Association between continued residence in temporary prefabricated housing and musculoskeletal pain in survivors of the Great East Japan Earthquake: a longitudinal study

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ABSTRACT

Objective Prolonged periods of living in prefabricated houses (PHs) may increase the risk of musculoskeletal (MSK) symptoms; however, the association is not clear. This study aimed to investigate the association between continued residence in PHs and MSK pain in a population affected by a natural disaster, the Great East Japan Earthquake (GEJE) survivors.

Design, setting and participants A panel study was conducted including 1059 and 792 survivors at 2 and 4 years, respectively, after the GEJE, using a self-reported questionnaire. Those with no response on living status and those who did not live in a PH were excluded. Participants were classified into two groups by living status: continued residence in a PH (lived in a PH during both periods) or moving out of a PH (lived in a PH in the first period and did not live in a PH in the second).

Primary outcome measure MSK pain included lower back, shoulder, knee, hand or foot, and neck pain. Changes in the occurrence of MSK pain during the two periods were assessed and defined as ‘new-onset’ and ‘continuing’ MSK pain. Multiple logistic regression analysis was used to examine the influence of continued residence in a PH on new-onset and continuing MSK pain.

Results Continued residence in a PH was significantly associated with new-onset MSK pain, even after adjustment for covariates (adjusted OR 2.18, 95% CI 1.25 to 3.79, p=0.006). Participants who continued living in a PH had higher rates of continuing MSK pain than those who moved out; however, the difference was not significant (adjusted OR 1.69, 95% CI 0.94 to 3.05, p=0.079).

Conclusion Continued residence in a PH was associated with new-onset MSK pain among survivors. Public support should be provided to such people to ensure a more comfortable life.

INTRODUCTION

The Great East Japan Earthquake (GEJE) and the tsunami that followed occurred in the northeastern coast of Japan on 11 March 2011 and caused enormous damage to personnel and property.1 Furthermore, the Fukushima Dai-ichi Nuclear Power Plant underwent major damage due to the tsunami, leading to radiation leaks and contamination. According to government reports, approximately 345 000 people were forced to evacuate due to the loss of their homes or radiation exposure.2 The evacuees then moved into small temporary prefabricated houses (PHs), public housing estates or relatives’ homes.3 Although 8 years have elapsed since the disaster, more than 50 000 people have not moved back to their own homes.2 Residential relocation following major disasters negatively affects the mental health and social capital of survivors.4 5 However, the influence of prolonged residential relocation for refugees was not well known. In a previous study, the rate of psychological distress among evacuees increased with longer duration of residing in a PH.6 Most PHs are smaller than the former homes of evacuees, have poor isolation, thin internal walls and lower
soundproof effect, which leads to health problems.7 PHs are not suitable for long-term living; long-term residence in them could have negative effects. However, many evacuees are forced to continue living in PHs due to delays in the reconstruction of their homes.8

Numerous studies have reported on the physical and mental health problems that are observed following natural disasters.4–9 Following the GEJE, the development of musculoskeletal (MSK) symptoms, both acute and chronic, has been a major concern among survivors.10

The most commonly observed MSK symptoms following the GEJE are knee, shoulder and lower back pain, with several reports indicating that these are related to multiple factors.3–10–13 Survivors are susceptible to psychological and social influences, due to having lost their friends, families and homes, as well as social isolation.14

In addition, subjective economic hardship is also related to shoulder, neck and lower back pain.3 13 16 Prolonged periods of residence in PHs may affect the development of MSK symptoms; however, its association is not clarified in previous study. The purpose of the present study was to investigate the influence of continued residence in a PH on MSK pain among GEJE survivors.

