



Physical and financial impacts caused by the COVID-19 pandemic exacerbate knee pain: A longitudinal study of a large-scale general population

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ABSTRACT

Objectives: This study aimed to evaluate the changes in knee pain, a dominant cause of physical disability, following the coronavirus disease (COVID-19) pandemic, and to identify factors affecting the changes in knee pain.

Methods: We analysed the pre- and post-COVID-19 longitudinal data set of the Nagahama Study. Knee pain was assessed using the Knee Society Score (KSS). The estimated KSS from the age and sex using regression model in the pre- and post-COVID-19 data set was compared. Factors including the activity score, educational level, and various impacts of COVID-19 were analysed for correlation analyses with changes in KSS.

Results: Data collected from 6409 participants showed statistically significant differences in KSS, pre- (mean = 22.0; SD = 4.4) and post-COVID-19 (mean = 19.5; SD = 6.4). Low activity score ($p = .008$), low educational level ($p < .001$), and undesirable financial impact ($p = .030$) were independently associated with knee pain exacerbation.

Conclusion: The harmful effects of the COVID-19 pandemic on knee pain were suggested. People should be encouraged to engage in physical activities, such as walking, despite the state of emergency. Furthermore, social support for economically disadvantaged groups may improve healthcare access, preventing the acute exacerbations of knee pain.

KEYWORDS: Osteoarthritis; knee pain; pandemic; population cohort; COVID-19

Introduction

Worldwide, the coronavirus disease (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has negatively affected the physical [1], psychosocial [2, 3], socio-economic [4, 5], and family environmental [6] aspects of people of all ages. Evidence is accumulating that the forced changes due to this disease, including social distancing measures, affect global and personal health through the unavoidable decrease in activity [7, 8], social isolation [9, 10], and poor access to medical services [11, 12]. As such, there is growing interest and concerns in the direct health effects of the pandemic and in its indirect effects associated with behavioural changes caused by the pandemic itself and by alterations in therapeutic interventions.

Knee pain is a common cause of walking-related disability, affecting approximately 50% of older people [13–15]. Osteoarthritis (OA), one of the significant causes of knee pain, is a multifactorial disorder related to activity, psychological

factors, and economic factors. Results on the relationship between knee pain and physical activity have been contradicting, depending on the severity of OA. Aerobic walking has been reported to reduce knee pain [16], and increasing levels of regular physical activity have been also suggested to lower the risk of OA progression [17]. On the contrary, it has been reported that activity level and knee pain were positively correlated in patients with severe knee pain [18], while psychosocial and socio-economic factors were correlated with the prevalence and the levels of knee pain [19, 20]. Therefore, it is worthwhile to evaluate the multifaceted effects of the COVID-19 pandemic on common knee pain. In a previous study, the COVID-19-related lockdown was reported to significantly impact pain, joint function, physical function, and physical activity in 63 patients with end-stage knee or hip OA [21]. However, to date, there have been no longitudinal studies among large-scale samples of the general population to examine the relationship between knee pain and COVID-19 pandemic.

Table 1. Pre- and post-COVID-19 KSS.

	Whole participants		Female over 65 years old		Male over 65 years old		Female under 65 years old		Male under 65 years old		Female	Male
Number of participants	6409		2190		1262		2234		723			
	Score	SD	Score	SD	Score	SD	Score	SD	Score	SD	<i>p</i> -value [†]	<i>p</i> -value [†]
Pre-COVID-19 KSS pain score	22.0	4.4	21.0	5.0	21.7	4.7	22.9	3.6	23.2	3.5	<.001	<.001
Post-COVID-19 KSS pain score	19.5	6.4	17.9	7.0	18.5	6.7	21.3	5.3	21.0	5.6	<.001	<.001
Change in KSS pain score	-2.5	5.5	-3.1	6.0	-3.2	6.0	-1.6	4.7	-2.2	5.2	<.001	<.001
<i>p</i> -value*	<.001		<.001		<.001		<.001		<.001			

Result of pre- and post-COVID-19 KSS.

*Significant difference between pre- and post-COVID-19 KSS was tested using Wilcoxon signed-rank test.

†Significant differences in the KSS and KSS change following the COVID-19 between group over 65 years old and group under 65 years old was tested using the Mann-Whitney U test.

