




BMJ Open Association of decreased physical activity due to the COVID-19 pandemic with new-onset neck pain in survivors of the Great East Japan Earthquake: a prospective cohort study

Takuya Sekiguchi ¹, Yoshihiro Hagiwara ², Yutaka Yabe,² Yumi Sugawara ³, Ichiro Tsuji,³ Eiji Itoi⁴

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¹Department of Orthopaedic Surgery, JR Sendai Hospital, Sendai, Japan

²Department of Orthopaedic Surgery, Tohoku University School of Medicine, Sendai, Japan

³Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine, Sendai, Japan

⁴Department of Orthopaedic Science, Tohoku Rosai Hospital, Sendai, Japan

Correspondence to

Dr Yoshihiro Hagiwara;
hagi@med.tohoku.ac.jp

ABSTRACT

Objectives The COVID-19 pandemic has forced many people to stay at home and to maintain social distancing. This study aimed to assess the association of reduced physical activity during the COVID-19 pandemic with new onset of neck pain (katakori) among a rural Japanese population living in areas damaged by the Great East Japan Earthquake (GEJE).

Design, setting and participants This prospective cohort study has been conducted continuously since 2011 after the GEJE. This study used longitudinal data from 1608 adults who responded to the self-reported questionnaire before and during the COVID-19 pandemic. Changes in physical activity due to the COVID-19 pandemic were categorised into four groups: 'no change', 'decreased by 20%–30%', 'decreased by half' and 'almost never go out'. Multiple logistic regression analysis was used to estimate the OR and 95% CI of the association between COVID-19 pandemic-related physical inactivity and new-onset neck pain.

Results In total, 'no change', 'decreased by 20%–30%', 'decreased by half', and 'almost never go out' were reported by 9.2%, 27.7%, 31.2% and 21.9% of respondents, respectively. Among them, 9.8% reported new-onset neck pain. A significantly higher rate of new-onset neck pain was observed in participants who reported 'decreased by half' (adjusted OR 1.85, 95% CI 1.04 to 3.30) and who 'almost never go out' (adjusted OR 2.13, 95% CI 1.16 to 3.91), compared with those who reported 'no change.'

Conclusions Decreased physical activity has increased due to the COVID-19 pandemic and was significantly associated with new-onset neck pain among GEJE survivors.

INTRODUCTION

Regular physical activity has beneficial effects on human health such as reducing the risks for obesity, type 2 diabetes, coronary heart disease, some cancers and all-cause mortality.^{1 2} It is also important for musculo-skeletal health, including supporting bone

Strengths and limitations of this study

- This is the first study to examine the association of decreased physical activity due to the COVID-19 pandemic with new-onset neck pain among survivors of a major natural disaster.
- This study used a longitudinal design, requiring protracted efforts from the researchers and survivors to undertake surveys in the aftermath of a disaster.
- The question about physical activity associated with the COVID-19 pandemic was newly generated and has not previously been studied.
- We assessed neck pain using a self-reported and simple question, and therefore, the underlying pathology of pain-related disabilities and the degree of neck pain were not assessed.
- Study participants of this study were residents of disaster areas; however, we could not directly interpret any changes in neck pain caused by the disaster.

and skeletal muscle mass and reducing pain.^{3–5} Physical inactivity has increased due to societal changes and increasingly sedentary lifestyles. Indeed, one out of five adults worldwide was estimated to be physically inactive, which has caused physical inactivity to be recognised as a global pandemic that requires international action.⁶ Indeed, despite WHO's recommendations for regular physical activity, 27.5% of adults do not meet these guidelines.⁷ Similarly, among the Japanese population, the prevalence of insufficient physical activity among adults was 35.5% in 2016.⁸

COVID-19 is an infectious disease caused by the SARS-CoV-2, which was first detected in December 2019 in Wuhan, China.⁹ The world is experiencing an extraordinary, life-altering challenge due to the COVID-19 pandemic.

An increasing number of governments are instituting nationwide quarantines, or considering various forms of lockdown in order to hinder the spread of the novel COVID-19.¹⁰ In the absence of a preventive vaccine and efficacious pharmaceutical options, public health measures are essential towards containing the spread of the virus. Strict hygienic rules, isolation, quarantine and social distancing have been identified as successful strategies.¹¹ Indeed, a rapid review indicated that quarantine measures, such as school closures, travel restrictions and social distancing would reduce the number of COVID-19 infections and deaths.¹² However, while home isolation and lockdown are likely to decrease physical activity and increase sedentary behaviour,¹³ the impact that the COVID-19 pandemic will have on physical activity levels and physical health remain unclear.

