoskeletal pain with onset of sleep disturbance is different according to pain sites. The prevalence of new-onset sleep disturbance in the younger group was 17.1% (94/551), which was higher than the 14.6% (67/551) of the older group. However, the association of musculoskeletal pain with new-onset sleep disturbance was stronger in the older than in the younger group. Younger survivors may have strong anxiety for the future because they needed to earn money, restore their homes, and support their families. These feelings might lead to psychological distress, which was an associated factor of sleep disturbance and is related to a higher rate of new-onset sleep disturbance and lower association of musculoskeletal pain with new-onset sleep disturbance compared to older survivors. The relationship between pain and sleep disturbance is considered to be quite complex (Smith and Haythornthwaite 2004). The survivors of the GEJE suffer from various physical, mental, and socioeconomic problems that are probably related to pain and sleep disturbance (Matsumoto et al. 2014; Tomata et al. 2015; Sone et al. 2016; Watanabe et al. 2016). Musculoskeletal pain was associated with new-onset sleep disturbance in such a complicated situation. Reducing sleep disturbance is an important issue after natural disasters. Improving living environments and building communities with neighbors are considered as possible ways to decrease sleep disturbance of survivors (Matsumoto et al. 2014; Kawano et al. 2016). Further, care for musculoskeletal pain is also important, and former studies have suggested that creating environments to avoid immobility and support for economic anxiety can decrease that pain (Yabuki et al. 2015; Yabe et al. 2017), which may prevent sleep disturbance in the survivors of the natural disasters.

This study has several limitations. First, sleep disturbance was assessed at only two periods and the changes of this during other periods are not clear. Second, musculoskeletal pain was evaluated by a self-report questionnaire, and the exact portion and degree of pain were not assessed. Third, the questionnaire and documented informed consent were mailed and the response rate was not high. The responders might have higher health status than non-responders, which could alter the association between pain and sleep disturbance. Finally, the participants of this study were all disaster survivors and suffering from great psychological trauma. It is unknown whether the results are applicable to the general Japanese population.

In conclusion, the presence of musculoskeletal pain is associated with new-onset sleep disturbance among the survivors in the chronic phase of the GEJE.

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## Conflict of Interest

The authors declare no conflict of interest.

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