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Assessment of risk factors in post- COVID-19 patients and its associated musculoskeletal manifestations: A cross-sectional study in India

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ABSTRACT

Introduction: Musculoskeletal manifestations of COVID-19, post COVID-19, and post COVID-19 vaccination include arthralgia, myalgia, new-onset backache, fatigue, inflammatory arthritis either symmetrical or polyarticular, reactive arthritis, osteoporosis, osteonecrosis of the femoral head, neuropathies, myositis, and myopathies. Almost 15% and 44% of post-COVID-19 patients reported arthralgia and myalgia. We aim to analyze the musculoskeletal manifestations of COVID-19 infection and the factors determining their severity.

Methodology: This is a retrospective multicentric cross-sectional study conducted from all the four regions (northern, southern, eastern, and western regions) in India. The recruitment period was from June 1st, 2021, to September 30th, 2021. All patients with COVID-19 positivity in the past were classified into three groups (mild, moderate, and severe). The primary outcome is to find the correlation of musculoskeletal symptoms with disease positivity, severity, and demographic variables. We focused at clinical characteristics and symptoms at the time of admission, as well as comorbidities, laboratory findings, immunological findings, treatments, and outcomes.

Results: The study was conducted among 2334 subjects across all the regions of India. Out of which 719 were COVID-19 positive individuals. Non-vaccinated were about 62.6% compared to 37.4% vaccinated among COVID-19 positive individuals. The total average musculoskeletal scores calculated were about 15.94 ± 54.86. MSK scores were significantly higher ($p < 0.001$) among males, uneducated, those with co-morbidities, and non-vaccinated individuals. Multivariate regression analysis showed a 1.63 times higher risk of having COVID-19 infection among smokers, those who don't exercise regularly are 1.25 times at risk of having COVID-19 infection. Similarly, those who have comorbidities are 1.93 times at risk of having COVID-19 infection. Non-vaccinated individuals were 2.33 times at risk of having COVID-19 infection.

Conclusion: Factors such as male sex, non-vaccination, and associated co-morbidities increased the risk of developing severe MSK manifestations upon infection with COVID-19 and needs extended monitoring to control the morbidity due to the same.

1. Introduction

Coronavirus disease 2019 (COVID-19) pandemic created huge havoc among global health care practitioners in terms of identification of primary disease symptomatology, signs, diagnosis, and management.[1] The consequences of the COVID-19 disease and the vaccination poses a major challenge to treat the disease manifestations.[2,3] Epidemiological data from the SARS pandemic have paved the way to identify the disease symptomatology such as muscle soreness, arthralgia, myalgia, myopathies, osteoporosis, osteonecrosis and thereby plan a line of

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management.[4,5] World Health Organization (WHO) had declared the emergency usage of COVID-19 vaccines to combat the spread of COVID-19 infection worldwide. The vaccine acceptance rate in India is about 74%.[6]

The SARS-CoV-2-caused COVID-19 pandemic added mortality and morbidity in the adult population around the world, affecting all aspects of daily life.[6] Despite the fact that COVID-19 is classified as a respiratory disease, numerous studies have documented the disease's extra-pulmonary manifestations, making it a widespread public health concern.[7] COVID-19 has a 30% prevalence of symptoms related to the musculoskeletal system (MSK).[7–9] MSK manifestations of COVID-19, post COVID-19, and post COVID-19 vaccination are arthralgia,[10] myalgia,[10] new-onset backache,[10] fatigue,[10] inflammatory arthritis either symmetrical or polyarticular,[11] reactive arthritis,[12] osteoporosis,[13] osteonecrosis of femoral head,[14] neuropathies,[15] myositis,[16] and myopathies.[17] Almost 15% and 44% of post-COVID-19 patients reported arthralgia and myalgia.[8,11]