Neck pain is one of the most common symptoms present within the general population.¹⁴ Similarly, *katakori*, which presents similarly to neck pain,^{15 16} is also one of the most common subjective symptoms in the Japanese population, with a prevalence of approximately 10%.¹⁵ Both neck pain and *katakori* negatively impact the quality of life (QOL) and have become one of the most significant contributors to global disease burden.^{16 17} The disease burden in Japan was further augmented by the Great East Japan Earthquake (GEJE) and the devastating tsunami which hit the northeastern coast of Japan on 11 March 2011. In addition to causing a total of 18 440 deaths or missing cases,¹⁸ the earthquake is associated with chronic and long-term health problems including psychological disorders, physical inactivity and functional disabilities.^{19 20} A high prevalence of neck pain was also reported after the GEJE,²¹ which negatively impacted the QOL for survivors.¹⁶

Insufficient physical activity and back and neck pain are health problems that may persist throughout life.^{22 23} Moreover, neck pain has been reported to be associated with a number of factors, including a lack of physical activity.²⁴ Indeed, regular physical activity was reported to protect against neck pain.²⁵ We hypothesised that physical activity levels would also decrease due to the COVID-19 pandemic in Japan, and this would increase the prevalence of neck pain. As a result, this study aimed to evaluate the association between COVID-19 pandemic-related reductions in physical activity with new-onset neck pain among the GEJE survivors.

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 in the Miyagi prefecture in Japan. Initial medical health checks and questionnaire surveys after the GEJE were conducted from June to November 2011. Questionnaire surveys have been repeated every half-year thereafter and remain ongoing. The initial study population was residents registered in

the basic residential registry of the Ogatsu, Oshika and Ajishima areas. Although most participants were forced to live in temporary housing after the GEJE, they have now mostly finished moving into permanent housing, including public reconstruction housing and new houses.²⁶ Given the global spread of COVID-19, we added the questionnaire items about COVID-19 in the 2020 survey (conducted from July to August 2020 during the COVID-19 pandemic). In this work, we linked and analysed the self-reported questionnaire data from May to October 2019 (before the COVID-19 pandemic) to that during the COVID-19 pandemic.

Exposure

Changes in physical activity due to the COVID-19 pandemic were ascertained by asking the participants 'Has the frequency of going out changed due to the COVID-19 pandemic?'. This item was based on the participants' perception. They were asked to select a self-reported response from the following alternatives: 'no change,' 'decreased by 20%–30%,' 'decreased by half,' and 'almost never go out'.

Outcome

On the basis of the Comprehensive Survey of Living Conditions, we asked the participants whether they had experienced neck pain (*katakori*) during the past few days.²⁷ The question was 'Have you had symptoms within the last few days? If yes, please circle your symptoms' (multiple choices were allowed at the time of the questionnaire). Examples of the possible responses were 'dizziness,' 'irritation,' 'diarrhoea,' 'palpitation,' 'headache,' 'low back pain,' 'shoulder pain,' 'knee pain,' and 'neck pain (*katakori*)'.²⁸ The outcome of interest was new-onset neck pain, which was defined as the presence of neck pain on the questionnaire taken during the COVID-19 pandemic but absent before the pandemic.

Covariates

On the basis of the previous studies,^{21 29–33} the following variables at baseline were included in this analysis as potential confounding factors: sex, age, body mass index (BMI: calculated from self-reported height and weight values), smoking habits, drinking habits, health complications (hypertension, diabetes mellitus and cerebral stroke), employment status, walking time, subjective economic status, living environment, social isolation, psychological distress and sleep disturbance. Subjective economic status was assessed by the question: 'How do you feel about the current state of your household economy?' Available responses were 'fair,' 'poor,' 'poorer' and 'poorest'. Social isolation was assessed by the Lubben Social Network Scale (LSNS-6) and defined by a score of <12/30 as being socially isolated.³⁴ Psychological distress was defined by a score of $\geq 10/24$ on the Kessler Psychological Distress Scale-6 (K6).³⁵ Sleep disturbance was defined as a score of $\geq 6/24$ points on the Athens Insomnia Scale (AIS).³⁶

Statistical analysis

Categorical variables were summarised as percentages. Continuous variables were summarised as means with SD. For baseline characteristics, the effect of decreased physical activity during the COVID-19 pandemic (encoded as a categorical variable), was assessed via a χ^2 test for categorical variables and one-way analysis of variance for continuous variables.

