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Preceding Poor Physical Function Is Associated with New-Onset Musculoskeletal Pain among Older Natural Disaster Survivors: A Longitudinal Study after the Great East Japan Earthquake

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Musculoskeletal pain is a major problem among survivors of natural disasters. Functional disabilities in older adults increase after disasters and can lead to musculoskeletal pain. However, the effects of poor physical function on musculoskeletal pain after natural disasters remain unclear. This study aimed to elucidate the association of poor physical function with new-onset musculoskeletal pain among older survivors after the Great East Japan Earthquake (GEJE). Survivors aged ≥ 65 years, 3 years after the GEJE, were assessed longitudinally for 1 year (n = 646). Musculoskeletal pain was assessed using a self-reported questionnaire, and new-onset musculoskeletal pain was defined as absence and presence of pain at 3 years and 4 years, respectively, after the disaster. Physical function at 3 years after the disaster was assessed using the Kihon Checklist physical function score, which consists of 5 yes/no questions, and poor physical function was defined as a score of ≥ 3/5. Multivariate logistic regression analyses were used to assess the association of poor physical function with new-onset musculoskeletal pain. The incidence of new-onset musculoskeletal pain was 22.4%. Participants with poor physical function had a significantly higher rate of new-onset musculoskeletal pain. Compared with high physical function, the adjusted odds ratio (95% confidence interval) for new-onset musculoskeletal pain was 2.25 (1.37-3.69) in poor physical function (P = 0.001). Preceding poor physical function was associated with new-onset musculoskeletal pain among older survivors after the GEJE. There is need to focus on the maintenance of physical function to prevent musculoskeletal pain after natural disasters.

Keywords: Great East Japan Earthquake; musculoskeletal pain; natural disaster; physical function; survivor
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Introduction

Survivors of natural disasters experienced various mental and physical health problems (Cao et al. 2015). In addition to the well-known symptoms following natural disasters, such as psychological distress and sleep disturbance (Brown et al. 2011; Goodwin et al. 2015), musculoskeletal pain is also a major problem for survivors (Yabuki et al. 2015). The Great East Japan Earthquake (GEJE) befell the north-east areas of Japan with colossal tsunami in 2011. The large-scale disaster left extensive damage (Ishigaki et al. 2013), and delays in the reconstruction of the post-disaster areas persist. Some reports have shown high prevalence of musculoskeletal pain after the GEJE (Hagiwara et al. 2018; Sekiguchi et al. 2018; Yabe et al. 2018b). An association was reported between musculoskeletal pain and the following factors, which increased after the disaster: sleep disturbance, subjective economic hardship, and psychological distress (Angeletti et al. 2014; Sekiguchi et al. 2018; Yabe et al. 2018b). Further, preceding musculoskeletal pain causes new-onset sleep disturbance and psychological distress (Yabe et al. 2018a,

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2019b), with an interactive relationship. Musculoskeletal pain is a notable problem after natural disasters, and clarifying the related factors is important.

Survivors of natural disasters easily become inactive, as the affected areas have less population and stores (Kuroda et al. 2018). Further, many survivors have refugeed from their hometowns and are living in small prefabricated housing, which can also lead to inactivity for survivors (Ito et al. 2016). These conditions have caused loss of motor function, and as reported, functional disability prevalence was higher in the disaster-stricken areas than in the non-disaster areas after the GEJE (Tomata et al. 2015). We hypothesized that poor physical function could cause musculoskeletal pain and increased poor physical function could be related to the high rate of musculoskeletal pain after the GEJE. However, there have been no reports evaluating the influence of preceding poor physical function on the onset of musculoskeletal pain after natural disasters. The present study aimed to assess the association of poor physical function with new-onset musculoskeletal pain among older survivors after the GEJE.

