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EPIDEMIOLOGY

Association Between Sleep Disturbance and Low Back Pain

A 3-Year Longitudinal Study After the Great East Japan Earthquake

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Study Design. A longitudinal study.

Objective. The aim of this study was to clarify the association between sleep disturbance and low back pain (LBP) using 3-year longitudinal data after the Great East Japan Earthquake, with a focus on the duration or frequency of sleep disturbance and the effect of sleep disturbance on LBP.

Summary of Background Data. Sleep disturbance and LBP are common health problems in the general population and natural disaster survivors. However, a longitudinal study in this field is rare, and the association between sleep disturbance and LBP has not been clarified.

Methods. A 3-year longitudinal study was conducted among people living in disaster-stricken areas after the Great East Japan Earthquake (n = 2059). Sleep disturbance and LBP were assessed at 4, 5, 6, and 7 years after the disaster. Multiple logistic regression analysis was performed to assess the association between the duration or frequency of sleep disturbance and LBP, and the effect of preceding sleep disturbance on the onset of LBP. The χ^2 test and crude and multiple logistic regression models were used in data analysis.

Results. The duration and frequency of sleep disturbance were significantly associated with LBP, and the effect was stronger with longer duration and increased frequency of sleep disturbance. Furthermore, the duration and frequency of preceding sleep disturbance were significantly associated with the onset of LBP, and the effect was stronger with an increase in the duration and frequency of sleep disturbance.

Conclusion. Sleep disturbance is associated with LBP in a dose-dependent manner. Attention should be paid to sleep disturbance for the treatment and prevention of LBP, especially with regard to the duration and frequency of sleep disturbance.

Key words: earthquake, Great East Japan earthquake, Japan, longitudinal study, low back pain, natural disaster, pain, sleep, sleep disturbance, spine.

Level of Evidence: 3

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Low back pain (LBP) is one of the most common health problems worldwide.[1] LBP is considered to originate from several spinal structures,[2] and some factors have been reported to be associated with LBP, such as age, sex, obesity, and psychosocial factors.[3–5] Some authors have also reported the association between sleep disturbance and LBP.[6–10] Sleep disturbance is a symptom commonly seen among patients with LBP,[10,11] and patients with sleep disturbance tend to complain severe LBP.[6] Although most of these studies had a cross-sectional design and the effect of sleep disturbance on LBP was rarely investigated, a few longitudinal studies have shown that sleep disturbance is associated with the onset of LBP and poor recovery from LBP.[12–15] To develop strategies for the treatment of LBP, further studies are necessary to clarify the effect of sleep disturbance on LBP, especially with regard to the dose-dependent effect of sleep disturbance.

LBP has also been reported to be increased among people after natural disasters.[16] The Great East Japan Earthquake (GEJE) was accompanied by a large tsunami that affected the north-east coastal areas in Japan on March 11, 2011 and caused serious damage to these areas.[17] A high prevalence of LBP was reported after the GEJE.[18] Furthermore, the rate of sleep disturbance was reported to be high after the GEJE.[19] The disaster caused stressful conditions with a deteriorated

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socioeconomic status and social network, which are considered to be associated with LBP and sleep disturbances.[20–22] A previous study showed an association between changes in sleep disturbance and the onset or continuation of LBP during a 1-year follow-up after the GEJE,[23] and this had been hardly argued after natural disasters. Clarifying the association between sleep disturbance and LBP is important for the treatment of LBP, which is beneficial for the general population and natural disaster survivors. Therefore, the present study aimed to clarify the association between sleep disturbance and LBP using 3-year longitudinal data after the GEJE, with a focus on the duration or frequency of sleep disturbance and the effect of sleep disturbance on LBP.

MATERIALS AND METHODS

Study Design and Participants

A panel study was conducted on people living in disaster-stricken areas such as the Ogatsu, Oshika, and Ajishima areas in Ishinomaki City and Wakabayashi Ward in Sendai City in the Miyagi Prefecture in Japan. The study was started 3 months after the GEJE and was repeated annually to assess the mental and physical conditions of people after the disaster. The initial study population included residents registered in the basic residential registry of the Ogatsu, Oshika, and Ajishima areas and people living in prefabricated housing in the Wakabayashi Ward. The present study was one part of this survey, and we used the data at 4, 5, 6, and 7 years after the GEJE for this 3-year longitudinal study. For each survey, we recruited people who had participated in a previous survey (age ≥18 yrs). The exclusion criterion was participants with missing data for sleep disturbance. Self-reported questionnaires and informed consent forms were mailed to all participants.

