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# Association between Low Back Pain and Neck Pain: A 3-Year Longitudinal Study Using the Data of the People after the Great East Japan Earthquake

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Low back pain (LBP) and neck pain (NP) are common health problems worldwide. LBP often coexists with NP; however, the association between these pains remains unclear. The purpose of this study was to clarify the association between LBP and NP, focusing on dose-dependent effects. This study used a 3-year longitudinal cohort data of people living in disaster-stricken areas after the Great East Japan Earthquake (n = 2,118). LBP and NP were assessed at 4, 5, 6, and 7 years after the disaster. LBP was categorized according to its frequency. Multivariate logistic regression analyses were performed to assess the association between LBP and NP, and the effect of preceding LBP on the subsequent onset of NP, according to the frequency of LBP. LBP was significantly associated with NP, and the association was stronger with increased frequency of LBP. Adjusted odds ratios (95% confidence intervals) were 2.40 (1.71-3.37) for "1", 3.99 (2.82-5.66) for "2", and 6.08 (4.40-8.41) for "≥ 3" in frequency when the absence of LBP was used as a reference (p for trend < 0.001). Furthermore, preceding LBP was significantly associated with subsequent onset of NP, and the effect was stronger with increased frequency of LBP. Adjusted odds ratios (95% confidence intervals) were 2.44 (1.62-3.68) for "1" and 2.68 (1.77-4.05) for "≥ 2" in frequency when the absence of LBP was used as a reference (p for trend < 0.001). LBP is associated with NP in a dose-dependent manner. The association between LBP and NP should be considered to effectively treat these pains.

**Keywords:** dose-dependent effects; Great East Japan Earthquake; longitudinal study; low back pain; natural disaster; neck pain
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## Introduction

Low back pain (LBP) and neck pain (NP) are common health problems worldwide (Carroll et al. 2008; Fujii and Matsudaira 2013). These pains are considered leading causes of disabilities because of their high prevalence (Blyth and Noguchi 2017; Yiengprugsawan and Steptoe 2018; Mansell et al. 2021). It has been revealed that people often have pain at multiple body sites simultaneously (Kamaleri et al. 2009; Wallace et al. 2018). Furthermore, some cross-sectional studies have reported that LBP often coexists with NP (Côté et al. 2000; Yeung et al. 2002; Haukka et al. 2006; Fernandez-de-las-Penas et al. 2011; Coggon et al. 2013). A previous study reported that comorbid LBP and NP affect the quality of life of individuals than NP alone (Kumagai et al. 2021). Hence, it is important to clarify the association between LBP and NP to treat these pains and prevent subsequent disabilities. Moreover, only a few longitudinal studies have investigated the association between LBP and NP (Croft et al. 2001; Hoving et al. 2004; Kaaria et al. 2009). These studies had designs using working population or relatively short-term period within 1 year, and the association between LBP and NP among the general population has not been fully clarified. Longitudinal studies involving longer terms are needed to assess the association between LBP and NP, which can clarify the causal

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relationships between these pains and their dose-dependent effects.

LBP and NP are significant experiences that occur after natural disasters (Yabuki et al. 2015; Yabe et al. 2020, 2021, 2022a, c). The Great East Japan Earthquake (GEJE) and subsequent tsunami happened at the northeastern coastal areas of Japan on March 11, 2011 (Ishigaki et al. 2013). The disaster left severe damages to these areas and exposed people to stressful conditions. The people also experienced a high rate of economic hardship and sleep disturbance, which is associated with LBP and NP (Yabe et al. 2017, 2018, 2022b; Sekiguchi et al. 2018). Reports investigating the association between LBP and NP after natural disasters are rare; however, a 1-year longitudinal study after the GEJE event revealed a significant association between LBP and NP (Yabe et al. 2020). It is also important to clarify the association between LBP and NP for people that experienced natural disasters using a longer-term longitudinal, which is helpful for the general population. The present study aimed to clarify the association between LBP and NP and the effect of preceding LBP on the onset of NP using a 3-year longitudinal data after the GEJE, especially focusing on the dose-dependent effect such as frequency of the pain.