Methods

Participants

Comprehensive survey has been conducted among the GEJE survivors who lived in disaster-stricken areas such as Ogatsu and Oshika areas in Ishinomaki City and Wakabayashi Ward in Sendai City, Miyagi Prefecture, Japan. These areas are located in the north-eastern part of Japan, and they were severely damaged by the GEJE and the subsequent devastating tsunami. The survey was initially conducted 3 months after the GEJE and every 6 months, thereafter. Self-reported questionnaires were mailed to the participants along with informed consent forms. Due to the increase in the number of participants in the survey up to 3 years after the GEJE, which was maintained constantly thereafter, the data from the surveys, examined at 3 and 4 years after the GEJE, were used for this study. The initial study population included registered residents in the Ogatsu and Oshika areas residential registry as well as survivors living in the prefabricated housing in Wakabayashi Ward. At 3 years after the GEJE, survivors aged ≥ 18 years who were registered in the Ogatsu and Oshika areas residential registry and survivors who participated in the survey held in the Wakabayashi Ward in the preceding year were recruited (n = 6,396). Among them, 2,853 (44.6%) consented to the study and completed the questionnaires. Physical function was assessed for the survivors aged 65 years and over (n = 1,400). Participants who already had musculoskeletal pain (n = 604) or had missing data regarding physical function (n = 16) were excluded. Those included in the study were followed up one year later. The follow-up rate at this point was 82.8% (646/780), and 646 participants were finally analyzed in this study (Fig. 1). This study was reviewed and approved by the institutional review board of Tohoku University School of Medicine (approval number: 201192).

Outcome variables

Musculoskeletal pain was evaluated using self-reported questionnaires, which was based on the Comprehensive Survey of Living Conditions. The following questions were asked: “Have you had symptoms in the last few days? If yes, please place a check mark next to all your symptoms.” The choices included various somatic symptoms including pain at different sites. The participants who marked hand or foot, shoulder, knee, low back, knee, and neck pain were considered as having musculoskeletal pain (Yabe et al. 2018a). New-onset musculoskeletal pain was defined as musculoskeletal pain that was absent at 3 years but present at 4 years after the GEJE.

Main predictor

Physical function, at 3 years after the GEJE, was eval-

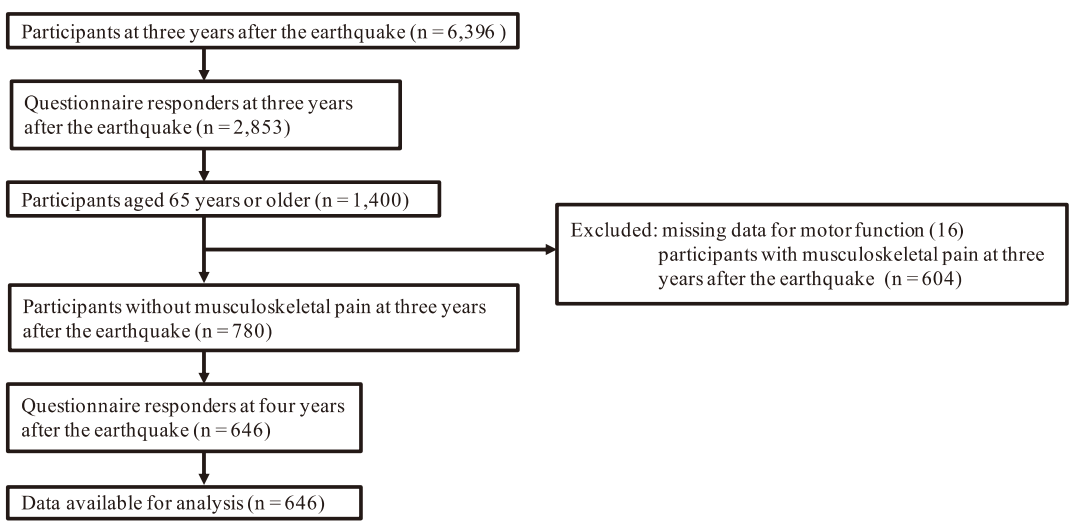

Fig. 1. Flowchart of the study process.

uated using the Kihon Checklist (KCL) physical function score, which consists of the following 5 yes/no questions: "Can you climb the stairs without holding onto a handrail or wall?"; "Can you get up from a chair without grabbing something?"; "Are you able to walk for about 15 minutes?"; "Have you fallen in the past year?"; "Are you very worried about falling?". Previous studies have reported on the validity and reliability of the KCL (Satake et al. 2016; Sentandreu-Mañó et al. 2019). Each negative response was scored as 1 point, and poor physical function was defined as a score of ≥ 3/5 (Ito et al. 2016).