Crude and multiple logistic regression analyses were performed to analyse the association between decreased physical activity due to the COVID-19 pandemic with new-onset neck pain. We used 'no change' for physical activity as a reference category. The OR and 95% CI for new-onset neck pain were calculated after simultaneous adjustment for potential covariates. Variables considered in the models were sex, age (<65 or ≥ 65 years), BMI (<18.5, 18.5–25, ≥ 25 kg/m² or unknown), smoking habits (non-smoker, smoker or unknown), drinking habits (non-drinker, <45.6 g, ≥ 45.6 g of alcohol/day or unknown), health complications (hypertension, diabetes mellitus and cerebral stroke), employment status (unemployed, employed or unknown), walking time (<30 min/day, 30 min to <1 hour/day and ≥ 1 hour/day), subjective economic hardship (fair, poor to poorest or unknown), living environment (living in the same house as before the earthquake, new house, public reconstruction housing, other or unknown), social isolation (LSNS-6 score: ≥ 12 , <12 or unknown), psychological distress (K6 score: <10, ≥ 10 or unknown) and sleep disturbance (AIS score: <6, ≥ 6

or unknown) at baseline. Further, we divided the participants into subgroups by age (<65 and ≥ 65 years) and sex (male and female) and calculated the ORs and 95% CIs in the same manner. For the stratified analysis, potential multiplicative interactions between neck pain in the first period and age or sex were tested using the Wald test.

All statistical analyses were performed with SPSS V.24.0 (SPSS Japan). All tests were two tailed, and differences at $p < 0.05$ were 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

Among the 3694 participants, 2389 responded to the health survey before the COVID-19 pandemic (response rate: 64.7%). Among those, all participants consented to this study and 388 who indicated having neck pain on the questionnaire before the pandemic were excluded from this study. Of the remaining 2001 participants, 1685 responded to the health survey during the COVID-19 pandemic. After excluding 77 participants because of

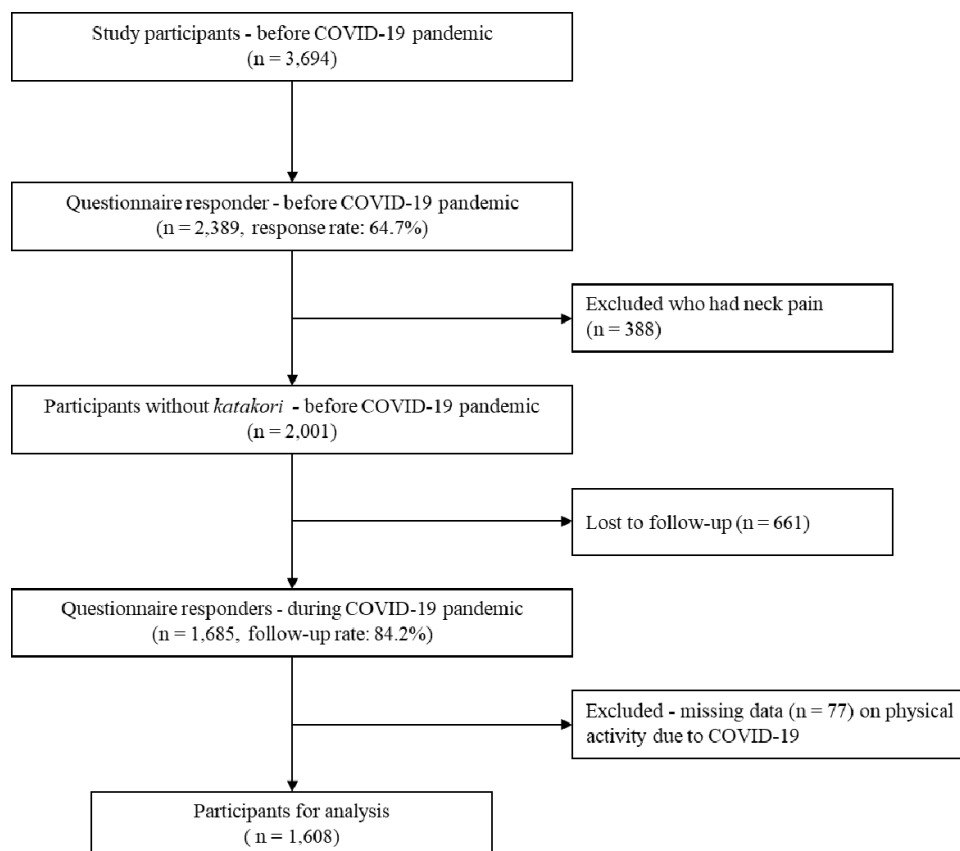


Figure 1 Flow diagram of the participants.