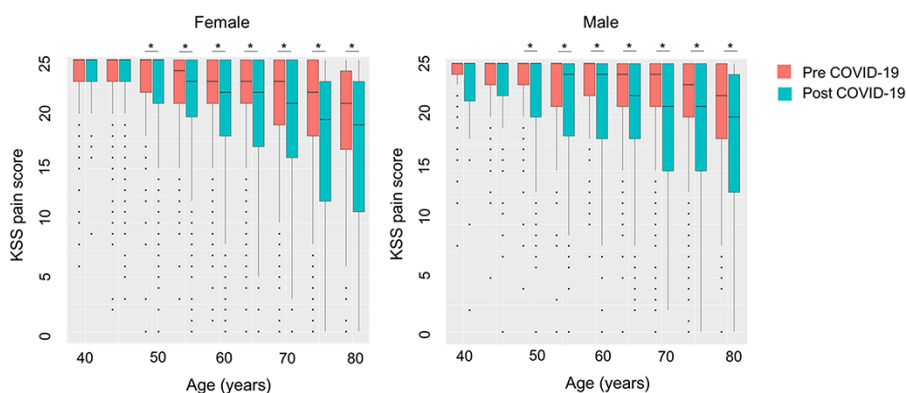


Figure 2. KSS stratified by sex and age.

Figure 2 KSS stratified by sex and age at which each questionnaire was completed. *Significant difference between pre- and post-COVID-19 KSS was tested using the Mann-Whitney U test.

Results

Data from 6409 participants (1985 males, 4424 females; mean age = 63.1 years; SD = 11.7 years) were used to statistically analyse the changes in KSS following the COVID-19 pandemic. As a result, pre- (mean = 22.0; SD = 4.4) and post-COVID-19 KSS pain scores (mean = 19.5; SD = 6.4) were significantly different (*p* < .001). Both pre- and post-COVID-19 KSS were lower in the group over 65 years old than in the group under 65 years old (*p* < .001), and the exacerbation by COVID-19 pandemic was more pronounced in the group over 65 years old, in both females and males (*p* < .001) (Supplementary Figure S1, Table 1).

KSS was statistically significant different between the pre- and post-COVID-19 for both male and female in all age groups over 45 years (Figure 2). Moreover, the prevalence of knee pain was higher in the post-COVID-19 survey than that in the pre-COVID-19 survey at every group of KSS cut-off, and the increase in prevalence was statistically significant for all ages at group of KSS ≤ 20 cut-off (Figure 3). The estimated KSS total score and subscores based on age using the quasi-Poisson regression model showed lower scores in the post-COVID-19 survey than that in the pre-COVID-19 survey, especially with increase of age (Figure 4). Among the subscores, pain with stairs or inclines was significantly exacerbated in female over 50 years.

For the association analysis of KSS with other measurements, data collected from 5804 participants (1847 males, 3957 females; mean age = 63.4 years; SD = 11.8 years, range = 39–85 years) were used. The numbers of responses to the questionnaires on the pre- and post-COVID-19 activity scores, educational level, and the self-reported impacts are shown in Table 2. The percentage of participants adversely affected by COVID-19 for each aspect was as follows: physical impact (37.1%), psychological impact (60.2%), financial impact (34.1%), work style (38.8%), social interaction (58.9%), and family relationships (26.7%). Table 3 presents the standardized β-coefficients and *p*-values from the single-factor and multi-factor linear regression models of the quintile of pre- and post-COVID-19 changes in the KSS. Low post-COVID-19 activity score (standardized β-coefficient, 0.049; *p* = .007), low educational level (standardized β-coefficient, 0.083; *p* < .001), undesirable financial impact (standardized β-coefficient, -0.061; *p* = .001), and undesirable impact on work style (standardized β-coefficient, -0.047; *p* = .011) were associated with exacerbation of KSS pain score in the single-factor model. Meanwhile, in the multi-factor model, exacerbation of KSS was independently susceptible with the low post-COVID-19 activity score (standardized β-coefficient, 0.048; *p* = .008), low educational level (standardized β-coefficient, 0.081; *p* < .001), and