Since COVID-19 emerged as a systemic disease, it is mandatory to understand the pathophysiology of MSK manifestations. Various published literature stated the interconnections between inflammatory viral diseases and MSK manifestations. COVID-19-related arthritis is due to immune complex deposition as seen in hepatitis and parvovirus B19 infections.[18] The proinflammatory cytokines such as INF-γ, IL-1b, −6, −17, and TNF-α induce myofibril proteolysis, reduced protein synthesis, and myofibrosis.[19,20] Satellite cells in muscles proliferate and differentiate into matured myocytes by blocking all proinflammatory molecules released in cytokine storm.[21] Osteoclastogenesis is induced by CXCL10, IL-17, and TNF- in bones and joints, which results in a decrease in bone mineral density. Chondrolysis and arthralgias and osteoarthritis are caused by IL-1b & −6 and TNF-, which are released into the body in large amounts.[22]

2. Need for study

COVID-19 was found to have a greater impact on people over the age of 55, according to the evidence. COVID-19 had a significant impact on people with pre-existing conditions like diabetes, hypertension, ischemic heart disease, and chronic obstructive pulmonary disease. According to the researcher's best knowledge, no other studies in India have attempted to identify post-COVID survivors with musculoskeletal symptoms and their associated factors. Hence, in this study we aim to analyze the musculoskeletal manifestations of post COVID-19 infection and the risk factors determining their severity.

3. Materials and methods

After obtaining institute ethical clearance, patients were recruited for this retrospective multicentric cross-sectional study from all the four regions (northern region, southern region, eastern region and western region) in India from June 1st, 2021, to September 30th, 2021 including 8 tertiary COVID care centres. COVID-19 diagnosis criteria from the fifth edition of the National Health Commission of China's Guidelines on the Diagnosis and Treatment of COVID-19 were applied to all patients enrolled in this study.The Institutional Ethics Committee, approval was obtained, and informed consent was received from all the participants. The participants were told the purpose of the study, the length of time of the survey and where the data will be stored, and for how long.

COVID-19 Clinical Classification: According to the clinical guidelines for the management of adult COVID-19 according to the Ministry of Health and Family Welfare, Government of India[23]; the severity was classified as follows in Table 1.

In this study, we classified our subjects with past COVID-19 into three groups (mild, moderate, and severe) based on clinical information collected until September 30, 2021.

Data Collection: A predesigned pre-tested validated semi-structured questionnaire was framed including their demographic characteristics, clinical features, laboratory parameters, outcome severity, and musculoskeletal score. Four-page Google form questionnaire created and distributed via social media platforms such as WhatsApp, Facebook, various social platforms where doctors are involved, e-mails, etc. Participants gave their consent to participate in the study before beginning it, and they had the option to withdraw at any time during the process if they so desired. Participants' privacy was protected at all times, and no identifying information was collected, including their names, addresses, or phone numbers. Around 2334 respondents were identified through convinient sampling technique in six months duration by unique IP address to avoid potential duplicate entries from the same user. All those who were willing to participate were included. Those who were presently Covid-19 positive, prexisting arthraligia, muskulosketal disorders, and age below 20 years and over 70 years were excluded. Clinical data collection was completed on September 30, 2021. Doctors and family members were consulted for additional information.

Table 1
Grading of COVID-19 infection.

Grading of COVID-19 infection	Significance
Mild	Upper respiratory tract symptoms (&/or fever) WITHOUT shortness of breath or hypoxia
Moderate	The disease is classified as severe if one of the following conditions is met: • Respiratory rate ≥24/min, breathlessness • SpO2: 90% to < 93% on room air
Severe	The disease is classified as severe if one of the following conditions is met: • Respiratory rate ≥30/min, breathlessness • SpO2 < 90% on room air

Measurements and Outcomes: Finding the link between musculoskeletal score and disease positivity, severity, and demographic variables is the primary goal of this study. The data included information on the patient's clinical characteristics and symptoms at the time of admission, as well as comorbidities, laboratory results, immunological findings, treatments, and outcomes.

