

# Use of Electrocardiographic Screening to Clear Athletes for Return to Sports Following COVID-19 Infection

Jacob L. Erickson, DO; Joseph T. Poterucha, DO; Alecia Gende, DO; Mark McEleney, MD; Corey M. Wencil, LAT; Marisa Castaneda, MS, ATC; Lindsay Gran, CMA; Joel Luedke, ATC, LAT; Jill Collum, LAT; Karen M. Fischer, MPH; and Andrew R. Jagim, PhD

## Abstract

**Objective:** To quantify the occurrence rate of abnormal electrocardiographic (ECG) findings and symptoms following coronavirus disease 2019 (COVID-19) infection.

**Patients and Methods:** In this retrospective analysis, we studied adult patients (>18 years old) who were participating in collegiate athletics and previously tested positive for COVID-19 between August 1, 2020, and December 30, 2020. The athletes underwent general examinations and ECG screening prior to being medically cleared for a return to sports following their COVID-19 diagnosis. Predetermined predictors were grouped into categorical variables including (1) sex, (2) symptom severity, and (3) body mass index (normal vs overweight [ $\geq 24 \text{ kg/m}^2$ ]). These variables were used to examine differences of abnormal rates that occurred between different predictor categories.

**Results:** Of the 170 athletes screened, 6 (3.5%) presented with abnormal ECG findings and were referred to cardiologists. We found no evidence that sex, symptom severity, and body mass index category were associated with a higher rate of abnormal ECG findings (all  $P > .05$ ). Greater severity of COVID-19 symptoms was associated with a higher percentage of ST depression, T-wave inversion, ST-T changes, and the presence of fragmented QRS complex. Loss of smell, loss of taste, headache, and fatigue were the most prevalent symptoms, with 38.8% (66), 36.5% (62), 32.9% (56), and 25.3% (43), respectively, of the 170 athletes reporting each symptom.

**Conclusion:** Preliminary findings indicate a low risk of myocardial injury secondary to COVID-19 infection, with less than 4% of the 170 patients in our study presenting with abnormal ECG findings and a total of 16 patients (9.4%) requiring referral to a cardiologist. Although viral myocarditis was not detected in any athlete referred for cardiological assessment, 2 patients experienced effusive viral pericarditis.

© 2021 THE AUTHORS. Published by Elsevier Inc on behalf of Mayo Foundation for Medical Education and Research. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>) ■ *Mayo Clin Proc Inn Qual Out* 2021;5(2):368-376

From Sports Medicine (J.L.E., A.G., M.M., C.M.W., M.C., L.G., A.R.J.), Division of Critical Care Medicine, Department of Medicine (J.T.P.), and Department of Community Pediatric and Adolescent Medicine (J.T.P.), Mayo Clinic Health System, La Crosse, WI; Division of Pediatric Cardiology, Department of Pediatric and Adolescent Medicine (J.T.P.) and Division

*Affiliations continued at the end of this article.*

There continues to be debate regarding the level of risk for athletes following coronavirus disease 2019 (COVID-19) infection and the appropriate diagnostic testing that may be warranted as part of a medical clearance for return to sports.<sup>1</sup> Epidemiological trends indicate that younger individuals tend to present with fewer symptoms and are less likely to be hospitalized.<sup>2</sup> However, given the novelty of the virus and the uncertainty regarding its systemic long-term effects, sports medicine clinicians are faced

with difficult decisions regarding how to clear athletes for return to sports. A primary concern for athletes is the potential risk for myocardial injury secondary to COVID-19 infection, which may elevate the risk of cardiac events during high levels of physical exertion.<sup>3,4</sup> In a recent study,<sup>5</sup> 4 of 26 collegiate athletes who had previously tested positive for COVID-19 presented with findings suggestive of myocarditis after cardiovascular magnetic resonance imaging despite 2 of the patients being completely asymptomatic.

