1 **Correlation between COVID-19 vaccination and inflammatory musculoskeletal**

2 **disorders**

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14

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16 responsibility for the integrity of the data and the accuracy of the data analysis. Drs Park and

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18 Concept and design: All authors.

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22   Statistical analysis: Kim.

23   Obtained funding: None.

24   Administrative, technical, or material support: Park, Chun.

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32   **Manuscript word count: 2,317**

33   **Abstract**

34   **Importance:** Earlier research on COVID-19 vaccines identified a range of adverse reactions

35   related to proinflammatory actions that can lead to an excessive immune response and

36   sustained inflammation. However, no study has been conducted on the association between

37   inflammatory musculoskeletal disorders and COVID-19 vaccines.

38   **Objective:** To investigate the incidence rates of inflammatory musculoskeletal disorders

39   following COVID-19 vaccination and to compare them with those of unvaccinated

40   individuals.

41   **Design, Setting, and Participants:** This retrospective nationwide cohort study used data

42   from the Korean National Health Insurance Service (NHIS) database, involving 2,218,715

43   individuals. Data were collected from January 1, 2021, to 12 weeks after the second dose of

44   vaccine for vaccinated individuals and 12 weeks after September 30, 2021, for unvaccinated

45   individuals.

46   **Exposures:** Status was categorized as unvaccinated and vaccinated with mRNA vaccine,

47   viral vector vaccine, and mixing and matching.

48   **Main Outcomes and Measures:** The primary outcome was the occurrence of inflammatory

49   musculoskeletal disorders that were selected as plantar fasciitis (ICD code, M72.2), rotator

50   cuff syndrome (M75.1), adhesive capsulitis (M75.0), herniated intervertebral disc (HIVD)

51   (M50.2/M51.2), spondylosis (M47.9), bursitis (M71.9), Achilles tendinitis (M76.6), and de-

52   Quervain tenosynovitis (M65.4). Multivariate logistic regression analysis was used to

53   determine the risk factors of musculoskeletal disorders after adjusting for potential

54   confounders.

55   **Results:** Among the 2,218,715 individuals, 1,882,640 (84.9%) received two doses of the

56   COVID-19 vaccine, and 336,075 (15.1%) did not. At 12 weeks after vaccination, the

57   incidences of plantar fasciitis (0.14-0.17%), rotator cuff syndrome (0.29-0.42%), adhesive

58   capsulitis (0.29-0.47%), HIVD (0.18-0.23%), spondylosis (0.14-0.23%), bursitis (0.02-

59   0.03%), Achilles tendinitis (0.0-0.05%), and de-Quervain tenosynovitis (0.04-0.05%) were

60   higher in all three vaccinated groups (mRNA, cDNA, and mixing and matching vaccines)

61   when compared to the unvaccinated group. All COVID-19 vaccines were identified as

62   significant risk factors for each inflammatory musculoskeletal disorder (odds ratio, 1.404-

63   3.730), except for mixing and matching vaccines for de-Quervain tenosynovitis.

64   **Conclusions and Relevance:** This cohort study found that individuals who received any

65   COVID-19 vaccine were more likely to be diagnosed with inflammatory musculoskeletal

66   disorders than those who did not. This information will be useful in clarifying the adverse

67   reactions to COVID-19 vaccines and informing people about their potential for inflammatory

68   musculoskeletal disorders after vaccination.

69

Introduction

The COVID-19 pandemic caused by the SARS-CoV-2 virus has had a profound impact on the world, with millions of infections and deaths reported globally. Therefore, extensive efforts were made to develop novel vaccines to combat the virus and curb its spread. The introduction of new COVID-19 vaccines has revolutionized vaccine science, offering unprecedented speed and efficacy during clinical trials.[1] As a result, more than five billion people worldwide have been vaccinated so far, and declarations of public health emergencies have ended in most countries.[2]

Vaccines, inherently designed to stimulate the immune system, have the potential to elicit adverse reactions, which are often linked to immune-mediated responses involving vaccine excipients, active components, or immunodeficiency of the vaccinated individual.[3,4] Traditional vaccines, with their longstanding accessibility to the public, have been associated with a predictable panel of adverse reactions, most of which are considered harmless.[3] The COVID-19 vaccines are no exception to this; therefore, providing clear and transparent information about adverse reactions and demonstrating predictability are essential to increasing public trust and confidence.