Covariates

The following variables were included as covariates in previous reports: sex, age, body mass index, living areas and environment, smoking and drinking habits, chronic conditions, working status, subjective economic conditions, psychological conditions, sleep conditions, and social conditions at 3 years after the GEJE (Sekiguchi et al. 2018). Psychological conditions, sleep conditions, and social conditions were assessed using Kessler Psychological Distress Scale (Suzuki et al. 2014), Athens Insomnia Scale (Soldatos et al. 2000), and Lubben Social Network Scale (Sone et al. 2016), respectively. Participants with a score of ≥ 10/24 on the Kessler Psychological Distress Scale, a score of ≥ 6/24 on the Athens Insomnia Scale, and a score of < 12/30 on the Lubben Social Network Scale were considered having psychological distress, sleep disturbance, and social isolation, respectively (Soldatos et al. 2000; Suzuki et al. 2014; Sone et al. 2016).

Statistical analysis

Crude and multivariate logistic regression analyses were performed to assess the association of poor physical function at 3 years after the GEJE with new-onset musculoskeletal pain; the odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated. Variables considered in the analysis included sex (male or female), age (< 75 or ≥ 75, years), body mass index (< 18.5, 18.5-24.9, ≥ 25 kg/m^2, or unknown) (National Heart, Lung, and Blood Institute 2002), living areas (Ogatsu area, Oshika area, or Wakabayashi Ward), smoking habits (non-smoking, smoking, or unknown), drinking habits (non-drinking, < 45.6 g of alcohol/day, ≥ 45.6 g of alcohol/day, or unknown), chronic conditions such as hypertension, diabetes mellitus, myocardial infarction, and cerebral stroke (absence or presence), and working status (unemployed, employed, or unknown) (Model 1). Additionally, considering the unusual situation after the disaster, variables that was presumed to be related to the disaster such as living environment (the same house as that before the GEJE, prefabricated house, new house, other, or unknown), subjective economic condition (normal, a little bit hard, hard, very hard, or unknown), psychological distress (absence, presence, or unknown), sleep disturbance (absence, presence, or unknown), and social isolation (absence, presence, or unknown) were added (Model 2). Further, we divided the participants into two subgroups by age (< 75 [n = 363], or ≥ 75 [n = 283] years) and sex (male [n = 324], or female [n = 322]); ORs and 95% CIs for new-onset musculoskeletal pain were assessed in the same manner. For the stratified analysis, multiplicative interaction between physical function and age or sex was tested using the Wald test. In addition, the association of poor physical function with new onset of each musculoskeletal pain was also evaluated. SPSS version 24.0 (SPSS Japan Inc, Tokyo, Japan) was used for statistical analyses and differences at $P < 0.05$ were considered to indicate statistical significance.

Results

Table 1 shows the participants' baseline characteristics. Of the 646 participants, 500 (77.4%) had high and 146 (22.6%) poor physical function, 3 years after the GEJE. The participants who reported poor physical function were predominantly female, older, unemployed, with no smoking or drinking habits, but with chronic conditions such as hypertension and cerebral stroke. They were also more likely to have subjective economic hardship, psychological distress, and sleep disturbance (Table 1). The incidence of new-onset musculoskeletal pain was 22.4% (145/646). The participants with poor physical function had a significantly higher incidence of new-onset musculoskeletal pain. The OR (95% CI) was 2.21 (1.41-3.48) for Model 1 and 2.25 (1.37-3.69) for Model 2 with poor physical function compared to that with high physical function (Table 2). In the stratified analysis, poor physical function was significantly associated with new-onset musculoskeletal pain among participants aged < 75 years (OR, 2.44 [95% CI, 1.12-5.31]) and those aged ≥ 75 years (OR, 2.04 [95% CI, 1.01-4.14]). Further, the association was also significant among both male (OR, 2.70 [95% CI, 1.16-6.27]) and female (OR, 2.03 [95% CI, 1.05-3.93]) (Table 3). Multiplicative interaction was not significant between physical function and age or sex. In each musculoskeletal pain, poor physical function was significantly associated with new-onset knee and shoulder pain; however, the association was not significant in low back, hand or foot, and neck pain. The adjusted ORs (95% CI) were 3.20 (1.65-6.18) in knee pain, 3.37 (1.02-11.16) in shoulder pain, 1.76 (0.87-3.53) in low back pain, 1.61 (0.64-4.07) in hand or foot pain, and 1.06 (0.44-2.55) in neck pain, respectively (Table 4).

