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Sleep Disturbance Is Associated with New Onset and Continuation of Lower Back Pain: A Longitudinal Study among Survivors of the Great East Japan Earthquake

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Lower back pain (LBP) is a common health problem after natural disasters. Although some related factors have been reported, the effect of sleep disturbances on LBP is not clear. The purpose of this study was to elucidate the influence of sleep disturbances on LBP after the Great East Japan earthquake (GEJE). A panel study was conducted with the survivors of the GEJE (n = 2,295) at three and four years after the disaster using self-reported questionnaires. The changes in the presence of LBP during the two periods were assessed; LBP was characterized as either new onset or continuation of LBP. The participants' sleep conditions were assessed, and the changes in sleep disturbances during the two periods were classified into four groups: absence, new onset, improvement, and continuation. Multivariate logistic regression models were used to analyze the association of the changes in sleep disturbance with new onset and continuation of LBP. The rates of new onset and continuation of LBP were 14.1% and 55.1%, respectively. The changes in sleep disturbances were significantly associated with new-onset and continuing LBP. Using "absence" as a reference for the change of sleep disturbance, the adjusted ORs (95% CI) for new-onset LBP were 2.19 (1.42-3.38) in "new onset," 1.38 (0.83-2.30) in "improvement," and 2.17 (1.50-3.15) in "continuation," and those for continuing LBP were 1.42 (0.71-2.84) in "new onset," 0.98 (0.55-1.74) in "improvement," and 1.60 (1.01-2.51) in "continuation." Careful attention should be paid to sleep disturbances to prevent and improve LBP after natural disasters.

Keywords: Great East Japan Earthquake; lower back pain; natural disaster; sleep disturbance; survivor
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Introduction

Lower back pain (LBP) is a common health problem worldwide (Kelly et al. 2011). The point prevalence of LBP was reported to be between 12-30% (Krismer and van Tulder 2007). Some related factors such as age, sex, physical demands on the body, obesity, and smoking have been presented (Deyo and Weinstein 2001; Fujii and Matsudaira 2013). Psychosocial issues are also considered to be a risk factor for LBP (Pincus et al. 2002). Further, some authors have shown associations between LBP and sleep disturbances (Alsaadi et al. 2013). Alsaadi et al. (2014) reported that at least 50% of patients with LBP had sleep disturbances. Although most of the reports have indicated that LBP causes sleep disturbances (Eadie et al. 2013; Goforth et al. 2014), sleep disturbance is also considered to worsen LBP intensity (Alsaadi et al. 2014). A small number of prospective studies have indicated that sleep disturbances are associated with the onset of LBP (Mork et al. 2014).

The Great East Japan earthquake (GEJE), which was followed by a devastating tsunami, struck the north-eastern coastal area of Japan on March 11, 2011, and left approximately 18,500 people dead or missing and 400,000 buildings destroyed (Ishigaki et al. 2013). Although seven years have passed, 73,000 survivors are still unable to return to their hometowns, and 13,000 people are living in prefabricated temporary housing (Reconstruction Agency of Japan 2018). The conditions after natural disasters have long-term negative effects on survivors' physical and mental health (Cao et al. 2015), and a high incidence of LBP was reported after the disaster (Angeletti et al. 2014). Living in unfamiliar places and psychosocial factors are thought to be

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associated with pain after natural disasters (Angeletti et al. 2012; Yabuki et al. 2015; Yabe et al. 2017). Sleep disturbances were also increased (Kawano et al. 2016) and were reported to be associated with the onset of knee and shoulder pain after the disaster (Hagiwara et al. 2017, 2018). However, the influence of sleep disturbances on LBP after natural disasters has not yet been reported.

The present study examined the influence of sleep disturbances on LBP in the recovery phase after the GEJE. For this purpose, we used panel data from surveys conducted at three and four years after the GEJE, and analyzed the associations between the changes in sleep disturbances with new-onset and continuing LBP.

Materials and Methods

Participants

A panel study was conducted among GEJE survivors who lived in the severely damaged coastal regions of the Ogatsu and Oshika areas in Ishinomaki city, and the Wakabayashi ward in Sendai city, in the Miyagi prefecture. These study evaluations were conducted every six months since June 2011, which was three months after the GEJE. The starting study population comprised residents included in the Residential Registry for the Ogatsu and Oshika areas and residents who lived in prefabricated homes in the Wakabayashi ward after the GEJE. From November 2013 to February 2014, three years after the GEJE, survivors (18 years old or over) registered in the Residential Registry for the Ogatsu and Oshika areas, and survivors who participated in the previous survey in the Wakabayashi ward were recruited for this study. The participants were followed from November 2014 to February 2015, four years after the GEJE. Self-reported questionnaires and documented informed consent forms were mailed to the participants. This study was approved by the institutional review board of our university (approval number: 201192).