Table 1 Baseline characteristics according to changes in physical activity due to the COVID-19 pandemic (n=1608)

	Changes in physical activity due to the COVID-19 pandemic				P value
	No change	Decreased by 20%–30%	Decreased by half	Almost never go out	
	n=308	n=446	n=291	n=352	
Sex (%)					
Female	53.2	49.1	46.2	38.9	0.002
Male	46.8	50.9	53.8	61.1	
Age (years)					
	65.6 (19.6)	61.3 (18.6)	63.1 (18.6)	68.2 (20.3)	0.003
Age (%)					
<65 years	35.7	45.3	42.0	29.5	<0.001
≥65 years	64.3	54.7	58.0	70.5	
BMI (kg/m²)					
	23.8 (3.5)	24.3 (3.6)	24.3 (3.6)	23.8 (3.6)	0.09
BMI (%)*					
<18.5	3.2	2.2	2.0	3.2	0.001
18.5–24.9	60.4	57.4	55.2	58.2	
≥25	33.4	38.3	40.4	31.3	
Smoking habits (%)*					
Non-smoker	75.6	79.6	81.1	80.4	0.34
Smoker	20.5	17.0	15.3	14.5	
Drinking habits (%)*					
Non-drinker	62.0	61.9	59.2	67.3	0.051
<45.6 g of alcohol/day	19.2	20.0	21.5	13.9	
≥45.6 g of alcohol/day	10.7	8.7	9.8	6.3	
Complications (%)					
Hypertension	41.9	39.2	42.0	48.9	0.05
Diabetes mellitus	9.1	9.4	8.8	9.9	0.95
Stroke	1.9	1.3	1.2	3.7	0.045
Employment status (%)*					
Unemployed	54.2	44.2	49.8	59.7	<0.001
Employed	43.2	53.8	48.0	36.6	
Walking time/day (%)*					
<30 min	34.7	28.3	34.7	42.6	0.006
30 min to 1 hour	32.8	40.4	36.1	31.3	
≥1 hour	31.2	30.5	28.3	24.1	
Subjective economic status (%)*					
Fair	54.2	54.9	51.2	49.7	0.68
Poor to poorest	44.2	43.5	46.2	48.0	
Living environment (%)*					
Same house as before the GEJE	30.8	31.6	30.7	35.8	0.004
New house	28.2	35.4	34.3	25.6	
Public reconstruction housing	27.9	21.7	24.3	20.7	
Other	13.0	11.2	10.8	17.9	
Social isolation (%)*					
LSNS-6 score: ≥12	64.9	78.0	75.7	71.0	<0.001
LSNS-6 score: <12	35.1	22.0	24.3	29.0	
Psychological distress (%)*					
K6 score:<10	91.2	92.2	90.2	83.5	0.001
K6 score:≥10	7.1	6.5	7.6	14.8	

Continued

Table 1 Continued

	Changes in physical activity due to the COVID-19 pandemic				P value
	No change	Decreased by 20%–30%	Decreased by half	Almost never go out	
	n=308	n=446	n=291	n=352	
Sleep disturbance (%)*					
AIS score: <6	76.0	72.0	71.5	69.6	0.47
AIS score: ≥6	23.4	26.9	28.1	29.8	

Data are shown as percentages or mean (SD).

*Sum of % does not equal 100% due to missing data.

AIS, Athens Insomnia Scale; BMI, body mass index; GEJE, Great East Japan Earthquake; K6, Kessler Psychological Distress Scale-6; LSNS-6, Lubben Social Network Scale.

missing physical activity data, 1608 participants were included in the analysis (figure 1).

The mean age of the participants was 63.7 years (SD: 16.3) and 52.2% (n=709) were women. Among the participants, 'no change,' 'decreased by 20%–30%,' 'decreased by half,' and 'almost never go out' were 9.2% (n=308), 27.7% (n=446), 31.2% (n=502) and 21.9% (n=352), respectively. The participants who reported new-onset neck pain were 9.8% (n=157). Baseline characteristics disaggregated by COVID-19 pandemic-related physical activity changes are shown in table 1.