**MATERIALS AND METHODS**

**Participants**

We have been conducting a panel study among survivors of the GEJE. (aged 18 years or older) who lived in Ogatsu district, Oshika district in Ishinomaki city or Wakabayashi ward in Sendai city, in Miyagi prefecture, which were severely affected by the earthquake and tsunami. Every 6 months since 2011, medical health check-ups and self-administered questionnaire surveys were being conducted among the survivors. The questionnaire was described in details in a previous report.15 The questionnaire requested the following information from each participant: the condition of house before and after the GEJE, health condition, lifestyle, working status, amount of activities, psychological distress, quality of sleep and social capital (online supplementary file 1). During our study period, the questionnaire and a document of informed consent were mailed to participants, and the returned questionnaires were collected and analysed longitudinally from the fourth phase (November 2012 to February 2013, 2years after the GEJE) to the eighth phase (November 2014 to February 2015, 4years after the GEJE).

**Outcome variables**

It included items on the locations of pain, such as the lower back, shoulders, knees, hand or feet, and neck (multiple choices were allowed). MSK pain was defined as the presence of pain in at least one of these locations. The outcomes of interests were ‘new-onset’ and ‘continuing’ MSK pain. New-onset MSK pain was defined as the absence of MSK pain in the first period (November 2012 to February 2013) and its presence in the second period (November 2014 to February 2015). Continuing MSK pain was defined as the presence of MSK pain during both periods.

**Exposures**

The questionnaire included surveys on present living status, and participants chose an answer from the following options: same house as before the earthquake, temporary PH, rental house, relative’s house, newly established house, public funded rental accommodation or other. Participants who had lived in a PH during the first period were investigated to identify if they lived in the PH in the second period too. Living status was accordingly classified as continued residence in a PH (lived in a PH in both periods) or moving out of PH (lived in a PH in the first period and did not live in one in the second).

**Covariates**

The following were included in the analyses as covariates because they were considered as potential confounding factors3–10–13 16: sex, body mass index (BMI), age, living areas, smoking habits, drinking habits, chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status, walking time per day, subjective economic hardship, psychological distress (Kessler Psychological Distress Scale, K6),17 quality of sleep (Athens Insomnia Scale, AIS),18 and social capital (Lubben Social Network Scale, LSNS-6).19 The following continuous variables were divided into categories according to distribution or clinical significance when necessary: BMI (<18.5 kg/m², 18.5 to <25 kg/m² or ≥25 kg/m²), age (<65 years or ≥65 years) and drinking habits (non-drinker, <45.6g or ≥45.6g of alcohol per day). Questions pertaining to drinking habits included: “Do you drink alcoholic beverages? If yes, please describe the kind and amount of beverage consumed per day”. We calculated the amount of alcohol consumed and divided the consumption level into the three categories described above. Higher psychological distress was defined as a score ≥10 points in the K6.20 Sleep disturbance was defined as a score ≥6 in the AIS.21 Lower social capital was defined as a score <12 in the LSNS-6.20 Pre-coded questions included those on living area (Ogatsu, Oshika or Wakabayashi), smoking habits (smoker or non-smoker), working status (unemployed or employed), walking time per day (<30min, 30min to <1hour or ≥1hour) and subjective economic hardship (normal, a little hard, hard or very hard).

**Statistical analysis**

Categorical variables were presented as numbers and percentage (%). We performed crude and multiple logistic regression analyses to examine the influence of continued residence in a PH on new-onset and continuing MSK pain. The ORs and their 95% CIs for new-onset and continuing MSK pain, according to living status, were calculated after simultaneous adjustment for covariates. Covariates included sex (male or female), BMI (<18.5 kg/m², 18.5 to <25 kg/m² or ≥25 kg/m² or unknown),...
age (<65 or ≥65 years), living area (Ogatsu, Oshika or Wakabayashi), smoking habits (smoker, non-smoker or unknown), drinking habits (non-drinker, <45.6 g, ≥45.6 g of alcohol per day or unknown), chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status (employed, unemployed or unknown), walking time per day (<30 min, 30 min to <1 hr, ≥1 hr or unknown), subjective economic hardship (normal, a little hard, very hard or unknown), K6 score (<10 or ≥10, or unknown), AIS score (<6 or ≥6, or unknown) and LSNS-6 score (<21 or <12, or unknown). Further, we performed stratified analyses according to age (<65 or ≥65 years), and the crude and adjusted OR (95% CI) for new-onset and continuing MSK pain were assessed in the same way as mentioned above. For the stratified analyses, we examined for the interactions between age and living in PH, tested by Wald test. All statistical analyses were performed with IBM SPSS Statistics V.24.0 (SPSS Japan, Tokyo, Japan). All tests were two-tailed, and a p value <0.05 was considered statistically significant.