Outcome variables

The outcomes of interest were new-onset and continuing LBP. New-onset LBP was defined as having an absence of LBP in the first period (three years after the GEJE) and a presence of LBP in the second period (four years after the GEJE). Continuing LBP was defined as the presence of LBP in both periods. The presence of LBP was assessed by the self-reported questionnaires, which were not quantified.

Main predictor

Sleep conditions were assessed using the Athens Insomnia Scale (AIS). Sleep disturbance was defined as a score of ≥ 6/24 on the AIS in both periods (Soldatos et al. 2000). Changes in sleep disturbances over the two periods were classified into the following four groups: “absence” (absent in both periods), “new onset” (absent in the first period and present in the second period), “improvement” (present in the first period and absent in the second period), and “continuation” (present in both periods).

Covariates

The following were included in the analysis as covariates because they were considered as potential cofounding factors: sex, age, body mass index (BMI: calculated using self-reported height and weight values), living area, smoking habits, drinking habits, comorbid conditions (hypertension [HT], myocardial infarction [MI: medical history of coronary artery disease or myocardial infarction], diabetes mellitus [DM], and cerebral stroke [medical history of any type of cerebral stroke]), working status, time spent in walking activities per day, living status (housing condition), subjective economic hardship, psychological distress (Kessler Psychological Distress Scale-6 [K6]) and social isolation (Lubben Social Network Scale [LSNS-6]) in the first period (Sone et al. 2016). Based on a previous report, psychological distress and social isolation were defined by a score of ≥ 10/24 on the K6 and < 12/30 on the LSNS-6 (Sone et al. 2016).

Statistical analysis

A chi-squared test was conducted to compare baseline characteristics among the participants according to changes in sleep disturbance.

Univariate and multivariate logistic regression models were used to calculate the odds ratio (OR) and 95% confidence interval (95% CI) for new onset and continuation of LBP according to the changes in sleep disturbances. Variables included in the analysis 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), smoking habits (non-smoker, smoker, or unknown), drinking habits (none, < 45.6 g of alcohol/day, ≥ 45.6 g of alcohol/day, or unknown), comorbid conditions (HT [absence or presence], MI [absence or presence], DM [absence or presence], and cerebral stroke [absence or presence]), working status (unemployed, employed, or unknown), time spent in walking activities per day (< 30 min, 30 min to < 1 h, ≥ 1 h, or unknown), living status (living in the same house as before the earthquake, living in a prefabricated house, new house, others, or unknown), subjective economic hardship (normal, a little bit hard, hard, very hard, or unknown), K6 (< 10, ≥ 10, or unknown), and LSNS-6 (< 12, ≥ 12, or unknown). All statistical analyses were performed using SPSS version 24.0 (SPSS Japan Inc., Tokyo, Japan). A P value of < 0.05 was considered statistically significant.

Results

The response rate in the first period was 44.6% (2,853/6,396). The follow-up rate in the second period was 81.4% (2,321/2,853), and 26 individuals were excluded because data regarding their sleep conditions were missing. Finally, data from 2,295 participants were included in this analysis (Fig. 1). Baseline characteristics of the participants are shown in Table 1. The participants who had sleep disturbances in each period during this study were more likely to be female, live in prefabricated housing, have lower walking activities and subjective economic status, and higher rate of cerebral stroke, psychological distress, and social isolation.

The point prevalence of LBP in the first period was 23.3% (535/2,295). The rates of new onset and continuation of LBP in the second period were 14.1% (249/1,760) and 55.1% (295/535), respectively. Furthermore, 41.4% (949/2,295) of participants had sleep disturbances in each period. The crude and adjusted ORs (95% CI) for new-onset and continuing LBP according to the changes in sleep disturbances are shown in Tables 2 and 3, respectively. The changes in sleep disturbances were significantly associated