MSK Scoring: A musculoskeletal scoring questionnaire was developed having about eleven questions based on the fatigue assessment scoring for COVID-19 infected individuals by M Cella et al.[24] (Supplementary File 1). (Tiredness, the need to rest, feeling sleepy or drowsy, difficulties starting things, a lack of energy, less muscle strength, feeling weak, difficulties concentrating, slips of the tongue while speaking, difficulty finding the right word, and difficulty remembering things). Each question had three options; no more than usual scores as 1, more than usual as 2, and much more than usual as 3. A total score is about 33 with a minimum score of 11 and a maximum score of 33. The reliability of the questionnaire was tested using Cronbach's alpha which was 0.89 and the intraclass correlation coefficient was 0.91; 95% CI (0.90, 0.95) ($p < 0.001$). The test-retest reliability was assessed showing $r = 0.91$ (Pearson correlation coefficient). The content validity was evaluated with the help of a team of expert specialists.

Statistical Analysis: Statistical software used to analyze data were MS Excel, and SPSS for Windows Inc. Version 25. Chicago, Illinois. Mean and standard deviation were used to describe continuous variables, and frequencies (percentages) were used to describe categorical variables. The chi-square test was used to compare proportions. For the purpose of determining the likelihood of disease positivity in the presence of demographic variables, we turned to multiple logistic regression. Statistical significance was defined as the p-value being less than 0.05 for each comparison.

4. Results

The study was conducted among 2334 subjects across all the regions

of India. Out of which 719 were COVID-19 positive individuals. A total of 2334 adults participated in this study. Majority of the study participants were in the age group 25–34yrs 38.6%, followed by 18–24yrs 36.8%, 35–44yrs 10.3%, 45–54yrs 7.1%, 55–64 4.6% and >65yrs 2.6%. There were about 52.9% males and 47.1% females. COVID-19 positivity rate was comparatively high among those whose education is about master's degree. This could be due to the developing urban population (Table 2).

Active smokers (10.4% vs 8.7%) and alcoholics (2.2% vs 1.6%) had a significantly high COVID-19 positivity rate compared to COVID-19 negative individuals. Those who did not exercise regularly (65.9% vs 34.1%) and with co-morbidities (76.8% vs 23.2%) were having a high positivity rate. History of surgical intervention for any bone, joint, muscle, soft tissue, or nerve-related conditions were having positivity rate of 89% vs 11% for those who do not have a history of surgical intervention. Multivariate regression analysis showed 1.63 times higher risk of developing COVID-19 than nonsmokers, those who don't exercise regularly are 1.25 times at risk of developing COVID-19 (Table 3). Similarly, those who have comorbidities are 1.93 times at risk of developing COVID-19 infection. Non-vaccinated were about 62.6% compared to 37.4% vaccinated among COVID-19 positive individuals (Table 2). Among them, non-vaccinated were 2.33 times at risk of developing COVID-19 infection compared to non-vaccinated individuals (Table 3).

Our study participants with COVID-19 positive (n = 719) were categorized into mild, moderate, and severe (Table 4). Males were significantly more among all categories of COVID-19 infection. This can be due to male preponderance in our study participants. Among education, those who have bachelor's and master's degrees were significantly more among mild, moderate, and severe COVID-19 infections than other educational statuses. Among substance use; active smokers and those who consume occasionally were having more COVID-19 infection; among them, many were having a moderate infection. Those who do not exercise regularly were having significantly more severe COVID-19 infections than others. History of surgical intervention for any bone, joint, muscle, soft tissue, or nerve-related conditions was having equal disease severity of 89.7% having a mild infection, 88.5% moderate, 82.9% severe infection. Among those who were vaccinated,

Table 2
Association of disease positivity with demographic variables (N = 2334).