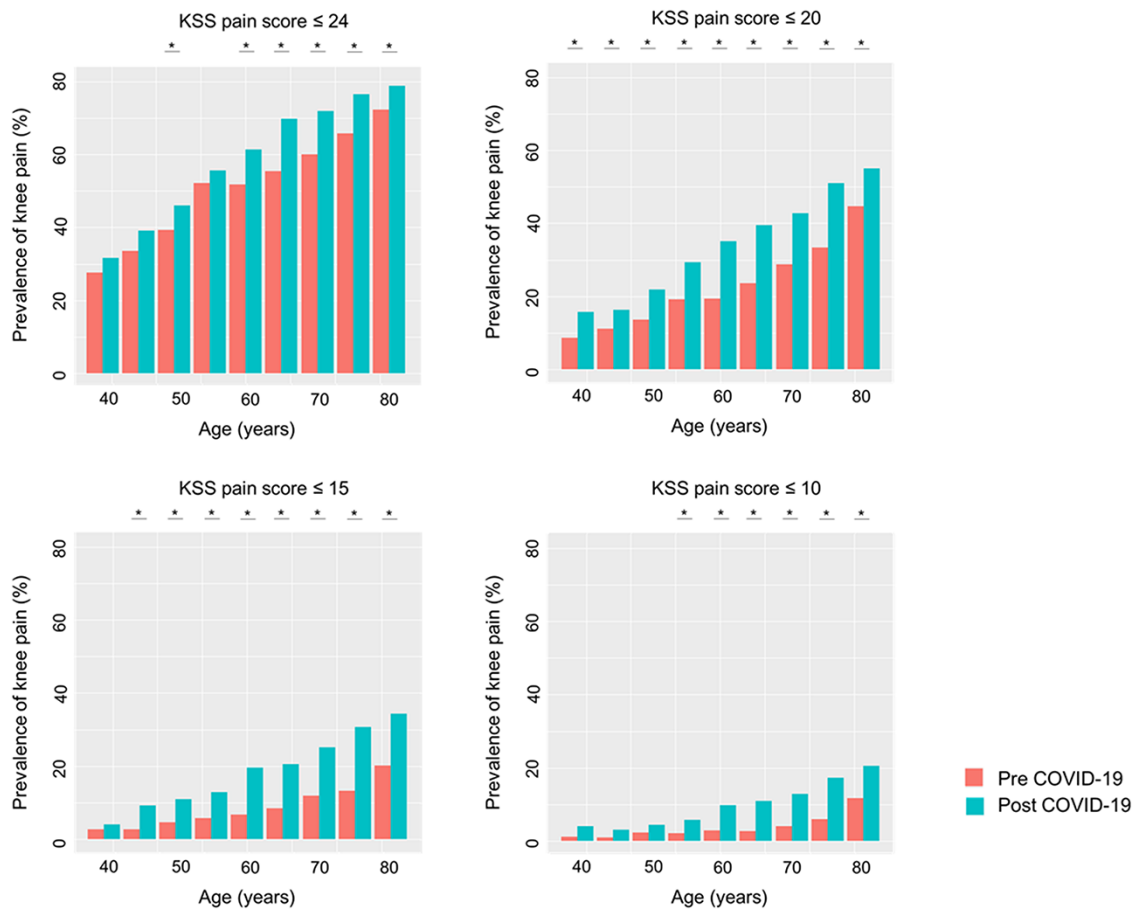


Figure 3. Prevalence of knee pain stratified by age. Bar plot showing prevalence of knee pain divided every 5 years at each KSS cut-off (KSS ≤ 24 , ≤ 20 , ≤ 15 , or ≤ 10).

*Significant difference between pre- and post-COVID-19 prevalence of knee pain was tested using the Mann–Whitney U test. KSS: Knee Society Score.

undesirable financial impact (standardized β -coefficient, -0.050 ; $p = .030$).

The results, stratified by age and sex, showed that low educational level (standardized estimates, 0.176 ; $p < .001$) among male participants over 65 years and undesirable financial impact (standardized estimates, -0.081 ; $p = .028$) among female participants under 65 years were significantly associated with exacerbation of KSS in the multi-factor model.

Discussion

The Japanese government declared a state of emergency to prevent the spread of COVID-19 in the capital and metropolitan areas on 7 April 2020, expanding to include the entire nation on 16 April 2020 [24]. Public behavioural changes, including avoiding crowding, the closure of nonessential businesses, staying at home, and movement restrictions, have been strongly encouraged. However, such behavioural and social restrictions have already been initiated almost 2 months before the emergency declarations. As expected, these greatly depressed the economy, and many health communities immediately raised the reasonable fear of the decline in the general population's health status, especially among the elderly. Knee pain has been shown to be substantially related to quality of life [25] and is a complex condition that affects even healthy people [26], reflecting socio-economic inequalities, including

economic and educational inequalities [27]. Therefore, this study aimed to analyse the changes in knee pain, a common symptom that limits function and mobility and impairs quality of life [28] during the COVID-19 pandemic, and identify the related factors for the development of preventive measures.