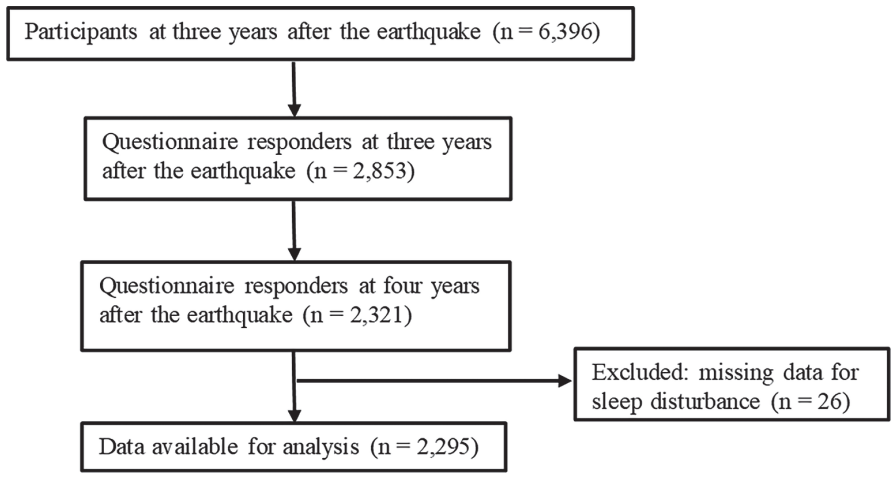

Fig. 1. Flowchart of the present analysis.

with new-onset LBP in both the crude and adjusted analyses. Using "absence" as a reference for the changes in sleep disturbances, the adjusted ORs (95% CI) for new-onset LBP were 2.19 (1.42-3.38) in "new onset," 1.38 (0.83-2.30) in "improvement," and 2.17 (1.50-3.15) in "continuation," respectively. Furthermore, the changes in sleep disturbances were also significantly associated with continuing LBP in both the crude and adjusted analyses. Using "absence" as a reference for the changes in sleep disturbances, the adjusted ORs (95% CI) for continuing LBP were 1.42 (0.71-2.84) in "new onset," 0.98 (0.55-1.74) in "improvement," and 1.60 (1.01-2.51) in "continuation," respectively.

Discussion

The present study has revealed that sleep disturbances are associated with new-onset and continuing LBP among survivors after the GEJE. Continuing and new-onset sleep disturbances are associated with new-onset LBP. Furthermore, continuing sleep disturbances are associated with the continuation of LBP.

There have been some cross-sectional studies indicating that LBP leads to sleep disturbances because most of the reports have assessed sleep disturbances in LBP patients (Eadie et al. 2013; Goforth et al. 2014). On the other hand, Kelly et al. (2011) reported that 40% of individuals with sleep disturbance experienced some type of pain, including LBP. Further, Mork et al. (2014) reported that sleep disturbances were associated with LBP one year later in a prospective study. However, there was a possibility that sleep conditions would change during the study. The present study assessed the changes in sleep disturbances and showed that continuing sleep disturbances were significantly associated with new onset of LBP, which meant that sleep disturbances preceded LBP. Although the reason why sleep disturbance leads to LBP is not clear, it is considered that sleep disturbance lowers the pain threshold (Kelly et al. 2011) and decreases the mental capacity to manage pain (van de Water et al. 2011). Experimental data showed that sleep disturbances prevent the analgesic effects of endogenous and exogenous opioids (Lautenbacher et al. 2006). Sleep disturbances also induce low-level systemic inflammation, which sensitizes the nociceptive system (Mork et al. 2014). These conditions can lead to the onset of LBP. Moreover, new-onset sleep disturbances over the duration of this study were also associated with the onset of LBP. Interestingly, the OR (95% CI) was similar to that of continuing sleep disturbances, which could mean that the presence of sleep disturbance could be associated with new-onset LBP irrespective of the duration of the sleep disturbance. Although the reason is not clear, sleep disturbances can change pain thresholds and the effects on LBP may be limited (Kelly et al. 2011). Furthermore, reverse causality can be a possibility, which means that LBP might precede and lead to sleep disturbances. On the other hand, in participants with improvement of sleep disturbances during this study, the association with new-onset LBP was not significant compared to participants with an absence of a sleep disturbance. As far as we know, there have been no reports indicating that an improvement in sleep disturbance prevents the onset of pain. Some authors have reported that restorative sleep is associated with the resolution of pain, such as headache or widespread pain (Davies et al. 2008; Roehrs 2009). The present study also showed that improvements in sleep disturbance could prevent the onset of LBP. Furthermore, continuing sleep disturbances were significantly associated with the continuation of LBP. Sleep disturbances lower the pain threshold and reduce opioidergic activation (Lautenbacher et al. 2006; Kelly et al. 2011), which could result in poor recovery from LBP. Sleep disturbances were also reported to worsen the intensity of pain in patients with LBP (Alsaadi et al. 2013). Interventions for sleep disturbances may be used to improve LBP.