Sl No	Variable	COVID-19 Positive (n = 719)	COVID-19 negative (n = 1615)	$X,^2$ (df), p
1	**Gender**			
	Male	397 (55.2)	836 (51.8)	2.779 (2)
	Female	323 (44.8)	778 (48.2)	0.249
2	**Education**			
	Bachelor's degree	365 (50.8)	834 (51.6)	17.452 (4)
	Doctorate	66 (9.2)	156 (9.7)	0.002
	High school graduate	59 (8.2)	211 (13.1)	
	Master's degree	213 (29.6)	382 (23.7)	
	None of the above	16 (2.2)	32 (2)	
3	**Smoking**			
	No history of smoking	560 (77.9)	1358 (84.1)	15.632 (3)
	Yes, passive smoker	41 (5.7)	61 (3.8)	0.001
	Yes, a regular active smoker	43 (6)	56 (3.5)	
	Yes, occasional active smoker	75 (10.4)	140 (8.7)	
4	**Alcohol**			
	No history of alcohol consumption	434 (60.4)	1079 (66.8)	9.313 (2)
	Yes, continue occasionally	269 (37.4)	510 (31.6)	0.009
	Yes, consume regularly	16 (2.2)	26 (1.6)	
5	**Exercise**			
	Yes	474 (65.9)	979 (60.6)	5.960 (1)
	No	245 (34.1)	636 (39.4)	0.01
6	**Co-morbidities**			
	Yes	552 (76.8)	1391 (86.1)	31.232 (1)
	No	167 (23.2)	224 (13.9)	<0.001
7	**Any history of surgical intervention for any bone, joint, muscle, soft tissue, or nerve-related conditions?**			
	Yes	640 (89)	1439 (89.1)	0.004 (1)
	No	79 (11)	176 (10.9)	0.949
8	**If so, how recently were u been operated**			
	<1 month ago	619 (86.1)	9 (0.6)	3.330 (4)
	>1 year ago	8 (1.1)	193 (12)	0.51
	1–6 months ago	81 (11.3)	10 (0.6)	
	6–12 months ago	7 (1)	7 (0.4)	
	Nil	4 (0.6)	1396 (86.4)	
9	**Vaccinated**			
	Yes	269 (37.4)	336 (20.8)	71.465 (1)
	No	450 (62.6)	1279 (79.2)	<0.001

Table 3
Multivariate regression analysis of disease positivity with demographic variables (N = 2334).

SlNo	Variable	COVID-19 Positive (n = 719)	COVID-19 negative (n = 1615)	OR	95% CI
1	**Education**				
	Bachelor's degree	365 (50.8)	834 (51.6)	0.87	0.47 to 1.62
	Doctorate	66 (9.2)	156 (9.7)	0.46	0.44 to 1.65
	High school graduate	59 (8.2)	211 (13.1)	0.56	0.28 to 1.08
	Master's degree	213 (29.6)	382 (23.7)	1.15	0.59 to 2.07
	None of the above	16 (2.2)	32 (2)	1	
2	**Smoking**				
	No history of smoking	560 (77.9)	1358 (84.1)	1	
	Yes, passive smoker	41 (5.7)	61 (3.8)	1.63	1.08 to 2.45
	Yes, a regular active smoker	43 (6)	56 (3.5)	0.43	0.05 to 3.28
	Yes, occasional active smoker	75 (10.4)	140 (8.7)	0.76	0.22 to 2.56
3	**Alcohol**				
	No history of alcohol consumption	434 (60.4)	1079 (66.8)	1	
	Yes, continue occasionally	269 (37.4)	510 (31.6)	0.654	0.34 to 1.23
	Yes, consume regularly	16 (2.2)	26 (1.6)	0.857	0.45 to 1.63
4	**Exercise**				
	Yes	474 (65.9)	979 (60.6)	1	
	No	245 (34.1)	636 (39.4)	1.25	1.03 to 1.52
5	**Co-morbidities**				
	Yes	552 (76.8)	1391 (86.1)	1.93	1.54 to 2.44
	No	167 (23.2)	224 (13.9)	1	
6	**Vaccinated**				
	Yes	269 (37.4)	336 (20.8)	1	
	No	450 (62.6)	1279 (79.2)	2.33	1.92 to 2.84

Table 4
Association of disease severity with demographic variables (N = 719).