## Materials and Methods

*Participants*

Comprehensive panel researches have been conducted among people living in areas damaged by the GEJE, such as Ogatsu, Oshika, and Ajishima areas in Ishinomaki City and Wakabayashi Ward in Sendai City in Japan. The researchers aim to check up on people in these areas and support their health conditions because the GEJE destroyed the health systems in these areas. The first research was performed 3 months after the disaster and has been repeated every year. The first surveyed populations were all residents in Ogatsu, Oshika, and Ajishima areas and people living in prefabricated houses in Wakabayashi Ward. A self-reported questionnaire and informed consent form were sent to all these people. The present study used the data at 4 (first time point), 5 (second time point), 6 (third time point), and 7 (fourth time point) years after the GEJE to assess the association between LBP and NP by a 3-year longitudinal data. People under 18 years of age were excluded from this study. At the first time point, people who had participated in the previous surveys were recruited and 3,032 (≥18 years) responded to the questionnaires. Of these 3,032, 2,635 participated in the study at the second time point (with a response rate of 86.9%). Of these people, 2,361 responded to the survey at the third time point (89.6%). Among these, 2,118 (89.7%) participated in the survey at the fourth time point and enrolled for this study (Fig. 1). The study protocol was reviewed and approved by the institutional review board of our institution (approval number: 201192).

*Low back pain and neck pain*

LBP was assessed using self-reported questionnaires at each time point. Participants were asked if they had experienced LBP in the last few days. NP, which is called "katakori" in Japan, was also assessed in the same manner. LBP frequency at the fourth time point was defined as the number of LBP at the first, second, third, and fourth time points, and categorized into four groups: absence, 1, 2, and ≥ 3. Furthermore, the frequency of LBP at the third time point was defined as the number of LBP at the first, second, and third time points, and categorized into three groups: absence, 1, and ≥ 2.

*Covariates*

The following variables at the third or fourth time point were included in the analyses as covariates because they were thought to be potential confounding factors: sex, age, body mass index, living area and status, smoking and drinking habits, comorbid conditions, working status, walking time, subjective economic condition, psychological distress, sleep disturbance, and social isolation. Psychological distress was defined as a score of ≥ 10/24 on the Kessler Psychological Distress Scale (Kessler et al. 2002). Sleep disturbance was defined as a score of ≥ 6/24 on the Athens Insomnia Scale (Soldatos et al. 2000). Social isolation was defined as a score of < 12/30 on the Lubben Social Network Scale (Sone et al. 2016). These variables were categorized and are presented in Table 1.

*Statistical analyses*

The variables of the participants at the fourth time point are presented as numbers and percentages (%). The Chi-square test was used to compare the variables due to LBP at the fourth time point. Crude and multivariate logis-

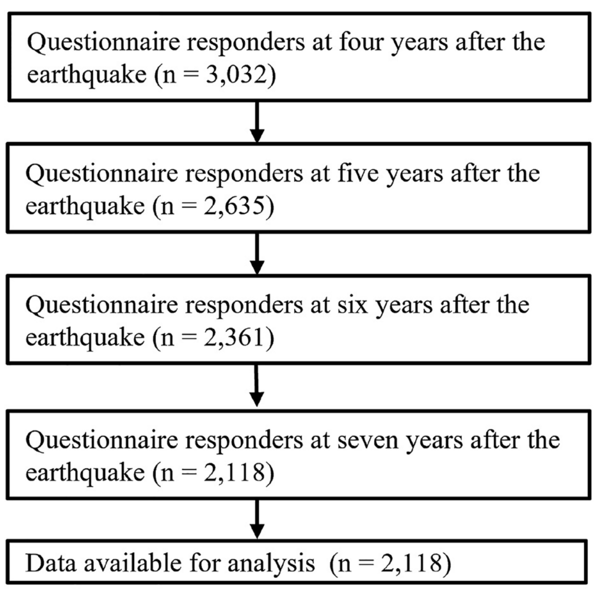


Fig. 1. Flow chart of the study.

Table 1. Baseline characteristics.