The rate of LBP three years after the GEJE was 23.3%, and 14.1% of the participants had new-onset LBP four years after the disaster. LBP was a common symptom after

Table 1. Baseline characteristics of the participants according to the changes in sleep disturbances.

		Sleep disturbance, n (%)					
		Total	Absence	New onset	Improvement	Continuation	
		2,295	1346 (58.6)	214 (9.3)	226 (9.8)	509 (22.2)	P value
Sex	Male	1,040 (45.3)	667 (49.6)	90 (42.1)	85 (37.6)	198 (38.9)	< 0.001
	Female	1,255 (54.7)	679 (50.4)	124 (57.9)	141 (62.4)	311 (61.1)	
Age	< 65	1,168 (50.9)	663 (49.3)	115 (53.7)	121 (53.5)	269 (52.8)	0.195
	≥ 65	1,127 (49.1)	683 (50.7)	99 (46.3)	105 (46.5)	240 (47.2)	
BMI*	18.5 to < 25	1,316 (57.3)	775 (57.6)	128 (59.8)	140 (61.9)	273 (53.6)	0.164
	< 18.5	62 (2.7)	37 (2.7)	3 (1.4)	4 (1.8)	18 (3.5)	
	≥ 25	836 (36.4)	485 (36.0)	73 (34.1)	72 (31.9)	206 (40.5)	
Living area	Ogatsu	1,003 (43.7)	581 (43.2)	90 (42.1)	94 (41.6)	238 (46.8)	0.001
	Oshika	841 (36.6)	527 (39.2)	85 (39.7)	84 (37.2)	145 (28.5)	
	Wakabayashi	451 (19.7)	238 (17.7)	39 (18.2)	48 (21.2)	126 (24.8)	
Smoking habits*	Non-smoker	1,719 (74.9)	1,024 (76.1)	155 (72.4)	163 (72.1)	377 (74.1)	0.623
	Smoker	446 (19.4)	252 (18.7)	42 (19.6)	49 (21.7)	103 (20.2)	
Drinking habits*	Non-drinker	1376 (60.0)	816 (60.6)	133 (62.1)	140 (61.9)	287 (56.4)	0.322
	< 45.6g of alcohol/day**	454 (19.8)	275 (20.4)	35 (16.4)	41 (18.1)	103 (20.2)	
	≥ 45.6g of alcohol/day**	238 (10.4)	133 (9.9)	18 (8.4)	24 (10.6)	63 (12.4)	
Complication	HT	883 (38.5)	528 (39.2)	94 (43.9)	86 (38.1)	222 (43.6)	0.557
	DM	227 (9.9)	122 (9.1)	24 (11.2)	30 (13.3)	52 (10.2)	0.139
	MI	141 (6.1)	83 (6.2)	13 (6.1)	12 (5.3)	43 (8.4)	0.198
	Cerebral stroke	30 (1.3)	23 (1.7)	4 (1.9)	1 (0.4)	14 (2.8)	0.034
Working status*	Unemployed	1,186 (51.7)	674 (50.1)	119 (55.6)	115 (50.9)	278 (54.6)	0.263
	Employed	1,061 (46.2)	643 (47.8)	91 (42.5)	103 (45.6)	224 (44.0)	
Walking time/day*	≥ 1h	658 (28.7)	411 (30.5)	52 (24.3)	79 (35.0)	116 (22.8)	< 0.001
	30min to < 1h	812 (35.4)	513 (38.1)	69 (32.2)	64 (28.3)	166 (32.6)	
	< 30min	815 (35.5)	416 (30.9)	90 (42.1)	83 (36.7)	226 (44.4)	
Living status*	Same house as before the GEJE	660 (28.8)	438 (32.5)	58 (27.1)	60 (26.5)	104 (20.4)	0.001
	Prefabricated house	936 (40.8)	508 (37.7)	94 (43.9)	97 (42.9)	237 (46.6)	
	New house	281 (12.2)	168 (12.5)	24 (11.2)	25 (11.1)	64 (12.6)	
	Others	406 (17.7)	226 (16.8)	36 (16.8)	44 (19.5)	100 (19.6)	
Subjective economic hardship*	Normal	987 (43.0)	703 (52.2)	83 (38.8)	66 (29.2)	135 (26.5)	< 0.001
	A little bit hard	599 (26.1)	332 (24.7)	63 (29.4)	73 (32.3)	131 (25.7)	
	Hard	459 (20.0)	204 (15.2)	43 (20.1)	58 (25.7)	154 (30.3)	
	Very hard	213 (9.3)	83 (6.2)	23 (10.7)	27 (11.9)	80 (15.7)	
K6*	< 10	1908 (83.1)	1,246 (92.6)	182 (85.0)	176 (77.9)	304 (59.7)	< 0.001
	≥ 10	313 (13.6)	54 (4.0)	24 (11.2)	47 (20.8)	188 (36.9)	
LSNS*	≥ 12	1623 (70.7)	1,020 (75.8)	149 (69.6)	142 (62.8)	312 (61.3)	< 0.001
	< 12	669 (29.2)	324 (24.1)	64 (29.9)	84 (37.2)	197 (38.7)	