However, the clinical relevance of these findings and appropriate timelines for a resumption of physical activity have yet to be fully elucidated. In the absence of strong clinical evidence regarding the prevalence of cardiac pathology following COVID-19, evidence-based decisions and the development of return to play guidelines prove challenging. A recent consensus statement recommended a 2-week surveillance period for asymptomatic patients and electrocardiography (ECG) plus transthoracic echocardiography in patients with mild symptoms following COVID-19 infection.<sup>6</sup> However, each level of competition may opt to consult with local sports medicine clinicians and cardiologists to utilize customized protocols and diagnostics to clear athletes for a return to sports depending on available resources. For example, professional and National Collegiate Athletics Association (NCAA) Division I programs may utilize a diverse array of diagnostic tests with cardiovascular magnetic resonance imaging likely serving as the criterion standard for the detection of myocarditis as a universal screening program for all athletes who test positive for COVID-19. At smaller institutions, this battery of testing may not be feasible, and therefore, athletes may be left to consult with their parents or primary care professionals to determine the best course of action.

At the NCAA Division III level within the United States, local institutions were advising athletes to obtain medical clearance from a physician prior to returning to sports. In addition to a general physical examination, all athletes underwent ECG to screen for any cardiac abnormalities that may have warranted further diagnostics and a consultation with a cardiologist. However, the utility of these tests to detect clinical abnormalities following COVID-19 infection in asymptomatic patients or those with mild to moderate symptoms has yet to be determined. Additionally, there is currently a lack of cardiovascular profiles in athletes following COVID-19 infection. This information would play an important role in appropriate risk stratification for return to play protocols in sports. Therefore, the aim of the current study was to quantify the occurrence rate of abnormal ECG findings when being used as part of a medical clearance for return to sports following COVID-19

infection. A secondary aim was to document the frequency and severity of COVID-19 symptoms in adult athletes.

## PATIENTS AND METHODS

### Study Design

We included in this retrospective analysis a convenience sample of collegiate athletes from 2 NCAA Division III universities who tested positive for COVID-19 during the fall semester of 2020. All athletes were required to obtain medical clearance from their respective university's medical director prior to returning to sports. It was determined that this clearance should consist of, at a minimum, a general physical examination, documentation of symptoms, and ECG to screen for any cardiac abnormalities that may warrant further diagnostics and follow-up with a cardiologist. In this retrospective study, a medical record review was completed to quantify the occurrence of abnormal ECG findings and document the severity and frequency of COVID-19-related symptoms. Predetermined predictors were grouped into categorical variables and included (1) sex, (2) symptom severity, and (3) body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) classification (normal weight vs overweight [ $\geq 24$  kg/m<sup>2</sup>]). These variables were used to examine whether statistically significant differences of abnormal rates occurred between different predictor categories. Symptoms were recorded through electronic questionnaire distributed by athletic training staff and self-reported during the clinical examination. Overall symptom severity was graded using a 1 to 4 scale with 1 = asymptomatic; 2 = mild (nonspecific and self-limited fatigue, anosmia or ageusia, nausea, vomiting, and/or diarrhea, headache, cough, sore throat, and nasopharyngeal congestion); 3 = moderate (persistent fever [temperature  $>38$  °C] or chills, myalgias, severe lethargy, hypoxia, or pneumonia, and/or cardiovascular symptoms [dyspnea and chest pain, tightness or pressure at rest or during exertion]); and 4 = severe (hospitalized) using previously described categories.<sup>3,7</sup> The study period was August 1, 2020 to December 30, 2020.