| | | Low back pain | | | |
|---|---|---|---|---|---|
| | | n (%) 2,118 | absence 1,555 | presence 563 | p value |
| Sex | Male | 939 (44.3) | 684 (44.0) | 255 (45.3) | 0.593 |
| | Female | 1,179 (55.7) | 871 (56.0) | 308 (54.7) | |
| Age | < 65 | 829 (39.1) | 616 (39.6) | 213 (37.8) | 0.458 |
| | ≥ 65 | 1,289 (60.9) | 939 (60.4) | 350 (62.2) | |
| Body mass index* | ≥18.5, < 25 | 1,278 (60.3) | 961 (61.8) | 317 (56.3) | 0.155 |
| | < 18.5 | 38 (1.8) | 27 (1.7) | 11 (2.0) | |
| | ≥ 25 | 722 (34.1) | 511 (32.9) | 211 (37.5) | |
| Living area | Ogatsu | 892 (43.1) | 653 (42.0) | 239 (42.5) | 0.718 |
| | Oshika | 755 (35.6) | 549 (35.3) | 206 (36.6) | |
| | Ajishima | 141 (6.7) | 109 (7.0) | 32 (5.7) | |
| | Wakabayashi | 330 (15.6) | 244 (15.7) | 86 (15.3) | |
| Smoking habits* | Non-smoker | 1,705 (80.5) | 1,272 (81.8) | 433 (76.9) | 0.022 |
| | Smoker | 334 (15.8) | 233 (15.0) | 101 (17.9) | |
| Drinking habits* | Non-drinker | 1,331 (62.8) | 1,001 (64.4) | 330 (58.6) | 0.029 |
| | < 45.6 g of alcohol/day** | 444 (21.0) | 302 (19.4) | 142 (25.2) | |
| | ≥ 45.6 g of alcohol/day** | 166 (7.8) | 120 (7.7) | 46 (8.2) | |
| Comorbid conditions | Hypertension | 910 (43.0) | 630 (40.5) | 280 (49.7) | < 0.001 |
| | Diabetes mellitus | 225 (10.6) | 155 (10.0) | 70 (12.4) | 0.104 |
| | Myocardial infarction | 140 (6.6) | 81 (5.2) | 59 (10.5) | < 0.001 |
| | Cerebral stroke | 35 (1.7) | 26 (1.7) | 9 (1.6) | 0.907 |
| Working status* | Unemployed | 1,074 (50.7) | 788 (50.7) | 286 (50.8) | 0.674 |
| | Employed | 987 (46.6) | 728 (46.8) | 259 (46.0) | |
| Walking time/day* | ≥ 1 h | 609 (28.8) | 451 (29.0) | 158 (28.1) | 0.051 |
| | 30 min to < 1 h | 767 (36.2) | 581 (37.4) | 186 (33.0) | |
| | < 30 min | 705 (33.3) | 493 (31.7) | 212 (37.7) | |
| Living status* | Same house as before the GEJE | 687 (32.4) | 497 (32.0) | 190 (33.7) | 0.705 |
| | Prefabricated house | 86 (4.1) | 60 (3.9) | 26 (4.6) | |
| | New house | 659 (31.1) | 496 (31.9) | 163 (29.0) | |
| | Others | 656 (31.0) | 480 (30.9) | 176 (31.3) | |
| Economic condition* | Normal | 1,045 (49.3) | 816 (52.5) | 229 (40.7) | < 0.001 |
| | A little hard | 499 (23.6) | 370 (23.8) | 129 (22.9) | |
| | Hard | 329 (15.5) | 202 (13.0) | 127 (22.6) | |
| | Very hard | 196 (9.3) | 126 (8.1) | 70 (12.4) | |
| Psychological distress* | Absence | 1,810 (85.5) | 1,364 (87.7) | 446 (79.2) | < 0.001 |
| | Presence | 263 (12.4) | 154 (9.9) | 109 (19.4) | |
| Sleep disturbance* | Absence | 1,406 (66.4) | 1,117 (71.8) | 289 (51.3) | < 0.001 |
| | Presence | 698 (33.0) | 426 (27.4) | 272 (48.3) | |
| Social isolation* | Absence | 1,485 (70.1) | 1,111 (71.4) | 374 (66.4) | 0.013 |
| | Presence | 625 (29.5) | 436 (28.0) | 189 (33.6) | |

*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, Great East Japan Earthquake.

tic regression analyses were used to assess the association between LBP and NP, and odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Missing data was used as one category. The outcome of the interest was set as NP at the fourth time point. First, to assess the association between LBP and NP, LBP at the fourth time point was set as the main predictor. Further, the frequency of LBP at the fourth time point was set as the main predictor to assess the association between LBP and NP with respect to the frequency of LBP. The variables at the fourth time point were used as covariates. Second, to assess the effect of preceding LBP on the onset of NP, the participants without NP at the third time point were selected and LBP at the third time point was set as the main predictor. Further, the frequency of LBP at the third time point was set as the main predictor to assess the effect of preceding LBP on the onset of NP with respect to the frequency of LBP. The variables at the third time point were used as covariates. All statistical analyses were performed using SPSS (version 28.0, IBM Corp, Armonk, NY, USA). A p-value of < 0.05 was considered significant.

## Results

The baseline characteristics of the participants are presented in Table 1. The rate of LBP at the fourth time point was 26.6%. The participants with LBP were more likely to have smoking and drinking habits, comorbid conditions such as hypertension and myocardial infarction, harder economic conditions, psychological distress, sleep disturbance, and social isolation. The rate of NP and LBP at each time point is shown in Table 2. Approximately 35% of the participants had NP or LBP, which was similar at each time point. The rate of NP at the fourth time point was 19.6% (415/2,118). LBP was significantly associated with NP, and the adjusted OR (95% CI) was 4.20 (3.27-5.39) when the absence of LBP was used as a reference (Table 3). Furthermore, with respect to the frequency of LBP, adjusted ORs (95% CIs) were 2.40 (1.71-3.37) for “1”, 3.99 (2.82-5.66) for “2”, and 6.08 (4.40-8.41) for “≥ 3” when the absence of LBP was used as a reference (p for trend < 0.001) (Table 4).