Low Back Pain

LBP was assessed using a self-reported questionnaire. The participants were asked if they had experienced LBP in the last few days. We used the information of LBP during the fourth period to assess the association between sleep disturbance and LBP, and LBP during the third and fourth periods to assess the effect of preceding sleep disturbance on LBP onset.

Sleep Disturbance

Sleep conditions were assessed using the Athens Insomnia Scale, and sleep disturbance was defined as a score of ≥6/24 on the Athens Insomnia Scale.[24] The duration of sleep disturbance during the fourth period was defined and categorized into four groups: absence, the absence of sleep disturbance during the fourth period; <1 year, the absence of sleep disturbance during the third period, and the presence of sleep disturbance during the fourth period; ≥1 year and <2 years, the absence of sleep disturbance during the second period and the presence of sleep disturbance during the third and fourth periods; and ≥2 years, the presence of sleep disturbance during the second, third, and fourth periods.

Further, the frequency of sleep disturbance during the fourth period was defined as the number of sleep disturbances during the first, second, third, and fourth periods. It was categorized into four groups: absence, 1, 2, and ≥3.

The duration of sleep disturbance during the third period was also defined and categorized into four groups: absence, the absence of sleep disturbance during the third period; <1 year, the absence of sleep disturbance during the second period and the presence of sleep disturbance during the third period; ≥1 year and <2 years, the absence of sleep disturbance during the first period and the presence of sleep disturbance during the second and third periods; and ≥2 years, the presence of sleep disturbance during the first, second, and third periods. Additionally, the frequency of sleep disturbance during the third period was defined as the number of sleep disturbances during the first, second, and third periods, and it was categorized into four groups: absence, 1, 2, and 3.

Covariates

The following variables during the fourth period were included in the analyses as covariates because they were considered as potential confounding factors: sex, age, the body mass index, living area, smoking habit, drinking habit, comorbid conditions (hypertension, diabetes mellitus, myocardial infarction, and cerebral stroke), working status, walking time/day, living status, economic condition, psychological distress, and social isolation. Psychological condition was assessed using the Kessler Psychological Distress Scale and psychological distress was defined as a score of ≥10/24.[25] Social network was assessed using the Lubben Social Network Scale and social isolation was defined as a score of <12/30.[26] These variables were categorized as shown in Table 1.

Statistical Analysis

Sleep disturbance during the fourth period and covariates are presented as numbers and percentages (%). The χ^2 test was used to compare the covariates with the presence of sleep disturbance reported during the fourth period. Crude and multiple logistic regression models were used to assess the association between sleep disturbance and LBP, and the odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. The outcome of interest was set as LBP during the fourth period. First, the main predictor was sleep disturbance during the fourth period to assess the association between sleep disturbance and LBP. Furthermore, the association between sleep disturbance and LBP regarding the duration of sleep disturbance during the fourth period was assessed. In addition, the main predictor was set as the frequency of sleep disturbance during the fourth period to assess the association between sleep disturbance and LBP with respect to the frequency of sleep disturbance. Second, to assess the effect of preceding sleep disturbance on the onset of LBP, the participants without LBP during the third period were selected and the main predictors were set as the sleep disturbance, duration of sleep disturbance, and