Discussion

The present study revealed that poor physical function was associated with new-onset musculoskeletal pain among older survivors after the GEJE. As reported, musculoskeletal pain increases after natural disasters (Angeletti et al. 2012). The disasters deprive people of their lives and property, and survivors have fear, grief, and anxiety for a long term, which can lead to severe stress and the lowering of pain threshold (Angeletti et al. 2014). Further, many survivors are forced to take refugee and live in unfamiliar places,

Table 1. Baseline characteristics of the participants according to the physical function.

		Level of physical function			
		Total n = 646	High n = 500	Poor n = 146	
Sex	Male	324 (50.2%)	274 (54.8%)	50 (34.2%)	< 0.001
	Female	322 (49.8%)	226 (45.2%)	96 (65.8%)	
Age	< 75	363 (56.2%)	312 (62.4%)	51 (34.9%)	< 0.001
	≥ 75	283 (43.8%)	188 (37.6%)	95 (65.1%)	
Body mass index*	18.5 to < 25	369 (57.1%)	295 (59.0%)	74 (50.7%)	0.07
	< 18.5	23 (3.6%)	14 (2.8%)	9 (6.2%)	
	≥ 25	234 (36.2%)	178 (35.6%)	56 (38.4%)	
Living area	Ogatsu	305 (47.2%)	242 (48.4%)	63 (43.2%)	0.16
	Oshika	249 (38.5%)	183 (36.6%)	66 (45.2%)	
	Wakabayashi	92 (14.2%)	75 (15.0%)	17 (11.6%)	
Smoking habits*	Non-smoker	533 (82.5%)	404 (80.8%)	129 (88.4%)	0.02
	Smoker	60 (9.3%)	55 (11.0%)	5 (3.4%)	
Drinking habits*	Non-drinker	389 (60.2%)	283 (56.6%)	106 (72.6%)	0.004
	< 45.6 g of alcohol/day**	118 (18.3%)	103 (20.6%)	15 (10.3%)	
	≥ 45.6 g of alcohol/day**	49 (7.6%)	41 (8.2%)	8 (5.5%)	
Chronic conditions	Hypertension	352 (54.5%)	264 (52.8%)	88 (60.3%)	0.03
	Diabetes mellitus	82 (12.7%)	60 (12.0%)	22 (15.1%)	0.33
	Myocardial infarction	57 (8.8%)	39 (7.8%)	18 (12.3%)	0.44
	Cerebral stroke	10 (1.5%)	3 (0.6%)	7 (4.8%)	0.005
Working status*	Unemployed	473 (73.2%)	346 (69.2%)	127 (87.0%)	< 0.001
	Employed	150 (23.2%)	136 (27.2%)	14 (9.6%)	
Living status*	Same house as before the GEJE	194 (30.0%)	150 (30.0%)	44 (30.1%)	0.2
	Prefabricated house	245 (37.9%)	194 (38.8%)	51 (34.9%)	
	New house	88 (13.6%)	71 (14.2%)	17 (11.6%)	
	Others	116 (18.0%)	84 (16.8%)	32 (21.9%)	
Subjective economic condition*	Normal	326 (50.5%)	267 (53.4%)	59 (40.4%)	< 0.001
	A little bit hard	168 (26.0%)	136 (27.2%)	32 (21.9%)	
	Hard	89 (13.8%)	60 (12.0%)	29 (19.9%)	
	Very hard	38 (5.9%)	16 (3.2%)	22 (15.1%)	
Psychological distress*	Absence	572 (88.5%)	452 (90.4%)	120 (82.2%)	0.02
	Presence	42 (6.5%)	26 (5.2%)	16 (11.0%)	
Sleep disturbance*	Absence	516 (79.9%)	410 (82.0%)	106 (72.6%)	0.004
	Presence	122 (18.9%)	82 (16.4%)	40 (27.4%)	
Social Isolation*	Absence	498 (77.1%)	390 (78.0%)	108 (74.0%)	0.22
	Presence	143 (22.1%)	105 (21.0%)	38 (26.0%)	

Categorical values are presented as numbers and percentage (%).
GEJE, Great East Japan Earthquake.
*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.

which adds the negative impact to their physical and mental health (Yabuki et al. 2015). After the GEJE, some longitudinal studies have reported the factors related to musculoskeletal pain, such as sleep disturbance, subjective economic hardship, and long-term living in prefabricated housing (Sekiguchi et al. 2018; Yabe et al. 2018b; Sogi et al. 2019). Further, the present study first reported that preceding poor physical function was associated with new onset of musculoskeletal pain among the survivors of natural disasters. There have been some reports showing the association between musculoskeletal pain and physical function among community-dwelling older adults (Leveille et al. 2009; Sawa et al. 2017). These reports show that musculoskeletal pain leads to functional decline by limiting the physical abilities or by causing disuse (Leveille et al. 2009; Sawa et al. 2017). However, to the best of our

Table 2. Influence of poor physical function on new-onset musculoskeletal pain.