**Patient and public involvement**

The patients and public were not involved in the development of the research questions, outcome measures or study design. The patients were also not involved in the recruitment and performance of the study. We will disseminate the final results to the participants after the results are published in a peer-reviewed journal.

**RESULTS**

Two years after the GEJE, we invited a total of 6283 survivors to participate in this study. Of these, 2412 (38.4%, 2412/6283) responded and 2286 (94.8%, 2286/2412) provided consent to participate. We excluded 82 participants with no responses on living status and 1145 participants who did not live in a PH in the first period. The follow-up rate in the second period was 75.7% (802/1059), and 10 participants who did not enter responses pertaining to living status were excluded. The final study population comprised 792 participants (figure 1). Of the 792 participants, 231 had moved out of the PH in the second period (newly established house, 137; public-funded rental accommodation, 38; the same house as before the earthquake, 38; rental house, 7; relative’s house, 4; others, 7) and 561 participants continued residence in a PH. The baseline characteristics of the participants are shown in table 1. A total of 51.9% of the participants who had moved out of the PH and 53.5% of those who continued residence in PHs were female. The mean age of the participants was 60.4 years (range, 18–91 years).

The number of participants who had MSK pain during the fourth phase was 323 (40.8%), and the prevalence of pain for each body sites was as follows: lower back, 24.7%; shoulders, 9.8%; knees 11.4%; hands or feet, 12.0%; neck, 21.5%. The number of participants who had MSK pain during eighth phase was 346 (43.7%), and the prevalence of pain for each body sites was as follows: lower back, 24.7%; shoulders, 9.8%; knees, 16.3%; hands or feet, 14.0%; neck, 19.7%. Of the 469 participants without MSK pain in the first period, 130 (27.7%) had new-onset MSK pain in the second period. The crude and adjusted ORs (95% CI) for new-onset MSK pain according to living status are shown in table 2. Continued residence in a PH was significantly associated with new-onset MSK pain, even after adjustment for covariates (adjusted OR 2.18, 95% CI 1.25 to 3.79, p=0.006). Further, of the 323 participants with MSK pain in the first period, 216 (66.9%) had continuing MSK pain in the second period. The crude and adjusted ORs (95% CI) for continuing MSK pain, according to living status, are shown in table 3. Participants with continued residence in a PH had higher rates of MSK pain than those who moved out of the PH; however, the difference was not significant (adjusted OR, 1.69 (0.94 to 3.05), p=0.079). There were no significant associations between new-onset or continuing pain for each body site and living status.

The results of the stratified analyses are shown in table 4. Among the younger participants (age <65 years), continued residence in a PH was significantly associated with new-onset MSK pain (adjusted OR 2.70 (1.03 to 7.09), p=0.044). However, there was no significant association between continued residence in a PH and continuing MSK pain. Among the older participants (age ≥65), continued residence in a PH was significantly associated with both new-onset MSK pain (2.27 (1.03 to 5.02), p=0.042) and continuing MSK pain (4.17 (1.52 to 11.45), p=0.006). There were statistically significant interactions between age and living in PH.