Table 2 shows the association between decreased physical activity due to the COVID-19 pandemic with new-onset neck pain, as assessed by multivariate logistic regression analysis. A significantly higher rate of new-onset neck pain was observed in participants who reported their physical activity to have 'decreased by half' (adjusted OR 1.85, 95% CI 1.04 to 3.30, p=0.035) and 'almost never go out' (adjusted OR 2.13, 95% CI 1.16 to 3.91, p=0.014), when compared with the 'no change' category. The results of the stratified analysis are shown in table 3. Decreased physical activity showed an interaction with male participants, and

those <65 years of age, indicating that these populations were particularly at risk for sedentary-associated neck pain. Moreover, there were statistically significant multiplicative interactions between decreased physical activity and these variables.

DISCUSSION

To our knowledge, this is the first study to investigate the longitudinal association between COVID-19 pandemic-related physical inactivity and neck pain among Japanese populations living in damaged coastal areas. We found that 80.8% of the participants experienced decreased physical activity due to the COVID-19 pandemic. Furthermore, decreased physical activity during the COVID-19 pandemic was significantly associated with new-onset neck pain.

Physical inactivity, a major risk factor for global mortality, accounts for 3.2 million deaths worldwide each year.³⁷ Decreased physical activity can increase the risk of heart disease directly, and also indirectly through increasing the risk for developing other

Table 2 OR and 95% CI of new-onset of neck pain disaggregated by the reduction in physical activity

	Changes in physical activity due to the COVID-19 pandemic			
	No change	Decreased by 20%–30%	Decreased by half	Almost never go out
No of participants	308	446	502	352
No of participants with new onset of neck pain	18 (5.8)	46 (10.3)	54 (10.8)	39 (11.1)
Crude OR (95% CI)	1.00 (Ref.)	1.85 (1.05 to 3.26)	1.94 (1.12 to 3.38)	2.01 (1.12 to 3.59)
P value		0.033	0.019	0.019
Multivariate OR (95% CI)*	1.00 (Ref.)	1.73 (0.96 to 3.12)	1.85 (1.04 to 3.30)	2.13 (1.16 to 3.91)
P value		0.066	0.035	0.014

*Adjusted for sex (male, female), age (<65, ≥65 years), body mass index (<18.5, 18.5–24.9, ≥25 kg/m², unknown), smoking habits (non-smoker, smoker, unknown), alcohol drinking habits (non-drinker, <45.6 g of alcohol/day, ≥45.6 g of alcohol/day, unknown), complications (hypertension, diabetes mellitus, stroke), employment status (unemployed, employed), walking time (≥1 hour, 30 min to <1 hour, <30 min, unknown), subjective economic status (fair, poor to poorest, unknown), living environment (same house as before the Great East Japan Earthquake, new house, public reconstruction housing, other, unknown), social isolation (Lubben Social Network Scale-6 score: ≥12, <12, unknown), psychological distress (Kessler Psychological Distress Scale-6 score: <10, ≥10, unknown), sleep disturbance (Athens Insomnia Scale score: <6, ≥6, unknown).

Table 3 Stratified analyses: OR and 95% CIs of new-onset of neck pain disaggregated by the reduction in physical activity

	Changes in physical activity due to the COVID-19 pandemic				P interaction
	No change	Decreased by 20%–30%	Decreased by half	Almost never go out	
No of participants	308	446	502	352	
Age group					
<65 years (n=627)					0.02
No of events/subjects	10/110 (9.1%)	27/202 (13.4%)	29/211 (13.7%)	19/104 (18.3%)	
Multivariate OR (95% CI)*	1.00 (Ref.)	1.64 (0.71 to 3.76)	1.54 (0.68 to 3.48)	2.23 (0.92 to 5.41)	
≥65 years (n=981)					
No of events/subjects	8/198 (4.0%)	19/244 (7.8%)	25/291 (8.6%)	20/248 (8.1%)	
Multivariate OR (95% CI)*	1.00 (Ref.)	2.02 (0.83 to 4.89)	2.39 (1.02 to 5.62)	2.18 (0.91 to 5.22)	
Sex					
0.001					
Male (n=752)					
No of events/subjects	7/164 (4.3%)	19/219 (8.7%)	24/232 (10.3%)	14/137 (10.2%)	
Multivariate OR (95% CI)*	1.00 (Ref.)	2.03 (0.80 to 5.13)	2.49 (1.01 to 6.15)	2.83 (1.05 to 7.59)	
Female (n=856)					
No of events/subjects	11/144 (7.6%)	27/227 (11.9%)	30/270 (11.1%)	25/215 (11.6%)	
Multivariate OR (95% CI)*	1.00 (Ref.)	1.44 (0.66 to 3.13)	1.38 (0.64 to 2.95)	1.72 (0.78 to 3.77)	