TABLE 1. Baseline Characteristics

	Sleep Disturbance			
	n (%)	Absence	Presence	*P* Value
	2059	1372	687	
Sex				
Male	911 (44.2)	662 (48.3)	249 (36.2)	< 0.001
Female	1148 (55.8)	710 (51.7)	438 (63.8)	
Age				
< 65	820 (39.8)	525 (38.3)	295 (42.9)	0.041
≥ 65	1239 (60.2)	847 (61.7)	392 (57.1)	
Body mass index*				
≥18.5, < 25	1240 (60.2)	832 (60.6)	408 (59.4)	0.54
< 18.5	38 (1.8)	22 (1.6)	16 (2.3)	
≥ 25	706 (34.3)	465 (33.9)	241 (35.1)	
Living area				
Ogatsu	857 (41.6)	534 (38.9)	323 (47.0)	< 0.001
Oshika	740 (35.9)	526 (38.3)	214 (31.1)	
Ajishima	137 (6.7)	117 (8.5)	20 (2.9)	
Wakabayashi	325 (15.8)	195 (14.2)	130 (18.9)	
Smoking habits*				
Non-smoker	1656 (80.4)	1100 (80.2)	556 (80.9)	0.866
Smoker	330 (16.0)	224 (16.3)	106 (15.4)	
Drinking habits*				
Non-drinker	1292 (62.7)	839 (61.2)	453 (65.9)	0.05
< 45.6 g of alcohol/d†	438 (21.3)	315 (23.0)	123 (17.9)	
≥ 45.6 g of alcohol/d†	161 (7.8)	110 (8.0)	51 (7.4)	
Comorbid conditions				
Hypertension	877 (42.6)	578 (42.1)	299 (43.5)	0.546
Diabetes mellitus	222 (10.8)	151 (11.0)	71 (10.3)	0.643
Myocardial infarction	135 (6.6)	85 (6.2)	50 (7.3)	0.349
Cerebral stroke	31 (1.5)	18 (1.3)	13 (1.9)	0.308
Working status*				
Unemployed	1033 (50.2)	667 (48.6)	366 (53.3)	0.105
Employed	973 (47.3)	671 (48.9)	302 (44.0)	
Walking time/d*				
≥ 1 h	594 (28.8)	438 (31.9)	156 22.7)	< 0.001
30 min to < 1 h	752 (36.5)	505 (36.8)	247 (36.0)	
< 30 m	685 (33.3)	408 (29.7)	277 (40.3)	
Living status*				
Same house as before the GEJE	670 (32.5)	489 (35.6)	181 (26.3)	0.001
Prefabricated house	83 (4.0)	48 (3.5)	35 (5.1)	
New house	654 (31.8)	419 (30.5)	235 (34.2)	
Others	629 (30.5)	400 (29.2)	229 (33.3)	
Economic condition*				
Normal	1020 (49.5)	798 (58.2)	222 (32.3)	< 0.001
A little hard	488 (23.7)	296 (21.6)	192 (27.9)	
Hard	324 (15.7)	174 (12.7)	150 (21.8)	
Very hard	191 (9.3)	77 (5.6)	114 (16.6)	
Psychological distress*				
Absence	1775 (86.2)	1289 (94.0)	486 (70.7)	< 0.001
Presence	253 (12.3)	56 (4.1)	197 (28.7)	
Social isolation*				
Absence	1454 (70.6)	1025 (74.7)	429 (62.4)	< 0.001
Presence	604 (29.3)	347 (25.3)	257 (37.4)	

**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 values are presented as numbers and percentage (%).

GEJE indicates Great East Japan Earthquake.

frequency of sleep disturbance during the third period. ORs and 95% CIs were calculated in the same manner. All statistical analyses were performed using SPSS (version 24.0; IBM Corp, Armonk, NY). Statistical significance was set at $P < 0.05$.

RESULTS

First, we contacted 4324 people and 3032 responded (response rate, 70.1%). Among these, 2635 participated in the survey during the second period (86.9%). Of these, 2361 responded during the third period (89.6%). Among these, 2119 participated in the survey during the fourth period (89.8%). Participants with missing data for sleep disturbance were excluded (n = 60), and 2059 people were included in this study (Figure 1).

The baseline characteristics of the participants are presented in Table 1. The rate of sleep disturbance during the fourth period was 33.4%. The participants who reported sleep disturbance during the fourth period were more likely to be female and younger, live in the Ogatsu or Wakabayashi area and in a different house before the GEJE, and have a shorter walking time per day, subjective economic hardship, psychological distress, and social isolation. The rate of LBP during the fourth period was 26.8% (551/2,059). Sleep disturbance was significantly associated with LBP during the fourth period. Using the absence of sleep disturbance during the fourth period as a reference, the adjusted OR (95% CI) for LBP was 2.24 (1.78–2.83) in the presence of sleep disturbance. Moreover, the duration of sleep disturbance was significantly associated with LBP during the fourth period. Using the absence of sleep disturbance as a reference, the adjusted ORs (95% CIs) for LBP were 1.93 (1.34–2.78) for <1 year, 1.70 (1.09–2.65) for ≥1 year and <2 years, and 2.62 (2.99–3.43) for ≥2 years of sleep disturbance during the fourth period (P for trend < 0.001) (Table 2). In addition, the frequency of sleep disturbance was significantly associated with LBP during the fourth period. Using the absence of sleep disturbance during the periods as a reference, the adjusted ORs (95% CIs) for LBP were 1.32 (0.95–1.84) for 1, 1.90 (1.35–2.67) for 2, and 2.67 (1.04–3.50) for ≥3 sleep disturbances (P for trend <0.001) (Table 3).