**DISCUSSION**

This study revealed that continued residence in a PH was significantly associated with new-onset MSK pain among GEJE survivors. Further, although there was no significant association between continued residence in a PH.
| Table 1  | Baseline characteristics of participants |
|------|----------------------------------------|
|       | Living in PH | Moving out  | Continued residence | P value |
|       | Total 792    | 231 (29.2) | 561 (70.8)          |         |
| Sex   |             |            |                     |         |
| Male  | 372 (47.0)  | 111 (48.1) | 261 (46.5)          |         |
| Female| 420 (53.0)  | 120 (51.9) | 300 (53.5)          | 0.70     |
| BMI (kg/m²) |     |            |                     |         |
| 18.5 to <25 | 421 (53.2) | 134 (58.0) | 287 (51.2)          |         |
| <18.5 | 24 (3.0)    | 3 (1.3)    | 21 (3.7)            |         |
| ≥25   | 313 (39.5)  | 90 (39.0)  | 223 (39.8)          | 0.021    |
| Age (years) |       |            |                     |         |
| <65   | 430 (54.3)  | 120 (51.9) | 310 (55.3)          |         |
| ≥65   | 362 (45.7)  | 111 (48.1) | 251 (44.7)          | 0.40     |
| Living area |       |            |                     |         |
| Ogatsu| 294 (37.1)  | 60 (26.0)  | 234 (41.7)          |         |
| Oshika| 190 (24.0)  | 45 (19.5)  | 145 (25.8)          |         |
| Wakabayashi | 308 (38.9) | 126 (54.5) | 182 (32.4)          | <0.001   |
| Smoking habits |     |            |                     |         |
| Smoker| 148 (18.7)  | 38 (16.5)  | 110 (19.6)          |         |
| Non-smoker | 606 (76.5) | 189 (81.8) | 417 (74.3)          | 0.015    |
| Drinking habits |   |            |                     |         |
| Non-drinker | 454 (57.4) | 139 (60.2) | 315 (56.3)          |         |
| <45.6 g of alcohol per day | 176 (22.3) | 52 (22.5)  | 124 (22.1)          | 0.57     |
| ≥45.6 g of alcohol per day | 81 (10.2)  | 21 (9.1)   | 60 (10.7)           |         |
| Chronic conditions |   |            |                     |         |
| Hypertension | 316 (39.3) | 95 (41.1)  | 221 (39.4)          | 0.65     |
| Diabetes mellitus | 81 (10.2)  | 26 (11.3)  | 55 (9.8)            | 0.54     |
| Myocardial infarction | 56 (7.1)  | 20 (8.7)   | 36 (6.4)            | 0.26     |
| Cerebral stroke | 16 (2.0)   | 8 (3.5)    | 8 (3.5)             | 0.064    |
| Working status |     |            |                     |         |
| Unemployed | 411 (51.9) | 125 (54.1) | 286 (51.0)          |         |
| Employed | 367 (46.3) | 104 (45.0) | 263 (46.9)          | 0.38     |
| Walking time per day |   |            |                     |         |
| <30 min | 283 (35.7)  | 84 (36.4)  | 199 (35.5)          |         |
| 30 min to <1 hour | 285 (36.0) | 79 (34.2)  | 206 (36.7)          |         |
| ≥1 hour | 211 (26.6)  | 66 (28.6)  | 145 (25.8)          | 0.58     |
| Subjective economic hardship |   |            |                     |         |
| Normal | 276 (34.8)  | 81 (35.1)  | 195 (34.8)          |         |
| A little hard | 219 (27.7) | 81 (35.1)  | 138 (24.6)          |         |
| Hard   | 183 (23.1)  | 44 (19.0)  | 139 (24.8)          |         |
| Very hard | 98 (12.4)  | 21 (9.1)   | 77 (13.7)           | 0.019    |
| K6 score |     |            |                     |         |
| <10   | 639 (80.7)  | 186 (80.5) | 453 (80.7)          |         |
| ≥10   | 129 (16.3)  | 34 (14.7)  | 95 (16.9)           | 0.16     |
| Athens Insomnia Scale score |   |            |                     |         |
| <6    | 477 (60.2)  | 138 (59.7) | 339 (60.4)          |         |
|       |             |            |                     |         |
|       |             |            |                     |         |
|       |             |            |                     |         |
|       |             |            |                     |         |
|       |             |            |                     |         |
|       |             |            |                     |         |
|       |             |            |                     |         |
Table 1  Continued