Early research on COVID-19 vaccines identified a range of adverse reactions related to their proinflammatory effect, which could lead to an excessive immune response and sustained inflammation.[5] However, other than presenting self-reported symptoms, no studies have been reported on the association of inflammation-related diseases with COVID-19 vaccines, especially in musculoskeletal disorders.[6-9] Therefore, this study aimed to investigate the incidence of inflammatory musculoskeletal disorders after COVID-19 vaccination through a large-scale population survey. We used data from the Korean National Health Insurance

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93   Service (NHIS) database, which comprises a comprehensive dataset of 2,218,715 individuals.

94

95   **Methods**

96   *Study Design and Population*

97   This nationwide, population-based, retrospective cohort study used data from the Korean

98   NHIS.[10] On January 1, 2021, 50% of the residents of Seoul were randomly selected and

99   included in the study population. The incidence of musculoskeletal disorders among the

100   participants was then analyzed according to their vaccination status. Individuals who received

101   two doses of the COVID-19 vaccine were defined as vaccinated, and their index date was the

102   date of their second vaccination, prior to September 30, 2021. In contrast, the index date for

103   unvaccinated individuals was September 30, 2021. Those who received only one dose of the

104   vaccine and those who started vaccination after September 30, 2021, were excluded from the

105   study. Diagnostic records for 365 d prior to the index date were reviewed, and individuals

106   with any target musculoskeletal disorders as a primary or secondary diagnosis were excluded.

107   If the target musculoskeletal disorder was the primary diagnosis on the day after the index

108   date, it was defined as an event (Figure 1).

109

110   *Data Collection*

111   We accessed the Korean NHIS data, which contains information on all medical claims,

112   including diagnoses. The NHIS data were generated by the accumulation of claims by

113   medical institutions under the Korean health insurance system.[11] Data collection was

114   approved by the NHIS and performed in accordance with the NHIS rules on data exploration

6

115   and utilization.

116   Information on the demographic characteristics of the selected study population, such as age

117   and sex, vaccination status and type, primary and secondary diagnoses from 2020 to 2021,

118   were collected along with dates of hospital visits, underlying disease, and history of COVID-

119   19. Age, sex, insurance level, Charlson comorbidity index (CCI), presence of diabetes,

120   hypertension, hyperlipidemia, and chronic obstructive pulmonary disease (COPD), and

121   history of COVID-19 were retrieved as covariates for the analysis. Regarding vaccination

122   status, the participants were categorized as unvaccinated, messenger ribonucleic acid

123   (mRNA)-vaccinated, viral vector-vaccinated, or mixed and matched. The mRNA vaccines

124   were the Pfizer-BioNTech (BNT162b2) and Moderna (mRNA-1273) vaccines, while the viral

125   vector vaccines were the Oxford-AstraZeneca (ChAdOx1 nCoV-19) and Johnson & Johnson

126   (Ad26.COV2-S) vaccines. Mixing and matching vaccination was defined as the vaccination

127   method that used heterologous vaccines in the first and second doses.[12] The insurance level

128   was classified as low, middle, and high based on the insurance premiums (medical benefit

129   recipients and grades 1–6 are low, grades 7–13 are middle, and grades 14–20 are high). The

130   CCI, which predicts the 10-year mortality of an individual with a range of comorbid

131   conditions, was calculated based on a previous study by Sundararajan et al.[13,14] The presence

132   of diabetes, hypertension, hyperlipidemia, and COPD was defined as being registered as a

133   primary or secondary diagnosis more than twice in the year prior to the index date. A history

134   of COVID-19 infection was defined as the presence of the International Classification of

135   Diseases 10th Revision (ICD-10) code U07.1, in either primary or secondary diagnoses

136   before the index date.

137   The target musculoskeletal disorders that were selected to investigate their association with

138 COVID-19 vaccination were musculoskeletal pathological conditions that could be induced,

139 mediated, or aggravated by an inflammatory response. The selection of target

140 musculoskeletal disorders was made through consensus among the authors based on previous

141 studies, and the ICD-10 codes for search were as follows: plantar fasciitis (M72.2),[15] rotator

142 cuff syndrome (M75.1),[16,17] adhesive capsulitis (M75.0),[18-20] herniated intervertebral disc

143 (HIVD) (M50.2/M51.2),[21-23] spondylosis (M47.9),[24,25] bursitis (M71.9),[26] Achilles tendinitis

144 (M76.6),[27,28] and de-Quervain tenosynovitis (M65.4).[29,30]

145

146 *Ethical Approval*

147 This study was approved by the local ethics committee and conducted in accordance with the

148 ethical standards of the Declaration of Helsinki.[31] The requirement for written informed

149 consent was waived owing to the retrospective nature of the study.