*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 (%).
HT, hypertension; DM, diabetes mellitus; MI, myocardial infarction; K6, Kessler Psychological Distress Scale; LSNS, Lubben Social Network Scale.

Table 2. Influence of the changes in sleep disturbances on new-onset lower back pain.

			Crude			Adjusted		
Sleep disturbance	Participants without LBP at 1st period, n	New-onset LBP, n (%)	OR	95% CI	P value	OR	95% CI	P value
Total	1,760	249 (14.1)						
Absence	1,129	123 (10.9)	1	Reference		1	Reference	
New onset	168	35 (20.8)	2.15	1.42-3.27	< 0.001	2.19	1.42-3.38	< 0.001
Improvement	152	22 (14.5)	1.38	0.85-2.26	0.193	1.38	0.83-2.30	0.215
Continuation	311	69 (22.2)	2.33	1.68-3.23	< 0.001	2.17	1.50-3.15	< 0.001

Adjusted for sex, age, body mass index, living area, smoking habits, drinking habits, complications, working status, walking time, living status, subjective economic hardship, K6, and LSNS-6.
LBP, lower back pain; OR, odds ratio; CI, confidence interval; K6, Kessler Psychological Distress Scale; LSNS, Lubben Social Network Scale.

Table 3. Influence of the changes in sleep disturbances on continuing lower back pain.

			Crude			Adjusted		
Sleep disturbance	Participants with LBP at 1st period, n	Continuing LBP, n (%)	OR	95% CI	P value	OR	95% CI	P value
Total	535	295 (55.1)						
Absence	217	107 (49.3)	1	Reference		1	Reference	
New onset	46	27 (58.7)	1.46	0.77-2.78	0.249	1.42	0.71-2.84	0.318
Improvement	74	39 (52.7)	1.15	0.68-1.94	0.614	0.98	0.55-1.74	0.947
Continuation	198	122 (61.6)	1.65	1.12-2.44	0.012	1.60	1.01-2.51	0.043

Adjusted for sex, age, body mass index, living area, smoking habits, drinking habits, complications, working status, walking time, living status, subjective economic hardship, K6, and LSNS-6.
LBP, lower back pain; OR, odds ratio; CI, confidence interval; K6, Kessler Psychological Distress Scale; LSNS: Lubben Social Network Scale.

the GEJE, which was consistent with former reports on the GEJE (Yabuki et al. 2015). As many as 41.4% of participants had sleep disturbance in each period at three to four years after the GEJE and the presence of sleep disturbance was associated with LBP. LBP has been reported to increase after natural disasters leading to lower quality of life (Angeletti et al. 2014; Yabuki et al. 2015). High incidences of sleep disturbances after the disaster were also reported (Kawano et al. 2016; Yabe et al. 2018a), and the present study showed that this could be one reason for the increase in LBP after natural disasters. Although reconstruction following the GEJE has progressed, many survivors have left their hometowns and are living in temporary housing. Continuous high rates of physical inactivity, subjective economic hardship, psychological distress, and social isolation among survivors have been reported (Tanji et al. 2017; Tsubota-Utsugi et al. 2018; Yabe et al. 2018b), and these conditions are suspected to be related to sleep disturbances. Careful attention should be paid to sleep disturbance to prevent and improve LBP and continuous support for the daily lives of survivors is considered to be important after natural disasters.

This study has several limitations. First, LBP was assessed using a self-reported questionnaire, and the exact portion, degree of pain, and history of LBP were not assessed. Second, the questionnaire and the informed consent forms were mailed and the response rate was low. The responders might have had better overall health status than did the non-responders, which could have affected the results. Further, this study assessed the changes in sleep disturbances and LBP between the two periods, and reverse causality could not be ruled out. Finally, this study was conducted among survivors of the disaster and it is unknown whether the results can be applied to the general population.

In conclusion, sleep disturbances are associated with new-onset and continuing LBP among the survivors of the GEJE.

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Conflict of Interest

The authors declare no conflict of interest.

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