SlNo	Variable	Mild (n = 475)	Moderate (n = 209)	Severe (n = 35)	X^2 (df), p
1	**Gender**				
	Male	253 (53.3)	119 (56.9)	25 (71.4)	4.703 (2)
	Female	222 (46.7)	90 (43.1)	10 (28.6)	0.09
2	**Education**				
	Bachelor's degree	269 (56.6)	82 (39.2)	14 (40)	
	Doctorate	51 (10.7)	12 (5.7)	3 (8.6)	60.755 (8)
	High school graduate	30 (6.3)	24 (11.5)	5 (14.3)	<0.001
	Master's degree	122 (25.7)	83 (39.7)	8 (22.9)	
	None of the above	3 (0.6)	8 (3.8)	5 (14.3)	
3	**Smoking**				
	No history of smoking	375 (78.9)	159 (76.1)	26 (74.3)	
	Yes, passive smoker	28 (5.9)	10 (4.8)	3 (8.6)	
	Yes, a regular active smoker	31 (6.5)	10 (4.8)	2 (5.7)	6.391 (6)
	Yes, occasional active smoker	41 (8.6)	30 (14.4)	4 (11.4)	0.38
4	**Alcohol**				
	No history of alcohol consumption	288 (60.6)	122 (58.4)	24 (68.6)	
	Yes, continue occasionally	179 (37.7)	80 (38.3)	10 (28.6)	3.190 (4)
	Yes, consume regularly	8 (1.7)	7 (3.3)	1 (2.9)	0.53
5	**Exercise**				
	Yes	156 (32.8)	80 (38.3)	9 (25.7)	3.054 (2)
	No	319 (67.2)	129 (61.7)	26 (74.3)	0.22
6	**Co-morbidities**				
	Yes	87 (18.3)	61 (29.2)	19 (54.3)	29.522 (2)
	No	388 (81.7)	148 (70.8)	16 (45.7)	<0.001
7	**Any history of surgical intervention for any bone, joint, muscle, soft tissue, or nerve-related conditions?**				
	No	49 (10.3)	24 (11.5)	6 (17.1)	1.628 (2)
	Yes	426 (89.7)	185 (88.5)	29 (82.9)	0.443
8	**If so, how recently were u been operated**				
	<1 month ago	4 (0.8)	2 (1)	26 (74.3)	35.354 (8)
	>1 year ago	53 (11.2)	25 (12)	2 (5.7)	<0.001
	1–6 months ago	4 (0.8)	0	3 (8.6)	
	6–12 months ago	3 (0.6)	0	3 (8.6)	
	Nil	411 (86.5)	182 (87.1)	26 (74.3)	
9	**Vaccinated**				
	Yes	309 (65.1)	126 (60.3)	15 (42.9)	7.524 (2)
	No	166 (34.9)	83 (39.7)	20 (57.1)	0.023

many were having a mild infection (see Fig. 1).

The musculoskeletal manifestations were significantly greater among non-vaccinated individuals (Fig. 2). The total average musculoskeletal scores calculated were about 15.94 ± 54.86. MSK scores were significantly higher among males, uneducated, those with co-morbidities, and non-vaccinated individuals (Table 5).

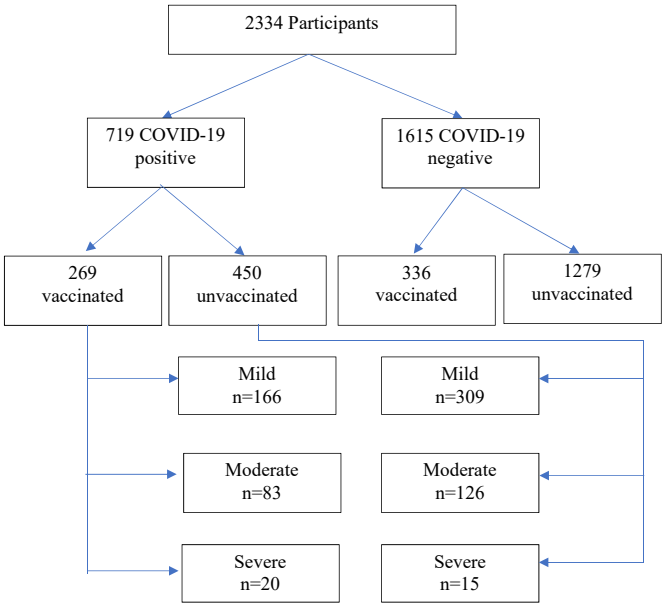

Fig. 1. Flowchart showing the study participants taken for analysis.