This study showed that the COVID-19 pandemic significantly exacerbated the KSS pain score. There was a 2.5-point difference on the averages, and since this difference was greater than 1.9 points, it was considered significant numerically as it was greater than the minimum clinically important difference [29]. Although there was a time lapse of 4–5 years between the pre- and post-COVID-19 surveys, the estimated KSS based on age by quasi-Poisson regression model revealed that the deterioration of KSS was unexplainable by the passage of years between the first and second surveys (Figure 4). The regression curve of the pre-COVID-19 survey was gentle, suggesting that the effect of ageing on changes in KSS was usually insignificant. This was consistent with a previous report that found no significant changes in knee pain among healthy samples during a 9-year interval [30]. On the other hand, the regression curve of the post-COVID-19 survey showed steep changes with age, suggesting the vulnerability of the elderly to the effects of the COVID-19 pandemic. Although the negative impact of the COVID-19 lockdown was reported among OA patients and patients with chronic knee pain [21, 31], the

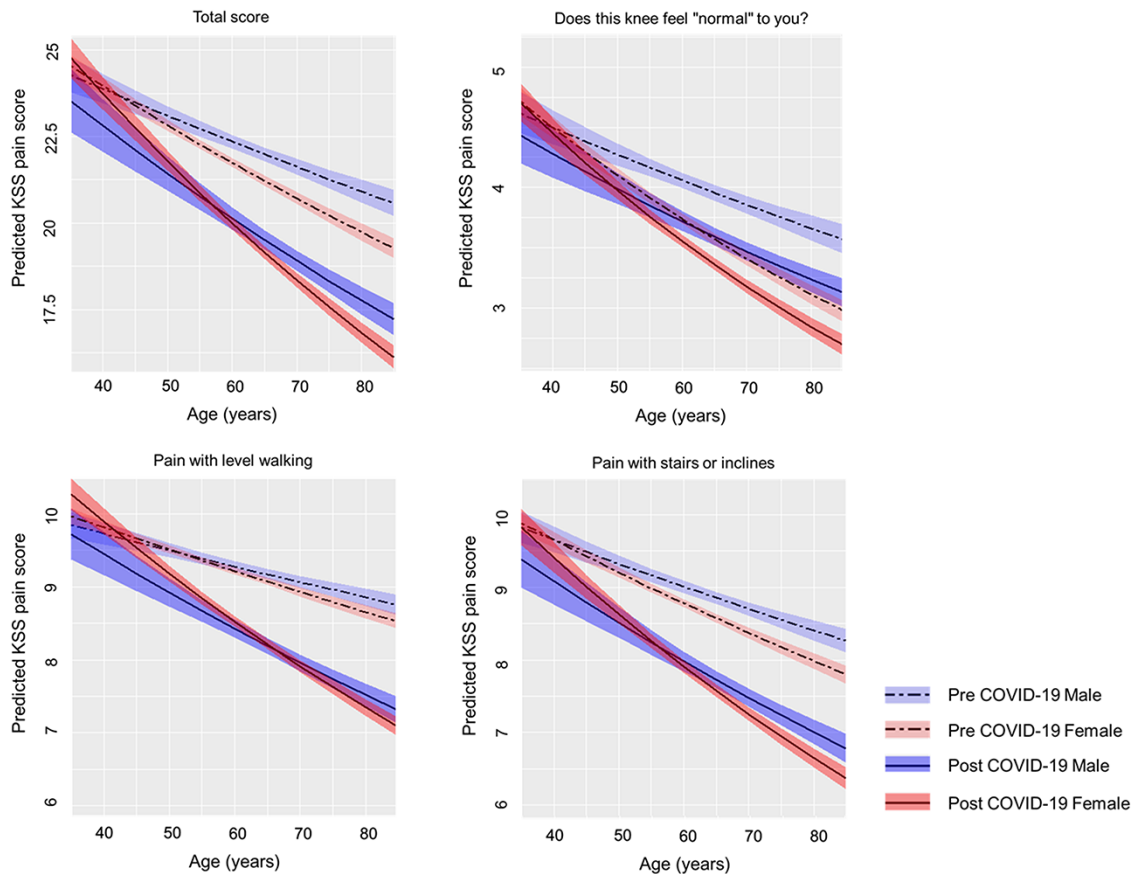


Figure 4. Predicted KSS pain score by sex and age. Line graphs showing estimated KSS total score and subscores from age by quasi-Poisson regression model (solid lines and dotted lines) and 95% confidence interval. (shading zones) Dotted line with blue shading zone showing pre-COVID-19 male estimated KSS, dotted line with red shading zone showing pre-COVID-19 female estimated KSS, solid line with blue shading zone showing post-COVID-19 male estimated KSS, solid line with red shading zone showing post-COVID-19 female estimated KSS.

current study showed the negative impact of the COVID-19 even in general population.