Among the participants without NP at the third time

Table 2. Rate of neck and low back pain at each time point (%).

| | Absence | NP only | LBP only | NP and LBP |
|---|---|---|---|---|
| First time point | 64.8 | 9.0 | 15.3 | 10.9 |
| Second time point | 65.8 | 9.3 | 15.4 | 9.6 |
| Third time point | 65.4 | 8.7 | 14.9 | 11.5 |
| Fourth time point | 64.1 | 9.3 | 16.3 | 10.3 |

NP, neck pain; LBP, low back pain.

Table 3. Association between low back pain and neck pain.

| | Low back pain | | | |
|---|---|---|---|---|
| | Total | Absence | Presence | p value |
| Participants | 2,118 | 1,555 | 563 | |
| Neck pain, n (%) | 415 (19.6) | 197 (12.7) | 218 (38.7) | |
| Crude OR (95% CI) | | 1 (Ref.) | 4.36 (3.48-5.46) | < 0.001 |
| Adjusted OR (95% CI) | | 1 (Ref.) | 4.20 (3.27-5.39) | < 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, sleep disturbance, and social isolation.
OR, odds ratio; CI, confidence interval.

Table 4. Association between the frequency of low back pain and neck pain.

| | Frequency of low back pain | | | | | |
|---|---|---|---|---|---|---|
| | Total | Absence | 1 | 2 | ≥ 3 | p for trend |
| Participants | 2,118 | 1,084 | 380 | 294 | 360 | |
| Neck pain, n (%) | 415 (19.6) | 102 (9.4) | 77 (20.3) | 89 (30.3) | 147 (40.8) | |
| Crude OR (95% CI) | | 1 (Ref.) | 2.45 (1.77-3.38) | 4.18 (3.03-5.77) | 6.64 (4.96-8.91) | < 0.001 |
| Adjusted OR (95% CI) | | 1 (Ref.) | 2.40 (1.71-3.37) | 3.99 (2.82-5.66) | 6.08 (4.40-8.41) | < 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, sleep disturbance, and social isolation.
OR, odds ratio; CI, confidence interval.

point, the rate of onset of NP at the fourth time point was 10.3% (176/1,701). LBP at the third time point was significantly associated with the onset of NP at the fourth time point and adjusted OR (95% CI) was 1.53 (1.04-2.26) when the absence of LBP at the third time point was used as a reference (Table 5). Moreover, with respect to the frequency of LBP, adjusted ORs (95% CIs) were 2.44 (1.62-3.68) for "1" and 2.68 (1.77-4.05) for "≥ 2" (p for trend < 0.001) (Table 6).

## Discussion

The present study revealed that LBP was significantly associated with NP, and the association was stronger with an increased frequency of LBP. Furthermore, a preceding LBP was significantly associated with subsequent onset of NP, and the association was stronger with an increased frequency of LBP.

Some cross-sectional studies have revealed the association between LBP and NP among female kitchen workers (Haukka et al. 2006), manual handling workers (Yeung et al. 2002), and the general population (Côté et al. 2000; Fernandez-de-las-Penas et al. 2011; Coggon et al. 2013). The prevalence of LBP and NP was very high among kitchen workers and manual handling workers, which was believed to be due to the high physical load on their back and neck, and these pains frequently coexisted (Yeung et al. 2002; Haukka et al. 2006). In a study that included the general population, Fernandez-de-las-Penas et al. (2011) reported that the 1-year prevalence of LBP and NP was 19.9% and 19.5%, and 60.8% of people with LBP had NP. The present study also revealed that the rate of LBP and NP was 26.6% and 19.6%, and 38.7% of people with LBP had NP, which was significantly higher than 12.7% of those without LBP. Both LBP and NP have been associated with several factors such as sex, age, work, economic status, psychological distress, and sleep disturbance (Pincus et al. 2002; Côté et al. 2004, 2008; Miranda et al. 2008; Fujii and Matsudaira 2013; Yabe et al. 2017, 2022b, d; Sekiguchi et al. 2018); hence, multivariate analyses should be performed to assess the association between LBP and NP, which have been rarely reported (Croft et al. 2001). The present study revealed a significant association between LBP and NP after adjusting for several potential confounding factors, which indicated that LBP and NP tend to coexist irrespective of other factors associated with pain. Moreover, no reports have revealed a dose-dependent association between LBP and NP, and according to our knowledge, the present study is the first to show their association according to the frequency of LBP. Compared to the absence of LBP for 3 years, the rate of NP increased clearly along with the increased frequency of LBP in this study. In other words, the association between LBP and NP is considered stronger among people who have chronic LBP.