*Adjusted for sex (male, female), age (<65, ≥65 years), body mass index (<18.5, 18.5–24.9, ≥25 kg/m², unknown), smoking habits (non-smoker, smoker, unknown), alcohol drinking habits (non-drinker, <45.6 g of alcohol/day, ≥45.6 g of alcohol/day, unknown), complications (hypertension, diabetes mellitus, stroke), employment status (unemployed, employed), walking time (≥1 hour, 30 min to <1 hour, <30 min, unknown), subjective economic status (fair, poor to poorest, unknown), living environment (same house as before the Great East Japan Earthquake, new house, public reconstruction housing, other, unknown), social isolation (Lubben Social Network Scale-6 score: ≥12, <12, unknown), psychological distress (Kessler Psychological Distress Scale-6 score: <10, ≥10, unknown), sleep disturbance (Athens Insomnia Scale score: <6, ≥6, unknown).

conditions, such as obesity, high blood pressure, high blood cholesterol levels and type 2 diabetes mellitus.³⁸ The fear of being infected and the mobility restrictions imposed during the COVID-19 pandemic may dissuade people from attaining the recommended levels of physical activity. Given the lack of studies employing a similar instrument, it is difficult to compare these findings with other research; nevertheless, this study suggests that the COVID-19 pandemic negatively impacted physical activity among the GEJE survivors.

Musculoskeletal pain, including neck pain negatively impacts the QOL, is a leading cause of disability, and as such is one of the most common reasons for seeking medical advice.¹⁷ Therefore, only a small reduction in the incidence of neck pain would have a significant beneficial effect for promoting health. In this study, the participants who experienced decreased physical activity had significantly greater chances of new-onset neck pain. This finding is consistent with previous studies,^{24 25 39} and thus decreased physical activity may represent a significant predictor of neck pain among the GEJE survivors. Although significant multiplicative interactions were observed, stratified analysis according to the categories of age and sex also showed positive associations between COVID-19 pandemic-related reductions in physical activity and new-onset neck pain. These results, therefore, suggest a robust association between decreased physical activity and neck pain. If sufficiently validated as a true

causal association, our study has profound implications for supporting public health. The results of this study would be useful to Japanese populations living in damaged coastal areas and their support structures (eg, family and public health nurses), as well as to clinicians and medical staff who treat musculoskeletal pain. Careful attention and continuous support are needed to improve the physical activity of people during the COVID-19 pandemic, which may affect the onset of neck pain.

This study had several limitations. First, the question about decreased physical activity was newly generated and thus has not been validated previously.⁴⁰ Second, neck pain was only assessed over two periods and changes in the incidence of neck pain across other periods were not evaluated. Further studies with longer follow-up periods are needed. Third, we assessed neck pain using a self-reported and simple question without any additional illustration. Moreover, pain severity and location were not assessed. Finally, the participants of our study were residents of disaster areas, however, we could not directly interpret any changes in neck pain caused by the GEJE.

CONCLUSION

This study showed that decreased physical activity due to the COVID-19 pandemic was significantly associated with new-onset neck pain. Our study indicates that being active while maintaining social distancing

is necessary for preventing neck pain among the GEJE survivors.

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Contributors All the authors have made a substantial contribution to the manuscript and have approved this submission. TS participated in the design of the study and statistical analysis of the data and wrote the manuscript. YH is the corresponding author of this study, participated in the design of the study and helped to draft and edit the manuscript. YS helped to analyse the data and draft the manuscript. YY and EI helped to draft the manuscript. IT conceived the study, collected the data, helped to analyse the data and to draft and edit the manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The study protocol was reviewed and approved by the Ethics Committee of Tohoku University Graduate School of Medicine, Sendai, Miyagi, Japan (approval number: 201192). All participants provided informed consent for the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. Not applicable.

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ORCID iDs

Takuya Sekiguchi <http://orcid.org/0000-0003-4642-854X>

Yoshihiro Hagiwara <http://orcid.org/0000-0002-2992-2178>

Yumi Sugawara <http://orcid.org/0000-0002-0197-6772>

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