A lower amount of walking (the activity score) under emergency declarations was suggested as a risk factor for exacerbating knee pain, as expected in this study. The decrease in the amount of walking under emergency declarations was primarily due to the government’s prohibition of physical and social activities. The decrease in KSS, which appeared within a short period after the COVID-19 pandemic, might have been due to muscle weakness or stiffness rather than the aggravation of joint diseases, as evidenced by previous reports [16, 32]. Associations of sedentary behaviour with bodily pain were reported [33], a similar association was found in knee pain. In particular, elderly people should be encouraged to engage as much as possible in physical activities, such as walking, even under emergency declarations [34]. However, this speculation requires considerable attention due to the insufficient diagnostic or examination data in this study.

One of the unexpected results of this study was that physical and psychological impacts did not correlate significantly with changes in knee pain, although these two are significantly associated as reported elsewhere. This fact suggests that people in this area coped well mentally during the pandemic, at least during this period. On the other hand, financial impact and lower educational level were significantly correlated with knee pain exacerbation. The significant correlation of knee

Table 2. Answer to each questionnaire.

Questionnaire	Number of responses				
	1	2	3	4	5
Pre-COVID-19 activity score	410	1567	1698	1164	965
Post-COVID-19 activity score	754	2100	1540	779	631
Educational level	3	923	2701	2177	–
Physical impact	129	498	3022	1798	357
Psychological impact	122	382	1808	2748	744
Financial impact	93	360	3372	1444	535
Work styles	99	359	3095	1724	527
Social interaction	118	358	1909	2650	769
Family relationships	139	612	3503	1288	262

Table 2 showing distribution of answer to each questionnaire. Activity score, (1) Only indoor walking, (2) ~3000 steps, (3) 3000–5000 steps, (4) 5000–7000 steps, and (5) more than 7000 steps; Educational level, (1) Educational institution, (2) Early secondary educational institution, (3) Post-secondary educational institution, and (4) Higher education institution; COVID-19 impact from each perspective, (1) A very positive impact, (2) Some positive impact, (3) Can’t say either, (4) Some negative impact, and (5) A very negative impact.

pain exacerbation with socio-economic factors suggests that the exacerbations in the short term were, at least, partially caused by the reduced access to healthcare and medical visits [1, 11, 12, 35] associated with financial pressures or fear of infection, rather than by the physical or psychological impacts. It is not surprising that undesirable financial impact

Table 3. Correlation between quintile of change in KSS and each measurement in single-factor model and multi-factor model.

Variables	Whole participants		Female over 65 years old		Male over 65 years old		Female under 65 years old		Male under 65 years old	
	β	<i>p</i> -value	β	<i>p</i> -value	β	<i>p</i> -value	B	<i>p</i> -value	β	<i>p</i> -value
Number of participants	5804		1860		1143		2097		704	
Single-factor model										
Pre-COVID-19 activity score	0.053	.004	0.081	.019	0.025	.563	0.047	.124	0.071	.155
Post-COVID-19 activity score	0.049	.007	0.057	.108	0.047	.279	0.066	.033	0.029	.546
Educational level	0.083	<.001	0.028	.416	0.176	<.001	0.100	.013	0.134	.032
Physical impact	-0.022	.225	-0.032	.306	-0.014	.728	-0.035	.283	0.016	.774
Psychological impact	-0.017	.360	-0.004	.900	-0.038	.359	-0.027	.425	0.015	.793
Financial impact	-0.061	.001	-0.046	.213	-0.086	.042	-0.088	.005	-0.008	.858
Work styles	-0.047	.011	-0.042	.248	-0.121	.008	-0.045	.135	-0.037	.422
Social interaction	-0.029	.108	-0.016	.629	-0.038	.363	-0.038	.233	-0.086	.103
Family relationships	-0.032	.082	-0.009	.786	-0.024	.575	-0.043	.160	-0.072	.199
Multi-factor model										
Post-COVID-19 activity score	0.048	.008	0.055	.126	0.057	.189	0.064	.037	0.026	.589
Educational level	0.081	<.001	0.025	.469	0.176	<.001	0.096	.017	0.138	.028
Physical impact	0.003	.921	-0.052	.300	0.084	.199	-0.015	.729	0.034	.632
Psychological impact	0.023	.424	0.063	.249	-0.043	.527	0.026	.580	0.060	.429
Financial impact	-0.050	.030	-0.037	.476	-0.034	.568	-0.081	.028	0.010	.861
Work styles	-0.015	.555	-0.021	.698	-0.121	.073	0.005	.891	0.001	.992
Social interaction	-0.012	.645	-0.009	.861	0.015	.814	-0.018	.674	-0.101	.154
Family relationships	-0.016	.465	0.010	.819	0.014	.800	-0.020	.559	-0.059	.382