150

151 *Statistical Analysis*

152 The Student's t-test was used to compare continuous variables, and the chi-square test or

153 Fisher's exact test was used to compare categorical variables. Incidence rates were calculated

154 as rates per 100,000 individuals. With demographic characteristics of the study population,

155 including the kind of vaccine received, multivariate logistic regression analysis was

156 performed to determine the risk factors of inflammatory musculoskeletal disorders after

157 adjusting for potential confounders. Associations between these factors and musculoskeletal

158 disorders are summarized as odds ratios (ORs) and 95% confidence intervals (CIs). Statistical

159 significance was set at $p < 0.05$. The SAS Enterprise Guide (SAS Institute, Cary, NC, USA)

160   was used for all statistical analyses and data curation.

161

162   **Results**

163   Among the 2,218,715 individuals in the dataset, 1,882,640 (84.9%) received two doses of the

164   COVID-19 vaccine, while 336,075 (15.1%) did not. The vaccinated group was older,

165   predominantly female, had a higher insurance level, and had more comorbidities compared

166   with the unvaccinated group (Table 1). Within the vaccinated group, the average time interval

167   between the two vaccinations was 50.5 d. For each dose, 1,100,243 (58.4%) individuals

168   received an mRNA vaccine, 656,184 (34.9%) received a viral vector vaccine, and 126,213

169   (6.7%) received a mixing and matching vaccine (Table 2).

170   The incidence of plantar fasciitis, rotator cuff syndrome, adhesive capsulitis, HIVD, and

171   spondylosis was consistently higher in all three vaccination groups (mRNA, cDNA, and

172   mixing and matching vaccines) than in the unvaccinated group. This disparity was evident at

173   2, 4, and 12 weeks after vaccination, with differences in incidence increasing over time

174   (Figures 1-A, 1-B, 1-C, 1-D, and 1-E). For bursitis and Achilles tendinitis, no significant

175   differences in incidence were observed between the three vaccinated groups and the

176   unvaccinated group after 1 and 2 weeks of vaccination. However, at 4 and 12 weeks after

177   vaccination, the incidences of bursitis and Achilles tendinitis were higher in the three

178   vaccinated groups than in the unvaccinated group (Figures 1-F and 1-G). Up to 4 weeks after

179   vaccination, no significant differences in the incidence of de Quervain tenosynovitis were

180   observed; however, at 12 weeks after vaccination, the vaccinated group exhibited a

181   significantly higher incidence than that of the unvaccinated group (Figure 1-H).

182   Multivariate logistic regression analysis showed that 6 weeks after vaccination, the mRNA

183   vaccine, viral vector, and mixing and matching vaccines were significant factors for each

184   musculoskeletal disorder, except for bursitis and de-Quervain tenosynovitis. Over a 12-week

185   period, all vaccines showed statistical significance in relation to each musculoskeletal

186   disorder, except for the mixing and matching vaccines for de-Quervain tenosynovitis (Table

187   3). In addition, female individuals and older individuals were vulnerable to musculoskeletal

188   disorders other than bursitis and Achilles tendinitis after COVID-19 vaccination (Supplement

189   1).

190

191   **Discussion**

192   In this nationwide population-based study, the incidence rates of inflammatory

193   musculoskeletal disorders in terms of adverse reactions after COVID-19 vaccination in Korea

194   were investigated. We found that initially after vaccination, the incidences of plantar fasciitis,

195   rotator cuff syndrome, adhesive capsulitis, HIVD, and spondylosis, which are inflammation-

196   related disorders involving tendons and connective tissues, were higher in the vaccinated

197   group than in the unvaccinated group, regardless of the type of vaccine received. At 12 weeks

198   after vaccination, all inflammatory musculoskeletal disorders investigated, including bursitis,

199   Achilles tendinitis, and de Quervain tenosynovitis, showed a higher incidence in the

200   vaccinated group than in the unvaccinated group. These findings provide detailed information

201   on the adverse reactions after COVID-19 vaccination, especially in terms of inflammation-

202   related musculoskeletal disorders. We believe that this information will be beneficial for

203   establishing the predictability of adverse reactions and enhancing public understanding of

204   COVID-19 vaccination.

205   Inflammatory musculoskeletal manifestations after COVID-19 vaccination have been

206   repeatedly reported in case reports and small cohort studies.[32] In one of the largest case