| Lubben Social Network Scale 6 score | Living in PH | Moving out | Continued residence | P value |
|-----------------------------------|--------------|------------|---------------------|---------|
| ≥6                                | 308 (38.9)   | 88 (38.1)  | 220 (39.2)          | 0.047   |
| ≥12                               | 558 (70.5)   | 168 (72.7) | 390 (69.5)          |         |
| <12                               | 233 (29.4)   | 63 (27.3)  | 170 (30.3)          | 0.60    |

As each item had a limited number of respondents, the actual number is not necessarily in accordance with the total.

22.8 g of alcohol amounts 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.

BMI, body mass index; K6, Kessler 6-item Psychological Distress Scale; PH, prefabricated temporary housing.

Table 2  Influence of changes in living status on new-onset MSK pain

| Participants without MSK pain at 2 years after the GEJE | Living in PH | Moving out | Continued residence | P value |
|--------------------------------------------------------|--------------|------------|---------------------|---------|
|                                                        |              |            |                     |         |
| New-onset MSK pain                                      |              |            |                     |         |
| n (%)                                                   | 25 (18.1)    | 105 (31.7) |                     | 0.003   |
| Crude OR (95% CI)                                       | 1.00         | 2.10 (1.29 to 3.43) | 0.006   |
| Adjusted OR (95% CI)                                    | 1.00         | 2.18 (1.25 to 3.79) |         |

Adjusted for sex, body mass index, age, living area, smoking habits, drinking habits, chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status, walking time per day, subjective economic hardship, K6 score, AIS score and LSNS-6 score.

AIS, Athens Insomnia Scale; GEJE, Great East Japan Earthquake; K6, Kessler 6-item Psychological Distress Scale; LSNS-6, Lubben Social Network Scale; MSK, musculoskeletal; PH, prefabricated temporary housing.
Table 3  Influence of changes in living status on continuing MSK pain

| Participants with MSK pain at 2 years after the GEJE | Living in PH | Moving out | Continued residence | P value |
|--------------------------------------------------------|--------------|------------|---------------------|---------|
|                                                        |              |            |                     |         |
| Continuing MSK pain                                     |              |            |                     |         |
|                                                       | 93           | 230        |                     |         |
| n (%)                                                  | 56 (60.2)    | 160 (69.6) |                     |         |
| Crude ORs (95% CI)                                     | 1.00         | 1.51 (0.92 to 2.49) | 0.11 |
| Adjusted ORs (95% CI)                                  | 1.00         | 1.69 (0.94 to 3.05) | 0.079 |

Adjusted for sex, body mass index, age, living area, smoking habits, drinking habits, chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status, walking time per day, subjective economic hardship, K6 score, AIS score and LSNS-6 score.

AIS, Athens Insomnia Scale; GEJE, Great East Japan Earthquake; K6, Kessler 6-item Psychological Distress Scale; LSNS-6, Lubben Social Network Scale; MSK, musculoskeletal; PH, prefabricated temporary housing.

The results of our stratified analysis showed that continued residence in a PH was associated with new-onset MSK pain among both younger and older survivors. However, the association between continued residence in a PH and continuing MSK pain was different between the two. The age-related differences we observed can be attributed to activity levels. Younger survivors had a greater number of opportunities to go out for work or shopping, shortening the time spent staying inside the PH. However, older survivors tended to be isolated from society and were homebound easily. Additionally, the areas in which the PHs were located were often far away from the survivors' previous homes, leading to isolation from their local communities. The resulting loss of social relationships led to evacuees being homebound. Attention should be paid to survivors, especially elderly people, with extended stays in PHs.