Level of physical function	Participants	New-onset musculoskeletal pain	OR (95% Cl)		
			Crude	Model 1	Model 2
Total	n = 646	n = 145 (22.4%)			
High	n = 500	n = 97 (19.4%)	Reference	Reference	Reference
Poor	n = 146	n = 48 (32.9%)	2.04 (1.35-3.07)	2.21 (1.41-3.48)	2.25 (1.37-3.69)
			P = 0.001	P = 0.001	P = 0.001

Adjusted for sex, age, body mass index, living area, smoking habits, drinking habits, chronic conditions, working status (Model 1). Additionally, adjusted for living status, subjective economic condition, psychological distress, sleep disturbance, and social isolation (Model 2).
OR, odds ratio; 95% CI, 95% confidence interval.

Table 3. Stratified analysis for each age or sex group.

	Level of physical function	Participants	New-onset musculoskeletal pain	Adjusted OR (95% CI)	Participants	New-onset musculoskeletal pain	Adjusted OR (95% CI)
Age		< 75 years old			≥ 75 years old		
	Total	n = 363	n = 82 (22.6%)		n = 283	n = 63 (22.3%)	
	High	n = 312	n = 63 (20.2%)	Reference	n = 188	n = 34 (18.1%)	Reference
	Poor	n = 51	n = 19 (37.3%)	2.44 (1.12-5.31)	n = 95	n = 29 (30.5%)	2.04 (1.01-4.14)
				P = 0.025			P = 0.047
				P-interaction = 0.74			
Sex		Male			Female		
	Total	n = 324	n = 63 (19.4%)		n = 322	n = 82 (25.5%)	
	High	n = 274	n = 48 (17.5%)	Reference	n = 226	n = 49 (21.7%)	Reference
	Poor	n = 50	n = 15 (30.0%)	2.70 (1.16-6.27)	n = 96	n = 33 (34.4%)	2.03 (1.05-3.93)
				P = 0.021			P = 0.035
				P-interaction = 0.75			

Adjusted for sex, age, body mass index, living area, smoking habits, drinking habits, chronic conditions, working status, living status, subjective economic condition, psychological distress, sleep disturbance, and social isolation.
OR, odds ratio; 95% CI, 95% confidence interval.

Table 4. Influence of poor physical function on new-onset pain in each body part.

		Level of physical function			
		Total	High	Poor	P value
	Participants	n = 646	n = 500	n = 146	
Low back pain	New onset of pain	n = 60 (9.3%)	n = 41 (8.2%)	n = 19 (13.0%)	
	Adjusted OR (95% CI)		Reference	1.76 (0.87-3.53)	0.114
Shoulder pain	New onset of pain	n = 20 (3.1%)	n = 12 (2.4%)	n = 8 (5.5%)	
	Adjusted OR (95% CI)		Reference	3.37 (1.02-11.16)	0.047
Knee pain	New onset of pain	n = 61 (9.4%)	n = 34 (6.8%)	n = 27 (18.5%)	
	Adjusted OR (95% CI)		Reference	3.20 (1.65-6.18)	0.001
Hand or foot pain	New onset of pain	n = 39 (6.0%)	n = 25 (5.0%)	n = 14 (9.6%)	
	Adjusted OR (95% CI)		Reference	1.61 (0.64-4.07)	0.311
Neck pain	New onset of pain	n = 44 (6.8%)	n = 34 (6.8%)	n = 10 (6.8%)	
	Adjusted OR (95% CI)		Reference	1.06 (0.44-2.55)	0.889

Adjusted for sex, age, body mass index, living area, smoking habits, drinking habits, chronic conditions, working status, living status, subjective economic condition, psychological distress, sleep disturbance, and social isolation.
OR, odds ratio; 95% CI, 95% confidence interval.