207   studies conducted, Ursini et al. concluded that inflammatory musculoskeletal disorders may

208   occasionally develop in close temporal association with COVID-19 vaccination.[33] Along with

209   these previous studies, our study highlights the development of inflammatory

210   musculoskeletal disorders after COVID-19 vaccination. However, an association between

211   COVID-19 vaccines and inflammatory musculoskeletal disorders is yet to be established.

212   According to the hypothetical mechanisms of autoimmune phenomena after COVID-19

213   vaccination, either adjuvants or the vaccine itself may induce an overactive immune reaction,

214   autoimmune consequences, or even inflammation in susceptible individuals.[34] As a form of

215   molecular mimicry, a hypothesis states that overwhelming systemic or local inflammation is

216   activated by the cross-reaction of the immune response between antigens in vaccines and

217   molecular structures *in vivo*.[35] The series of inflammatory musculoskeletal disorders that

218   showed a strong correlation with COVID-19 vaccinations in this study are expected to be

219   included in the list of adverse reactions to COVID-19 vaccines. Therefore, future studies are

220   needed to identify the mechanisms that link COVID-19 vaccines to inflammatory

221   musculoskeletal disorders and prevent or mitigate these adverse reactions.

222   Regarding the inflammatory musculoskeletal disorders investigated in this study, the

223   incidence rates of shoulder-related disorders, such as rotator cuff syndrome and adhesive

224   capsulitis, were notably higher than those of other disorders—nearly doubling the rate of

225   other disorders. We believe that shoulder injury related to vaccine administration (SIRVA),[36]

226   which has already been reported for existing vaccines, may have contributed to the high

227   incidence rates observed. SIRVA is thought to occur by provoking an inflammatory reaction

228   when vaccines are injected through the deltoid into underlying non-muscular tissues.[37]

229   Subsequent prolonged inflammatory responses after SIRVA could progress to bursitis,

230   tendinitis, and capsulitis around the shoulder joint.[38] The findings of this study indicate that

231   the COVID-19 vaccine is not exempt from SIRVA. Therefore, as with other vaccination

232   procedures, we emphasize increased attention to the injection site during the administration

233   of the COVID-19 vaccine.

234   Previous studies on adverse reactions to the COVID-19 vaccine showed that most systemic

235   adverse reactions were more frequent in female individuals than in male individuals and in

236   younger age groups than in older age groups.[6,7] In our study, the incidence rates of

237   inflammatory musculoskeletal disorders, regarded as adverse effects, were higher in females,

238   which is consistent with the reports of previous studies. However, in terms of age, older

239   individuals had a higher incidence of inflammatory musculoskeletal disorders compared to

240   younger individuals. Two possible explanations exist for the inconsistency between our age-

241   specific findings and those of previous reports. First, older individuals exhibit a reduced

242   capacity to mount an effective response to vaccines as well as a lower frequency of

243   neutralizing antibodies compared to younger populations.[39,40] Moreover, older patients may

244   be more prone to progressing from mild adverse reactions to inflammation-related

245   musculoskeletal disorders compared to their younger counterparts. Similarly, although the

246   overall incidence of adverse reactions after COVID-19 vaccination was higher in the younger

247   age group, the incidence of severe adverse reactions was reported to be higher in the older

248   age group.[41] Second, as with other adverse reactions, inflammatory musculoskeletal disorders

249   occurred more frequently in the younger than in the older age group; however, in the dataset,

250   diagnosis and insurance claims appeared to occur more frequently in older individuals

251   because younger patients visited medical institutions less often. Irrespective of which of these

252   two possibilities is true, we maintain that the need for attention after vaccination in older

253   individuals remains unchanged.

254

255   *Strengths and Limitations*

256   The strength of our study is underscored by its substantial sample size, which comprises data

257   from over 2 million individuals randomly selected from the Korean NHIS. This

258   comprehensive database, which encompasses medical services for 97% of the population,

259   enhances the reliability and representativeness of our findings.[10] Such large population-based

260   databases, which are available only in Taiwan, Sweden, and Korea, are excellent resources

261   for answering questions that are difficult to address using single-institution or small-scale

262   studies.[42]

263   Our study also has several limitations. First, because the target musculoskeletal disorders

264   were identified by ICD-10 codes in the claims database, coding, mismatching, or

265   misclassification errors could have occurred. Discrepancies might have occurred between the

266   actual disease and the diagnosis claimed by the healthcare provider, and over- or

267   underdiagnosis may occur. Second, our study could not confirm the pathophysiological

268   mechanism of the change in the incidence of musculoskeletal disorders after COVID-19

269   vaccination because it relied only on diagnoses claimed by healthcare providers. As COVID-

270   19 vaccines are frequently accompanied by arthralgia and myalgia,[6,7] whether these adverse

271   reactions were misdiagnosed as inflammation-mediated musculoskeletal disorders or whether

272   the pain was caused by an actual inflammatory disorder is unknown. Further studies

273   involving laboratory data and inflammatory biomarkers are required to address these

274   limitations.