Standard resting 12-lead ECG was completed for all athletes and recorded using

TABLE 1. Summary of Sport Participation by Sex

Sport	Men, No. (%)	Women, No. (%)	Total, No. (%)
Soccer	0 (0.0)	12 (15.2)	12 (7.1)
Hockey	11 (12.1)	1 (1.3)	12 (7.1)
Tennis	1 (1.1)	2 (2.5)	3 (1.8)
Football	30 (33.0)	0 (0.0)	30 (17.6)
Track	11 (12.1)	18 (22.8)	29 (17.1)
Volleyball	0 (0.0)	9 (11.4)	9 (5.3)
Gymnastics	0 (0.0)	14 (17.7)	14 (8.2)
Wrestling	7 (7.7)	0 (0.0)	7 (4.1)
Swim	4 (4.4)	4 (5.1)	8 (4.7)
Lacrosse	0 (0.0)	6 (7.6)	6 (3.5)
Cross Country	2 (2.2)	2 (2.5)	4 (2.4)
Baseball	16 (17.6)	0 (0.0)	16 (9.4)
Basketball	9 (9.9)	7 (8.9)	16 (9.4)
Other	0 (0.0)	4 (5.1)	4 (2.4)
Total	91 (53.5)	79 (46.5)	170 (100%)

on-screen digital software (Marquette 12SL ECG analysis program for adults, GE Healthcare MAC 3500) with a digital sampling rate of 4000 Hz. In our study, 2 physicians evaluated all study participants for consistency in management and test interpretation using the international consensus criteria for ECG interpretation in athletes.<sup>8</sup> All ECGs were independently reviewed by the 2 physicians for interpretation agreement, and in cases in which disagreement arose, a third physician was to review for majority agreement. We used threshold criteria for further cardiovascular consultation and testing in any athlete with moderate symptoms and/or abnormal or borderline ECG findings at the time of their initial evaluation ( $22.54 \pm 14.20$  days after positive test result). For consistency in medical record review, athletes were categorized on the basis of symptoms they listed on their questionnaire. Patients with an abnormal ECG result or prolonged moderate symptoms were referred to a cardiologist for further testing. If any athlete listed shortness of breath but the symptom was completely resolved at the time of their evaluation, they were not sent for further cardiovascular evaluation in the setting of a normal ECG result ( $n=15$ ).

### Study Participants

Study participants included collegiate male and female athletes between the ages of 18

and 25 years. The study protocols were approved by the Institutional Review Board at Mayo Clinic (IRB #20-011123), and a waiver of consent was provided because of the retrospective nature of the current study.

### Statistical Analyses

The presence and frequency of common COVID-19 symptoms were reported using percentages. Athlete descriptive characteristics by sex were reported using mean  $\pm$  SD for continuous variables and percentages for categorical variables. Predetermined predictors were grouped into categorical variables and included (1) sex, (2) symptom severity, and (3) BMI (normal vs overweight [ $\geq 24$  kg/m<sup>2</sup>]). We performed  $\chi^2$  tests to examine whether statistically significant differences of abnormal rates occurred between different predictor categories and the prevalence of symptoms across each category. In cases in which categorical variables or symptom categories had less than 5 patients, a Fisher exact test was used to examine differences between the variables. An  $\alpha$  level was set at  $P \leq .05$  for determination of statistical significance. All data were analyzed using SPSS Statistics for Windows, version 25.0 (IBM Corp).

### RESULTS

A total of 170 athletes (Table 1) were screened during the study period. Table 2 presents a

TABLE 2. Physical Characteristics of the 170 Study Patients<sup>a,b</sup>

Variable	Men (N=91)	Women (N=79)
Age (y)	19.56±1.51	19.44±1.19
Height (m)	1.84±0.07	1.67±0.07
Weight (kg)	88.97±18.01	63.96±9.22
BMI (kg/m <sup>2</sup> )	26.16±4.47	22.69±2.49
Categorical variables		
Sex	91 (53.5)	79 (46.5)
BMI category	Overweight	Normal
	74 (43.5)	96 (56.5)

<sup>a</sup>BMI, body mass index.  
<sup>b</sup>Data are presented as mean ± SD or No. (percentage) of patients.