Among the participants without LBP during the third period, the rate of onset of LBP during the fourth period was 14.2% (214/1,510). Sleep disturbance during the third period was significantly associated with the onset of LBP during the fourth period. Using the absence of sleep disturbance as a reference, the adjusted OR (95% CI) for the onset of LBP was 1.65 (1.18–2.32) in the presence of sleep disturbance during the third period. Furthermore, the

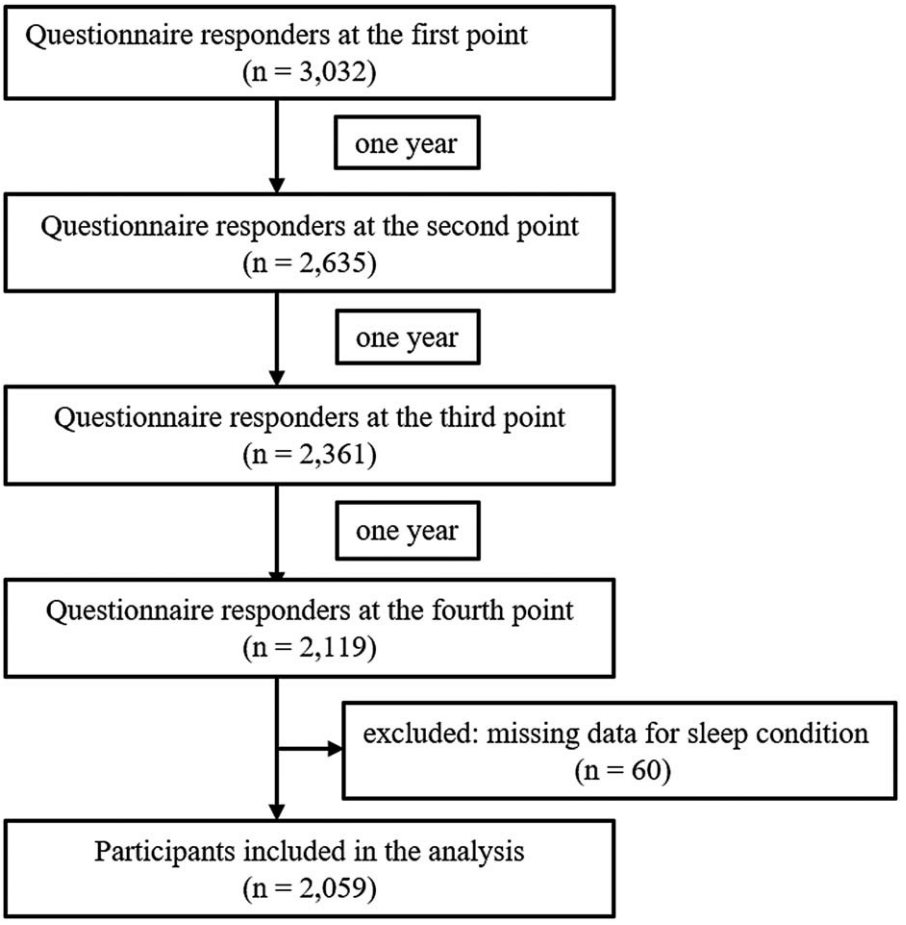

Figure 1. Flow chart of the study.

TABLE 2. Association Between Sleep Disturbance and Low Back Pain

	Sleep Disturbance			*P* Value
	Total	Absence	Presence	
Participants	2059	1372	687	
Low back pain, n (%)	551 (26.8)	282 (20.6)	269 (39.2)	
Adjusted OR (95% CI)		1	2.24 (1.78–2.83)	< 0.001

		Duration			*P* for Trend
		< 1 Year	≥ 1 Year, < 2 Years	≥ 2 Years	
Participants		168	109	410	
Low back pain, n (%)		56 (33.3)	35 (32.1)	178 (43.4)	
Adjusted OR (95% CI)	1	1.93 (1.34–2.78)	1.70 (1.09–2.65)	2.62 (1.99–3.43)	< 0.001

Adjusted for sex, age, body mass index, living area, smoking habits, drinking habits, comorbid conditions, working status, walking time, living status, subjective economic condition, psychological distress, and social isolation.