275

276   **Conclusions**

277   Individuals who received COVID-19 vaccines, either mRNA, viral vector, or mixing and

278   matching, were found to be more likely to be diagnosed with inflammatory musculoskeletal

279   disorders compared to those who did not. Our results provide detailed information on the

280   adverse reactions after COVID-19 vaccination, with a particular focus on inflammatory

281   musculoskeletal disorders. This information will be useful in clarifying adverse reactions to

282   COVID-19 vaccines and educating people about the potential risk of inflammatory

283   musculoskeletal disorders based on their vaccination status.

284

285   **Acknowledgment:** None

286   **Conflict of Interest Disclosures:** None

287   **Funding/Support:** None

288   **Data availability:** See Appendix 1.

289

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405 **Table 1.** Demographic characteristics of the study population

	Total	Vaccinated	Unvaccinated	p value
Sex				
Male	1,017,422 (45.9)	862,251 (45.8)	155,171 (46.2)	<0.001
Female	1,201,293 (54.1)	1,020,389 (54.2)	180,904 (53.8)	
Age				
Mean ± SD, years	54.1 ± 17.3	45.3 ± 17.2	55.7 ± 16.8	<0.001
20–29	264,779 (11.9)	201,896 (10.7)	62,883 (18.7)	<0.001
30–39	241,993 (10.9)	155,240 (8.3)	86,752 (25.8)	
40–49	282,150 (12.7)	211,572 (11.2)	70,578 (21.0)	
50–59	508,893 (22.9)	461,880 (24.5)	47,016 (14.0)	
60–39	502,417 (22.7)	468,525 (24.9)	33,892 (10.1)	
70–79	276,783 (12.5)	259,784 (13.8)	16,999 (5.1)	
≥80	141,700 (6.4)	123,743 (6.6)	17,957 (5.3)	
Insurance level				
Low	570,560 (25.7)	472,383 (25.1)	98,177 (29.2)	<0.001
Middle	611733 (27.6)	506,536 (26.9)	105,197 (31.3)	
High	1,036,422 (46.7)	903,721 (48.0)	132,701 (39.5)	
Comorbidity				

Diabetes mellitus	351,517 (15.8)	329,043 (17.5)	22,474 (6.7)	<0.001
Hyperlipidemia	708,007 (31.9)	666,137 (35.4)	41,870 (12.5)	<0.001
Hypertension	624,705 (28.2)	587,304 (31.2)	37,398 (11.1)	<0.001
COPD	93,785 (4.2)	85,634 (4.6)	8,151 (2.4)	<0.001
COVID-19 history	18,411 (0.8)	14,511 (0.8)	3,900 (1.2)	<0.001
CCI				
0	1,473,982 (66.4)	1,194,333 (63.4)	279,649 (83.2)	<0.001
1	372,684 (16.8)	346,869 (18.4)	25,815 (7.7)	
≥2	372,049 (16.8)	341,438 (18.2)	30,611 (9.1)	

406   Data are n (%), unless otherwise indicated.

407   SD, standard deviation; COPD, Chronic obstructive pulmonary disease; CCI, Charlson Comorbidity Index.

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413   **Table 2.** Summary of the first and second doses of the COVID-19 vaccines received

First dose	Second dose	Number (%)
Pfizer-BioNTech[a]	Pfizer-BioNTech	1,072,100 (56.9)
	Moderna	21 (0.0)
	Oxford-AstraZeneca	4 (0.0)
	Johnson & Johnson	2 (0.0)
Oxford-AstraZeneca[b]	Oxford-AstraZeneca	656,184 (34.8)
	Pfizer-BioNTech	126,196 (6.7)
	Johnson & Johnson	6 (0.0)
	Moderna	2 (0.0)
Moderna[a]	Moderna	28,110 (1.5)
	Pfizer-BioNTech	5 (0.0)
Johnson & Johnson[b]	Oxford-AstraZeneca	5 (0.0)
	Pfizer-BioNTech	5 (0.0)

414   [a] mRNA vaccine

415   [b] Viral vector vaccine

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424 **Table 3.** Results of multivariate logistic regression model to assess the risk of musculoskeletal disorders after COVID-19 vaccination.