Table 4  Stratified analysis for each age group

| New-onset MSK pain       | Living in PH | Moving out | Continued residence | P value | P interaction |
|--------------------------|--------------|------------|---------------------|---------|---------------|
| Younger (age <65 years)  |              |            |                     |         | 0.87          |
| n (%)                    | 10 (14.5)    | 44 (30.3)  |                     |         |               |
| Crude ORs (95% CI)       | 1.00         | 2.57 (1.20 to 5.49) | 0.013 |
| Adjusted ORs (95% CI)    | 1.00         | 2.70 (1.03 to 7.09) | 0.044 |
| Older (age ≥65 years)    |              |            |                     |         |               |
| n (%)                    | 15 (21.7)    | 61 (32.8)  |                     |         |               |
| Crude ORs (95% CI)       | 1.00         | 1.76 (0.92 to 3.36) | 0.086 |
| Adjusted ORs (95% CI)    | 1.00         | 2.27 (1.03 to 5.02) | 0.042 |

Continuing MSK pain n (%) 0.11

Younger (age <65 years) 0.60

n (%) 30 (71.4) 71 (67.0)

Crude ORs (95% CI) 1.00 0.81 (0.37 to 1.77)

Adjusted ORs (95% CI) 1.00 1.03 (0.37 to 2.87)

Older (age ≥65 years) 0.95

n (%) 26 (51.0) 89 (71.8)

Crude ORs (95% CI) 1.00 2.45 (1.25 to 4.80) 0.008

Adjusted ORs (95% CI) 1.00 4.17 (1.52 to 11.45) 0.006

Adjusted for sex, body mass index, living area, smoking habits, drinking habits, chronic conditions (hypertension, diabetes mellitus, myocardial infarction and cerebral stroke), working status, walking time per day, subjective economic hardship, K6 score, AIS score and LSNS-6 score.

AIS, Athens Insomnia Scale; GEJE, Great East Japan Earthquake; K6, Kessler 6-item Psychological Distress Scale; LSNS-6, Lubben Social Network Scale; MSK, musculoskeletal; PH, prefabricated temporary housing.
By Japanese law, PHs must be used within 2 years; however, the period was unavoidably extended in the case of the GEJE. After the Great Hanshin Awaji Earthquake in Japan in 1995, it took 3 years for all evacuees to move out of the PHs. The GEJE caused more serious damage, so we assumed that there were greater delays in reconstruction, resulting in prolonged PH stays. Although no study has focused on the relationship between accommodation and MSK pain among survivors, the results of the present study suggest that prolonged stays in a PH may lead to an undesirable MSK state; it may be better to shorten the lengths of redundant PH stay. Public-funded accommodation should be provided to survivors as early as possible after a disaster. Additionally, while survivors are forced to reside in PHs, lifestyle and exercise-related guidance should be provided to improve physical activity levels and prevent MSK pain.

This study had several limitations. First, the response rate to the questionnaire was not high as the questionnaire was mailed to the survivors. Some of them may have been evacuated to other locations; therefore, it was difficult to conduct a follow-up of the participants’ living status. Second, the responders may have been more concerned about maintaining a healthy lifestyle, and the occurrence of pain may be less common among them than among non-responders. Third, we assessed for pain using only the self-administered survey responses of the survivors. The severity or pathology of the pain, and disabilities caused by the pain were not assessed because we needed to make the questionnaire simple to enhance the collection rate. Further, the pain was assessed at two periods only, and changes at other points were not assessed, which meant that the chronicity of the pain was not evaluated. Finally, reverse causality could not be ruled out.

In conclusion, continued residence in a PH was associated with new-onset MSK pain among survivors. Public support and guidance are required for symptom management.

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Patient consent for publication Obtained.

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Data availability statement Data are available in a public, open-access repository.

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