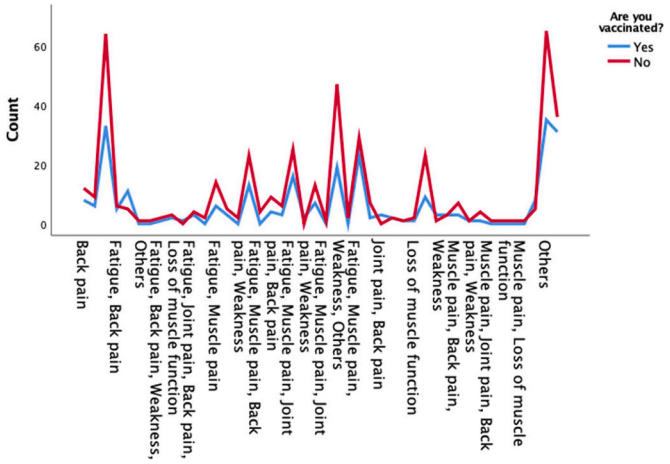

Fig. 2. Association of vaccination status with musculoskeletal manifestations during COVID-19 infection among study participants (n = 719).

5. Discussion

On March 11, 2020, WHO declared COVID-19 as a pandemic.[25] COVID-19 affection ranged from asymptomatic patients to severely ill acute respiratory distress syndrome (ARDS) and multiple organ dysfunction.[26] Though COVID-19 is a respiratory virus, it has affected almost all the systems in the body. The magnitude of COVID-19 viral replication correlates with plasma and upper respiratory secretion levels of interleukin-6 (IL-6) and tumor necrosis factor-α (TNF- α).[27] The pathophysiology of MSK affection by COVID-19 is still not properly understood. The affection of the MSK system by COVID-19 is due to indirect effects of cytokine storm, inflammatory cascade or immune reaction, and viral protein affection towards the bone, joints, and cartilage.[28] MSK manifestations are matched with pro-inflammatory mediators and markers such as ESR, CRP, procalcitonin, and IL-6.[29] Though the occurrence of MSK manifestations is not investigated, the involvement of bones, joints, and synovium during COVID-19 infections are evident.[30]

The molecular mimicry for the affection of COVID-19 and MSK systems has been identified with the bulk RNA sequencing libraries of

Table 5
Association of total MSK Score with demographic variables (N = 719).

Sl. No	Variable	COVID-19 Positive (n = 719)	p
1	**Gender**		
	Male	15.51 ± 4.75	0.008
	Female	16.47 ± 4.96	
2	**Education**		
	Bachelor's degree	15.94 ± 4.91	<0.001
	Doctorate	14.83 ± 4.25	
	High school graduate	17.20 ± 4.84	
	Master's degree	15.61 ± 4.82	
	None of the above	20.18 ± 4.21	
3	**Smoking**		
	No history of smoking	15.82 ± 4.85	0.520
	Yes, passive smoker	15.80 ± 4.38	
	Yes, a regular active smoker	16.53 ± 5.88	
	Yes, occasional active smoker	16.57 ± 4.74	
4	**Alcohol**		
	No history of alcohol consumption	16.01 ± 4.90	
	Yes, continue occasionally	15.70 ± 4.68	0.167
	Yes, consume regularly	15.94 ± 4.86	
5	**Exercise**		
	Yes	15.82 ± 4.92	0.651
	No	16.00 ± 4.84	
6	**Co-morbidities**		
	Yes	17.34 ± 5.40	<0.001
	No	15.52 ± 4.61	
7	**Any history of surgical intervention for any bone, joint, muscle, soft tissue, or nerve-related conditions?**		
	Yes	16.56 ± 5.38	
	No	15.86 ± 4.79	0.225
8	**If so, how recently were u been operated**		
	<1 month ago	15.12 ± 4.45	
	>1 year ago	16.19 ± .30	
	1–6 months ago	18.42 ± 7.69	0.637
	6–12 months ago	17.00 ± 6.92	
	Nil	15.88 ± 4.76	
9	**Vaccinated**		
	Yes	15.83 ± 5.04	<0.001
	No	17.13 ± 4.55	

homogenized bone tissues.[30] The distribution of ACE-2 and TMPRSS-2 receptors in the MSK domain were tabulated in Table 6. RNA sequencing identified the expression of ACE-2 receptor in bone tissues [cortical or trabecular] and osteoblast-rich samples whereas TMPRSS-2 receptor was expressed only in osteoblast-rich samples.[30] In tendons and ligaments both ACE-2 and TMPRSS-2 receptors were undetectable.[30] The above findings indicate that skeletal muscle tissues, synovium, and cortical bone tissues are the potential sites for the affection of SARS-CoV-2. Further molecular biology studies are needed to validate the presence or absence of viral proteins in cartilage, tendons, and ligaments.