		1 week			2 weeks			4 weeks			12 weeks		
	Variable	OR	95% CI	p value	OR	95% CI	p value	OR	95% CI	p value	OR	95% CI	p value
Plantar fasciitis	Unvaccinated [a]												
	mRNA vaccine	2.706	1.447-5.057	0.002	1.899	1.305-2.762	0.001	3.105	2.312-4.170	<0.001	2.957	2.493-3.507	<0.001
	Viral vector vaccine	4.261	2.231-8.137	<0.001	2.770	1.872-4.101	<0.001	3.642	2.675-4.958	<0.001	3.486	2.918-4.166	<0.001
	Mixing and matching	3.886	1.819-8.302	<0.001	2.871	1.787-4.611	<0.001	3.975	2.777-5.690	<0.001	3.730	3.023-4.602	<0.001
Rotator cuff syndrome	Unvaccinated [a]												
	mRNA vaccine	3.239	1.873-5.599	<0.001	3.210	2.222-4.637	<0.001	2.817	2.253-3.522	<0.001	2.732	2.420-3.084	<0.001
	Viral vector vaccine	4.459	2.560-7.767	<0.001	4.583	3.158-6.650	<0.001	3.564	2.840-4.473	<0.001	3.290	2.907-3.724	<0.001
	Mixing and matching	5.457	2.890-10.30	<0.001	5.137	3.338-7.903	<0.001	3.958	3.009-5.207	<0.001	3.469	2.978-4.040	<0.001
Adhesive capsulitis	Unvaccinated [a]												
	mRNA vaccine	1.913	1.276-2.868	0.002	2.301	1.710-3.096	<0.001	2.527	2.076-3.075	<0.001	2.550	2.284-2.847	<0.001
	Viral vector vaccine	2.313	1.530-3.496	<0.001	3.012	2.231-4.065	<0.001	2.958	2.422-3.611	<0.001	2.905	2.596-3.251	<0.001
	Mixing and matching	2.197	1.249-3.866	0.006	3.160	2.154-4.636	<0.001	2.894	2.234-3.749	<0.001	2.768	2.390-3.205	<0.001
HIVD	Unvaccinated [a]												
	mRNA vaccine	2.001	1.248-3.211	0.004	1.720	1.239-2.390	0.001	1.813	1.437-2.288	<0.001	1.971	1.730-2.246	<0.001
	Viral vector vaccine	2.138	1.295-3.529	0.003	2.043	1.448-2.880	<0.001	2.200	1.726-2.805	<0.001	2.257	1.969-2.587	<0.001
	Mixing and matching	1.786	0.902-3.540	0.096	2.103	1.342-3.296	0.001	2.327	1.707-3.172	<0.001	2.141	1.789-2.561	<0.001
Spondylosis	Unvaccinated [a]												
	mRNA vaccine	1.242	0.797-1.937	0.339	1.811	1.274-2.575	0.001	1.844	1.453-2.341	<0.001	2.232	1.926-2.586	<0.001
	Viral vector vaccine	1.405	0.889-2.222	0.145	1.829	1.273-2.628	0.001	1.777	1.390-2.273	<0.001	2.226	1.914-2.589	<0.001
	Mixing and matching	1.491	0.757-2.936	0.249	2.036	1.234-3.359	0.005	2.078	1.479-2.918	<0.001	2.345	1.912-2.877	<0.001
Bursitis	Unvaccinated [a]												
	mRNA vaccine	1.199	0.400-3.593	0.746	2.150	0.843-5.478	0.109	1.831	1.039-3.226	0.036	2.097	1.496-2.939	<0.001
	Viral vector vaccine	0.470	0.127-1.739	0.258	1.481	0.545-4.023	0.441	1.372	0.744-2.531	0.311	2.269	1.587-3.243	<0.001
	Mixing and matching	0.654	0.072-5.891	0.705	0.967	0.187-4.999	0.968	1.266	0.510-3.142	0.611	2.700	1.740-4.189	<0.001
Achilles tendinitis	Unvaccinated [a]												