Some reports have revealed an association between LBP and NP using longitudinal studies (Croft et al. 2001; Hoving et al. 2004; Kaaria et al. 2009; Yabe et al. 2020). Hoving et al. (2004) reported that people with LBP had a poor outcome of NP among the general population in a 1-year cohort study. Kaaria et al. (2009) revealed that LBP was associated with NP at 5 and 10 years later and not with

Table 5. Association between preceding low back pain and onset of neck pain.

| | Low back pain at the third time point | | | |
|---|---|---|---|---|
| | Total | Absence | Presence | p value |
| Participants without neck pain at the third time point | 1,701 | 1,385 | 316 | |
| Onset of neck pain at the fourth time point, n (%) | 176 (10.3) | 128 (9.2) | 48 (15.2) | |
| Crude OR (95% CI) | | 1 (Ref.) | 1.76 (1.23-2.51) | 0.002 |
| Adjusted OR (95% CI) | | 1 (Ref.) | 1.53 (1.04-2.26) | 0.031 |

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, sleep disturbance, and social isolation.
OR, odds ratio; CI, confidence interval.

Table 6. Association between the frequency of preceding low back pain and onset of neck pain.

| | Frequency of low back pain at the third time point | | | | |
|---|---|---|---|---|---|
| | Total | Absence | 1 | ≥ 2 | p for trend |
| Participants without neck pain at the third time point | 1,701 | 1,066 | 341 | 294 | |
| Onset of neck pain at the fourth time point, n (%) | 176 (10.3) | 74 (6.9) | 49 (14.4) | 53 (18.0) | |
| Crude OR (95% CI) | | 1 (Ref.) | 2.25 (1.53-3.30) | 2.95 (2.02-4.31) | < 0.001 |
| Adjusted OR (95% CI) | | 1 (Ref.) | 2.44 (1.62-3.68) | 2.68 (1.77-4.05) | < 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, sleep disturbance, and social isolation.
OR, odds ratio; CI, confidence interval.

NP at 28 years later among industrial employees. These longitudinal reports indicated the association between LBP and NP more clearly; however, it could not show the causal relationship between these pains. Croft et al. (2001) revealed that a history of LBP was a risk factor for the onset of NP among the general population in a 1-year longitudinal study. The present study also revealed that LBP among people without NP was significantly associated with subsequent onset of NP, meaning that preceding LBP was a risk factor for having NP later. Regarding the association between LBP and NP, there are some speculations. The association may be because these pains have similar risk factors. However, the association between preceding LBP and subsequent NP was significant irrespective of other potential confounding factors, and LBP was believed to affect the onset of NP independently. The other reasons are that neck and low back have a similar aging process of the spine, which may be related to pain in the upper and lower spine (Kaaria et al. 2009), and people with LBP may have NP easily. Furthermore, pain can cause postural changes or dysfunction of the musculoskeletal systems (Rahbar et al. 2015; Ito et al. 2019). LBP can lead to poor posture or impaired functioning of low back and put a burden on the neck. In addition, it is considered that people with pain will have pain in other parts during the central sensitization process (Fernandez-de-las-Penas et al. 2011), and people with LBP may be susceptible to NP. Furthermore, the present study is the first to reveal that the association between preceding LBP and subsequent onset of NP was stronger among people with increased frequency of LBP compared to those with a history of LBP in a 3-year cohort. The effect of LBP on the onset of NP is considered to be stronger among people with repetitive or continuous LBP. On the other hand, the previous 1-year cohort study showed that preceding NP was significantly associated with subsequent onset of LBP (Yabe et al. 2020). LBP and NP are considered to have an interactive relationship. The association between LBP and NP should be considered to effectively treat these pains.

There are some limitations to this study. First, we do not have information of people who did not respond to the questionnaire, which might affect the results. Second, the pain intensity might be related to the association between LBP and NP, which was not assessed. Finally, the participants of this study were people living in disaster-stricken areas and the generalizability of the results was not clear.

In conclusion, LBP was associated with NP irrespective of other factors and the association was stronger with increased frequency of LBP. Further, preceding LBP was associated with subsequent onset of NP and the association was stronger in LBP with increased frequency.

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## Conflict of Interest

The authors declare no conflict of interest.

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