Result of single-factor model and multi-factor model; General linear model that was controlled for sex and age by including the estimated change in KSS between pre- and post-COVID-19 survey as covariates. To facilitate interpretability, all scores were standardized. In multi-factor analysis, pre-COVID-19 activity score was excluded from the multi-factor model because of the strong correlation.

has a stronger influence on the exacerbation of knee pain in participants under 65 years of age, who have to pay more out-of-pocket due to the health insurance system in Japan. The correlation between personal income and health status has been well established, and those two are linked through several mechanisms [36, 37]. For example, healthcare may become inaccessible when one becomes unemployed, thereby losing health insurance [38]. There are also data suggesting that more educated subjects with knee or hip OA receive more comprehensive medical care, perhaps due to the better ability to access the healthcare system [39]. Another plausible association would be that educated people have more appropriate judgement to perform physical activities and to access to healthcare service. Income also allows people to purchase necessities, access health-enhancing resources, avoid harmful exposures, and participate in normal social activities. In contrast, low income predisposes people to psychosocial stress. The minimum income for healthy living establishes a standard required to maintain health in different settings. Crucially, not all are equally likely to lose their income since women, young people, and those who are already economically disadvantaged fare the worst. To avoid the widening health inequalities, social distancing must be accompanied by measures to safeguard the economically disadvantaged's incomes. Therefore, continuous medical financial support, telehealth services [40, 41], and health promotion efforts to provide proper medical care [1, 35, 36] may prevent the acute exacerbations of knee pain and physical disabilities.

This study has several notable limitations. First, the cause of the pain was not identified medically by any means. Each cause may have different effects on pain and physical activity. Second, this study was a short-term study conducted 6 months

after emergency declarations. Therefore, further follow-up is needed to evaluate the long-term course of knee pain. Third, this study was conducted on volunteers from a single rural area in Japan. As such, the distinction of areas, class of people, income, ethnicity, and health status may show different results. Fourth, the association between knee pain and financial burden or education should be investigated with sufficient related factors to develop effective countermeasures. Finally, the non-interventional design of this study precludes any conclusions regarding the actual effects of any intervention on clinical outcomes.

In conclusion, the harmful effects of the COVID-19 pandemic on knee pain were suggested. People should be encouraged to engage in physical activities, such as walking, even under emergency declarations to alleviate knee pain. Social support for the economically disadvantaged group, who were under the harmful influence of COVID-19, may improve healthcare access to prevent the short-term exacerbations of knee pain.

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Supplementary data

Supplementary data are available at *Modern Rheumatology* online.

Conflict of interest

H.I. has received a research grant from Bristol-Myers Squibb. Y.M., T.K., K.N., S.N., S.K., Y.S., Y.T., F.M., and S.M. declared no conflicts of interest. The sponsors were not involved in the study design, data collection or recruitment, analysis, interpretation of data, writing of this manuscript, or in the decision to submit the article for publication. We have nothing to be paid to write this article by a pharmaceutical company or other agency. The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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Authors’ contributions

H.I., Y.S., Y.T., F.M. and S.M. designed the study. Y.M. and H.I. wrote the manuscript. Y.M., H.I., K.N., S.N., S.K., Y.S., Y.T., and F.M. collected data and information of the subjects. Y.M. and T.K. performed the statistical analyses. H.I. and S.M. have verified the underlying data. H.I., Y.S., Y.T., F.M., and S.M. collected funding. F.M. and S.M. supervised the works. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This study was conducted according to the principles of the Declaration of Helsinki and was approved by the ethics committee of Kyoto University Graduate School of Medicine and by the Nagahama Municipal Review Board (No. C278). Written informed consent was obtained from all participants.

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