		OR	CI	p	OR	CI	p	OR	CI	p	OR	CI	p
	mRNA vaccine	1.586	0.654-3.843	0.308	1.581	0.866-2.886	0.136	2.500	1.546-4.044	<0.001	2.716	2.082-3.542	<0.001
	Viral vector vaccine	2.194	0.838-5.745	0.109	2.364	1.220-4.581	0.011	2.818	1.663-4.776	<0.001	3.404	2.536-4.570	<0.001
	Mixing and matching	3.572	1.236-10.32	0.019	2.467	1.123-5.419	0.025	3.188	1.734-5.863	<0.001	3.096	2.195-4.368	<0.001
de-Quervain tenosynovitis	Unvaccinated [a]												
	mRNA vaccine	0.781	0.415-1.469	0.443	1.074	0.663-1.738	0.772	1.537	1.070-2.208	0.020	1.404	1.141-1.728	0.001
	Viral vector vaccine	0.817	0.366-1.819	0.620	1.133	0.639-2.009	0.668	1.846	1.221-2.791	0.004	1.627	1.284-2.060	<0.001
	Mixing and matching	0.950	0.341-2.648	0.921	1.183	0.559-2.503	0.661	1.597	0.938-2.718	0.085	1.350	0.982-1.855	0.064

OR, Odds ratio; CI, confidence interval; HIVD, herniated intervertebral disc.

[a] Unvaccinated group was used for the reference value.

433   **Figures**

434   **Figure 1.** Flowchart of the study populations

435   Inflammatory musculoskeletal disorders include plantar fasciitis, rotator cuff syndrome,

436   adhesive capsulitis, herniated intervertebral disc, spondylosis, bursitis, Achilles tendinitis, and