knowledge, there have been no reports investigating the effect of poor physical function on musculoskeletal pain. It is well known that physical activity has beneficial effects on healthy aging, which includes musculoskeletal conditions (Ashe et al. 2009; Stefansdottir and Gudmundsdottir 2017). Further, physical inactivity or sedentary behavior has been reported to relate to the cause of musculoskeletal pain (Landmark et al. 2013; Stefansdottir and Gudmundsdottir 2017). Physical activity influences positively to regulate pain, and physical inactivity is considered to lower the pain threshold (Ellingson et al. 2012). Physical inactivity causes decrease in the strength of muscles, tendons, and ligaments, which can cause musculoskeletal disorders (Aweto et al. 2016). Further, sedentary behavior leads to incorrect posture (Edmondston et al. 2007), which is related to musculoskeletal pain (Kim et al. 2015). Stubbs et al. reported that older adults with fear of falling avoid activities and led sedentary life (Stubbs et al. 2014). Survivors with poor physical function become inactive and sedentary. These conditions are presumed to lead to the onset of musculoskeletal pain.

After natural disasters, survivors have various problems such as living in temporary housing, economic hardship, sleep disturbance, psychological distress, and social isolation. These factors possibly lead to musculoskeletal pain (Angeletti et al. 2014; Leung et al. 2016; Sekiguchi et al. 2018; Yabe et al. 2018b; Sogi et al. 2019). However, the association between poor physical function and new-onset musculoskeletal pain was similar after adjusting for these factors. Preceding poor physical function is associated with the onset of musculoskeletal pain even under the unusual situation, after the natural disaster. A previous longitudinal study showed that preceding musculoskeletal pain was associated with new-onset poor physical function among older survivors after the GEJE (Yabe et al. 2019a). Physical functional decline and musculoskeletal pain have an interactive relationship. Poor physical function is considered one possible reason for the increased musculoskeletal pain after natural disasters, which can also lead to further decline in function. Promoting physical activity reduces physical disability (Uthman et al. 2013) and can also prevent subsequent musculoskeletal pain.

The stratified analysis according to age and sex categories showed that the association of poor physical function, and new-onset musculoskeletal pain was also significant among categories in each group. The rate of poor physical function was higher in participants aged ≥ 75 years than in those aged < 75 years and in females than in males; however, the association was similar in both groups. These results suggest a robust association between poor physical function and new-onset musculoskeletal pain. Further, of all musculoskeletal pain sites, poor physical function was significantly associated with knee and shoulder pain but not with low back, hand or foot, and neck pain. There are some speculations concerning these results. The questionnaires for KCL to evaluate physical function emphasize on walking ability and falls (Ito et al. 2016). Survivors with poor physical function were supposed to have poor function of the lower extremities, which tends to enhance complaints about the lower extremities, especially the knee joint. Such patients might also need to use their upper extremities to support their body. Walking with aids put load on their upper extremities, which could lead to upper extremity pain, especially shoulder pain (Sie et al. 1992). Further, survivors who had musculoskeletal pain in the first period were excluded from this study, as the purpose of this study was to evaluate the effect of preceding poor physical function on the onset of musculoskeletal pain longitudinally. The survivors who already had both musculoskeletal pain and poor physical function were excluded, which could have lowered the association of poor physical function with each musculoskeletal pain.

The present study has some limitations. First, the questionnaires and informed consent forms were mailed to the participants and the response rate was not high. Responders might be healthier than non-responders, which could affect the results. Second, musculoskeletal pain was assessed using a self-reported questionnaire. It included five pain sites, while other pain sites such as the hip or elbow were excluded. Physical function could also affect these pain sites and it was not assessed in this study. Further, this study did not assess the association between physical function and musculoskeletal pain at the first period. The survivors who were excluded from this study due to musculoskeletal pain were presumed to have a higher rate of poor physical function. The association between poor physical function and new-onset musculoskeletal pain might be stronger than the results shown in this study. Finally, physical inactivity was not assessed using validated tools such as the global physical activity questionnaire (Armstrong and Bull 2006). The evaluation of the association between physical function and physical activity level is assumed to provide useful information, which should be considered in future studies.

In conclusion, the present study assessed the association between poor physical function and new-onset musculoskeletal pain among older survivors in the recovery period after the GEJE. Preceding poor physical function is associated with the onset of musculoskeletal pain even under an unusual situation after a natural disaster.

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Conflict of Interest

The authors declare no conflict of interest.

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