Table 6
Distribution of COVID-19 receptors in the MSK domain.

MSK domain	COVID-19 receptors
Skeletal muscle tissue including endothelial cells, smooth muscle cells, muscle fiber, pericytes, satellite cells, B cells, T cells, and natural killer cells	TMPRSS-2
Smooth muscle cells and pericytes	ACE-2
Synovial tissues including fibroblasts and monocytes	TMPRSS-2 & ACE-2
Articular cartilage including proliferative, hypertrophic, and effector chondrocytes	ACE-2
Homeostatic chondrocytes	TMPRSS-2
Meniscus	ACE-2

5.1. COVID-19 vaccination

Globally, the COVID-19 vaccine acceptance rate was 90% in China, 55% in Russia, and 74% in India.[6,31] The vaccination drive in India created major havoc among the health care workers and the population in terms of vaccine illiteracy, vaccine availability, and social and psychological stigma on vaccine safety and efficacy. The vaccines were given to the "at-risk" population strategically. There was a huge number of COVID-19 positive cases before the vaccination drive in India. Higher COVID-19 infectivity prevailed in the community due to illiteracy and psychological stigma toward the vaccine. The involvement of various social activists to educate and inculcate the knowledge about the vaccine and its usage to reduce COVID-19 infection played a significant role in the global acceptance of the COVID-19 vaccination drive in the world. Hence the infectivity in the community dropped considerably and withstood delta and delta plus variants of the COVID-19 virus.

The severity of MSK manifestation before and after the COVID-19 vaccination demonstrated a significant variation due to the presence of protective antibodies against COVID-19 viral particles. We also noted the severity of the MSK manifestations in patients with COVID-19 post-vaccination to be mild. Moreover, we noted that non-vaccinated individuals were 2.33 times at risk of developing COVID-19 infection compared to non-vaccinated individuals. Hence, our data support the protective efficacy of COVID vaccination and the reduction of severity upon infection in the post-vaccination period.

5.2. Comorbid conditions

The severity of COVID-19 infection and the mortality of severely ill COVID-19 patients are high with the patients having co-morbid conditions like diabetes mellitus,[32] hypertension,[33] rheumatic diseases,[34] and cardiovascular diseases.[35] We were able to validate this from the analysis of data from our study. However, we did not find any statistical association with other variables analyzed such as smoking, alcohol, activity level of the individual, and history of previous surgery or hospitalization to have an impact on the severity of the MSK manifestations due to COVID-19 disease.

Our study has certain limitations. The retrospective cross-sectional nature of the study has its limitations such as recall, and selection bias. However, we were able to cross verify the severity of the disease with the laboratory parameters and obtain objective segregation of patients into the appropriate category of severity. We circulated the study questionnaire on all the commonly used social communication platforms to minimize selection bias. There could be a chance of variability in the severity of the disease due to the geographical distribution of the included patients and the strain of SARS-CoV-2 that is prevalent in their region. We recommend prospective studies of sufficient sample size to validate the results of our study and arrive at a more precise estimate of predicting the severity of the MSK manifestations due to the disease based on the patient characteristics to make a structured follow-up protocol for its effective management.

6. Conclusion

The musculoskeletal manifestations were significantly greater among non-vaccinated individuals. Similarly, a non-vaccinated male with co-morbidities is at increased risk of developing severe MSK manifestations upon infection and needs extended monitoring to control the morbidity due to the same. We recommend prospective studies of sufficient sample size to validate the results of our study and predict the severity of the MSK manifestations due to the disease based on the patient characteristics to make a structured follow-up protocol for its effective management.

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Author contributions

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Declaration of competing interest

Nil.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jor.2022.07.011.

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