437   de-Quervain tenosynovitis. NHIS, Korean National Health Insurance Service.
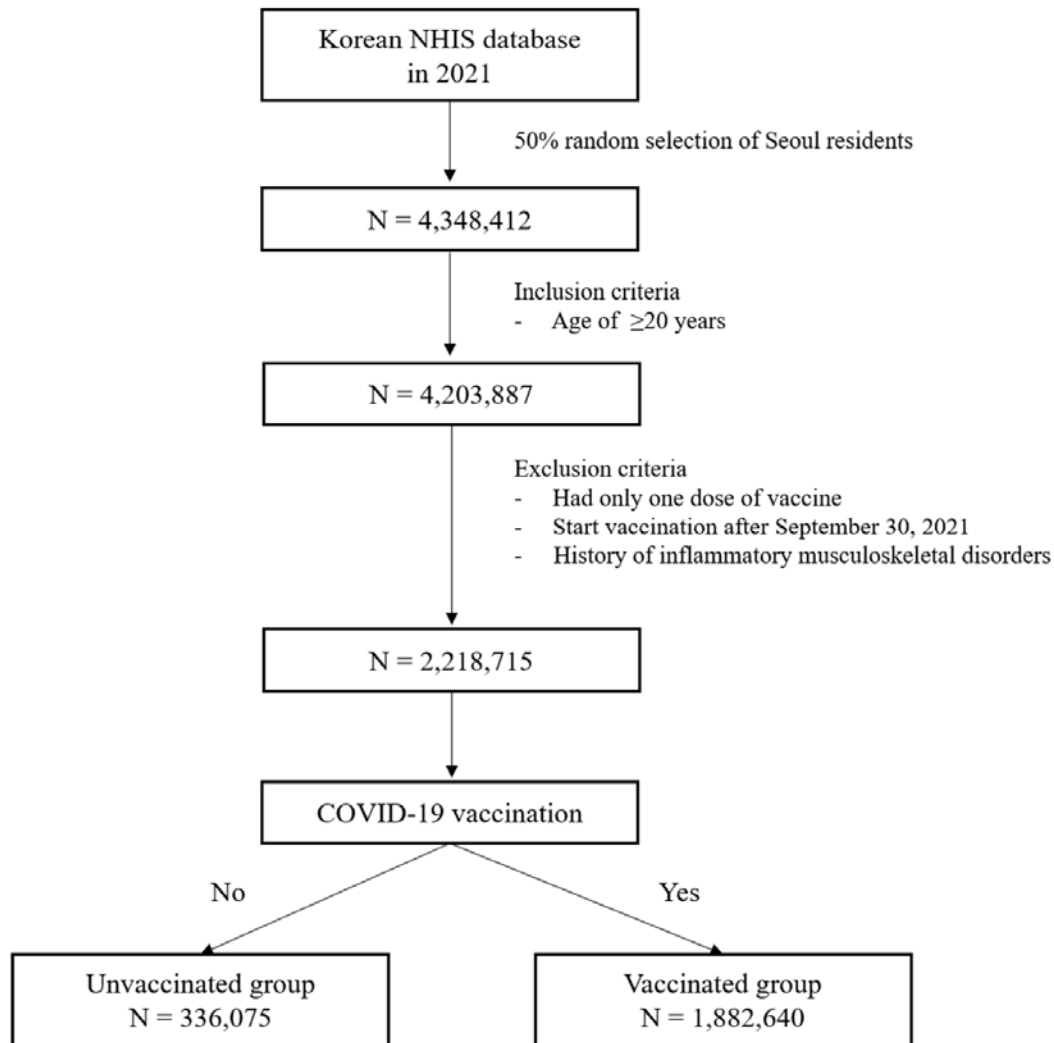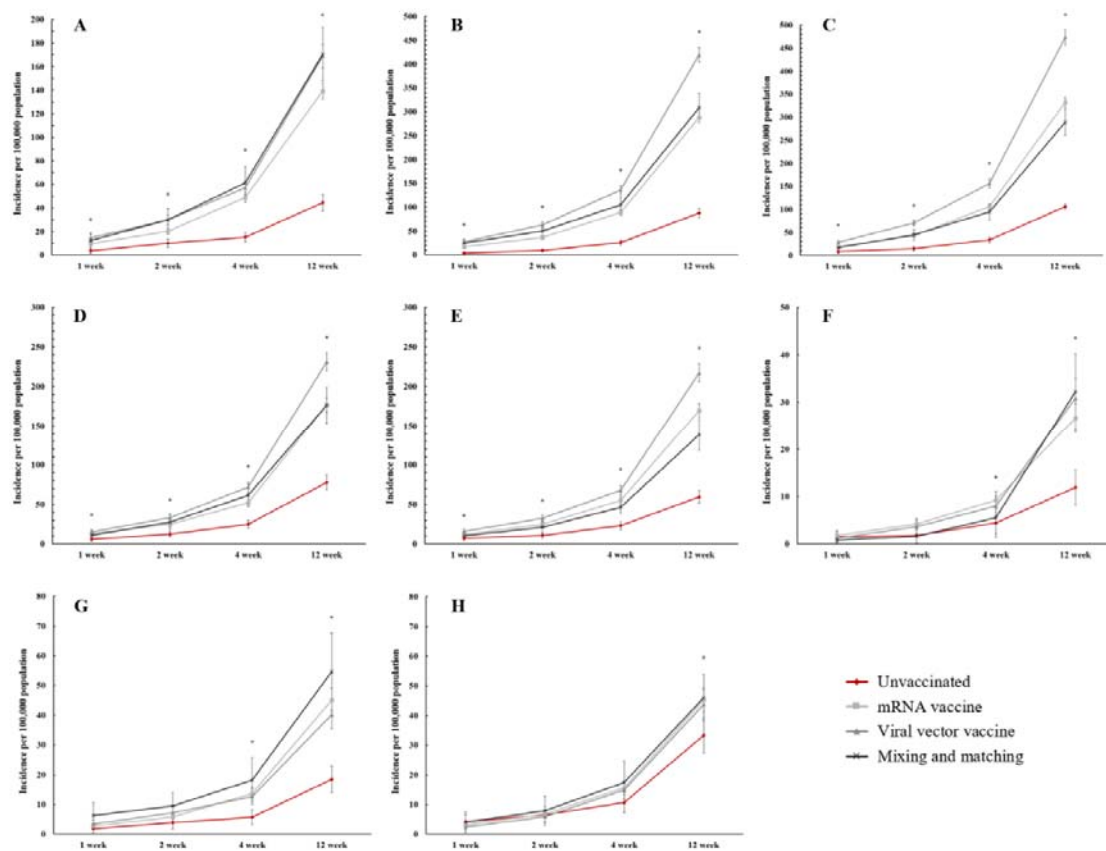

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440   **Figure 2.** Incidence of inflammatory musculoskeletal disorders over time after COVID-19

441   vaccination

442   (A) plantar fasciitis; (B) rotator cuff syndrome; (C) adhesive capsulitis; (D) herniated

443   intervertebral disc; (E) spondylosis; (F) bursitis; (G) Achilles tendinitis; and (H) de-Quervain

444   tenosynovitis. Asterisks indicate that all three vaccinated groups are significantly higher than

445   the unvaccinated group.

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