CI indicates confidence interval; OR, odds ratio.

duration of sleep disturbance during the third period was significantly associated with the onset of LBP during the fourth period. Using the absence of LBP as a reference, the adjusted ORs (95% CIs) were 1.61 (0.98–2.65) for <1 year, 1.56 (0.81–3.03) for ≥1 year and <2 years, and 1.71 (1.12–2.63) for ≥2 years of sleep disturbance during the third period (*P* for trend = 0.038) (Table 4). In addition, the frequency of sleep disturbance during the third period was significantly associated with the onset of LBP during the fourth period. Using absence as a reference, the adjusted ORs (95% CIs) were 1.95 (1.26–3.00) for one, 2.22 (1.43–3.45) for two, and 2.16 (1.38–3.39) for three sleep disturbances during the third period (*P* for trend <0.001) (Table 5).

DISCUSSION

The present study revealed that sleep disturbance is significantly associated with LBP among people living in disaster-stricken areas after the GEJE, and the association was stronger with an increase in the duration and frequency of sleep disturbance. Moreover, preceding sleep disturbance was significantly associated with the onset of LBP, and the effect was stronger with an increase in the duration and frequency of sleep disturbance.

Several reports have shown that sleep disturbance is associated with LBP.[10,11,14] Alsaadi *et al*[27] reported that as many as 59% of patients with LBP had sleep disturbance. In the current study, the rate of LBP among people with sleep disturbance was 39.2%, which was significantly higher than that among people without sleep disturbance (20.6%). LBP is thought to be more common in people with sleep disturbances. Further, the latest research studies indicated that the association changes due to the severity of the sleep disturbance.[12,13,28] Vinstrup *et al*[12] reported that the association between sleep disturbance and LBP was stronger with worse sleep disturbances. Skarpsno *et al*[13] also showed that the probability of recovery from LBP was lower in patients with sleep disturbance than in those without, and it depended on the frequency of sleep disturbance. As far as we know, the present study is the first to investigate the association between sleep disturbance and LBP due to duration of sleep disturbance, and the results showed that the association is stronger in people with a longer duration of sleep disturbance. In addition, the association between sleep disturbance and LBP was stronger with an increased frequency of sleep disturbance. It was reported that the proportion of onset of fibromyalgia was higher in people with more frequent sleep disturbances, and long-lasting sleep

TABLE 3. Association Between Frequency of Sleep Disturbance and Low Back Pain

	Frequency of Sleep Disturbance					*P* for Trend
	Total	Absence	1	2	3	
Participants	2059	999	284	225	551	
Low back pain, n (%)	551 (26.8)	187 (18.7)	67 (23.6)	71 (31.6)	226 (41.0)	
Crude OR (95% CI)		1	1.34 (0.98–1.84)	2.00 (1.45–2.77)	3.02 (2.39–3.81)	< 0.001
Adjusted OR (95% CI)		1	1.32 (0.95–1.84)	1.90 (1.35–2.67)	2.67 (2.04–3.50)	< 0.001

Adjusted for sex, age, body mass index, living area, smoking habits, drinking habits, comorbid conditions, working status, walking time, living status, subjective economic condition, psychological distress, and social isolation.

CI indicates confidence interval; OR, odds ratio.

TABLE 4. Association Between Preceding Sleep Disturbance and Onset of Low Back Pain

	Sleep Disturbance at the Third Point			*P* Value
	Total	Absence	Presence	
Participants without low back pain at the third point	1510	1086	424	
Onset of low back pain at the fourth point, n (%)	214 (14.2)	128 (11.8)	86 (20.3)	
Adjusted OR (95% CI)		1	1.65 (1.18–2.32)	0.004

		Duration			*P* for *t*rend
		< 1 Year	≥ 1 Year, < 2 Years	≥ 2 Years	
Participants without low back pain at the third point		136	72	216	
Onset of low back pain at the fourth point, n (%)		25 (18.4)	13 (18.1)	48 (22.2)	
Adjusted OR (95% CI)	1	1.61 (0.98–2.65)	1.56 (0.81–3.03)	1.71 (1.12–2.63)	0.038

Adjusted for sex, age, body mass index, living area, smoking habits, drinking habits, comorbid conditions, working status, walking time, living status, subjective economic condition, psychological distress, and social isolation.

CI indicates confidence interval; OR, odds ratio.

problems were considered to make people susceptible to the development or exacerbation of pain.[29] Sleep disturbance is associated with LBP and the association is considered to have a dose-dependent effect due to the severity of the sleep disturbance, which includes the duration and frequency as well as the intensity of the sleep disturbance, irrespective of other factors.

Only a few longitudinal studies have shown that preceding sleep disturbance is associated with the onset of LBP.[14,15,30] In a 1-year follow-up study, Miranda *et al*[14] reported that sleep disturbance was a predictor of LBP among the 40- to 49-year-old working population. Agmon and Armon[15] performed a study over 3.7 years and showed that increased insomnia symptoms predicted the onset of back pain among employed adults. Further, the present study revealed that preceding sleep disturbance was associated with the onset of LBP among people living in disaster-stricken areas after the GEJE, irrespective of working status and psychosocial factors. Although the mechanism of why sleep disturbance predicts LBP has not been clarified, sleep disturbance interferes with pain inhibitory effects mediated by opioidergic and monoaminergic mechanisms.[31] Sleep disturbance is considered to reduce pain thresholds and lead to the onset of pain.[32] Additionally, the present study investigated the effect of sleep disturbance on LBP in terms of the duration or frequency of sleep disturbance. The results showed that the effect of sleep disturbance on the onset of LBP was stronger with a longer duration of sleep

TABLE 5. Association Between Frequency of Preceding Sleep Disturbance and Onset of Low Back Pain

	Frequency of Sleep Disturbance at the Third Point					*P* for Trend
	Total	Absence	1	2	3	
Participants without low back pain at the third point	1510	879	216	199	216	
Onset of low back pain at the fourth point, n (%)	214 (14.2%)	88 (10%)	38 (17.6%)	40 (20.1%)	48 (22.2%)	
Crude OR (95% CI)		1	1.92 (1.27–2.90)	2.26 (1.50–3.41)	2.57 (1.74–3.79)	< 0.001
Adjusted OR (95% CI)		1	1.95 (1.26–3.00)	2.22 (1.43–3.45)	2.16 (1.38–3.39)	< 0.001

Adjusted for sex, age, body mass index, living area, smoking habits, drinking habits, comorbid conditions, working status, walking time, living status, subjective economic condition, psychological distress, and social isolation.

CI indicates confidence interval; OR, odds ratio.

disturbance, but it was significant only when sleep disturbance occurred for >2 years. Some people with the absence of sleep disturbance at one point could have sleep disturbance thereafter, which might have affected the result and be a limitation of this method. However, the effect of sleep disturbance on LBP was significantly stronger with an increased frequency of sleep disturbance. Mork *et al*[30] reported that the rate of LBP onset was higher along with the severity of sleep disturbance. Preceding sleep disturbance is considered to affect the onset of LBP in a dose-dependent manner. Attention should be paid to sleep disturbance for the treatment and prevention of LBP, especially with regard to the duration and frequency of sleep disturbance.

The present study has some limitations. First, LBP was assessed using a self-reported questionnaire, and the exact amount and intensity of pain were not assessed. Sleep disturbance can be associated with the intensity of LBP, which should be investigated in future studies. Second, LBP was assessed during four periods over 3 years, and the changes during the periods were not clear. Finally, this study was conducted among people living in disaster-stricken areas. Although 4 years had passed since the GEJE, the disaster might affect the lives, sleep condition, and sensitivity of pain of the participants, and the generalizability of the results of this study was not clear.

In conclusion, sleep disturbance was associated with LBP among people living in disaster-stricken areas after the GEJE, and the association was stronger with an increased duration and frequency of sleep disturbance. Furthermore, preceding sleep disturbance was associated with the onset of LBP, and the effect was stronger with an increase in the duration and frequency of sleep disturbance.

Key Points

- A 3-year longitudinal study of sleep disturbance and low back pain was conducted among people living in disaster-stricken areas.
- Sleep disturbance was associated with low back pain, and the effect was stronger with a longer duration and increased frequency of sleep disturbance.
- Preceding sleep disturbance was associated with the onset of low back pain, and the effect was stronger with an increase in the duration and frequency of sleep disturbance.

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