summary of the physical characteristics of all patients. The mean ± SD time between a positive test result and medical screening was 22.54±14.20 days (95% CI, 20.38 to 24.70 days). Of the 170 athletes screened, 6 (3.5%) presented with abnormal or borderline ECG findings and were referred to a cardiologist for further testing. Ten additional patients were referred on the basis of symptom severity or duration of symptoms. Table 3 provides a summary of further diagnostics and final outcomes for patients with abnormal ECG findings and those referred to cardiologists based on symptoms. Because no athletes had severe symptoms, this group was not analyzed. Symptom severity was not associated with a higher rate of abnormal ECG ( $\chi^2 = 0.054$ ;  $P = .817$ ). Greater severity of COVID-19 symptoms was associated with a higher percentage of ST depression, T-wave inversion, ST-T changes, and the presence of fragmented QRS complex in those with abnormal findings. Abnormal ECG results were found in 2 of the 91 men (2.2%) and 4 of the 79 women (5.1%). We did not find evidence that BMI category ( $P > .99$ ) or sex ( $P = .418$ ) was associated with abnormal ECG findings. Results of further cardiovascular diagnostic testing were indicative of post-COVID effusive viral pericarditis ( $n = 2$ ) and xiphoiditis ( $n = 1$ ); all 3 patients had moderate symptoms. There was a significant difference between sexes for symptom severity ( $\chi^2 = 14.136$ ;  $P < .01$ ). Table 4 presents a summary of symptom categorization and frequency by sex. Loss of smell, loss of taste, headache, and fatigue were the most prevalent symptoms with 38.8% (66), 36.5%

(62), 32.9% (56), and 25.3% (43), respectively, of the 170 athletes reporting each symptom.

## DISCUSSION

The primary aim of the current study was to examine the occurrence rate of abnormal ECG screenings in a convenience sample of collegiate athletes who had previously tested positive for COVID-19. The results of the current study revealed that of the 170 athletes who were screened, 6 (3.5%) presented with abnormal cardiac rhythms and a total of 16 patients (9.4%) required referral to a cardiologist. Of those with abnormal cardiac rhythms or who were referred to cardiologists based on symptom severity or duration, 8 patients reported mild symptoms and 8 reported moderate symptoms at the time of examination. In comparison, in a cohort of 431 older patients (mean age of 74 years) hospitalized with severe COVID-19 illness, ECG findings were abnormal in 93% of the patients.<sup>9</sup> In a similar study, it was reported that abnormal ECG findings appeared to be associated with severity of COVID-19 infection because a higher percentage of ST depression, T-wave inversion, ST-T changes, and the presence of fragmented QRS complex were noted in patients classified as having severe vs nonsevere illness.<sup>10</sup> Although athletes are markedly different from older adult populations, who are likely less active with a higher risk of comorbidities, the normal ECG findings in most of the athletes in the current study are encouraging.

A novel finding from the current study is that a higher percentage of women were

**TABLE 3. Study Patients Referred for Cardiology Consultation Because of Abnormal ECG Findings or Symptom Severity/Duration<sup>a</sup>**

Patient	Symptom severity <sup>b</sup>	ECG findings	Follow-up tests	Final findings
1	3	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms reported	Echo, $\dot{V}O_2$ , Holter monitor	No cardiac pathology
2	3	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms reported	Echo, $\dot{V}O_2$ , Holter monitor	Patient deferred medical evaluation
3	3	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms reported/duration of symptoms	Referred to cardiology	Patient deferred medical evaluation
4	2 <sup>c</sup>	Sinus bradycardia, septal infarct (age undetermined)	Echo	No cardiac pathology
5	2 <sup>c</sup>	Sinus bradycardia with sinus arrhythmia, T-wave abnormality, consider anterior ischemia	Echo, troponin	No cardiac pathology
6	2 <sup>c</sup>	Normal sinus rhythm with sinus arrhythmia. Nonspecific ST abnormality	Echo, troponin	No cardiac pathology
7	2	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms reported	Echo, $\dot{V}O_2$ , Holter monitor	No cardiac pathology
8	3	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms reported	Echo, $\dot{V}O_2$ , Holter monitor, troponin, cardiac MRI, D-dimer, chest CT, spirometry	Xiphoiditis. Post—COVID-19 costochondritis. Cardiac MRI: no scar or inflammation on delayed enhancement imaging to suggest myocarditis
9	2	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms reported	No further testing required	No cardiac pathology
10	2	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms reported	Echo, troponin	No cardiac pathology
11	2 <sup>c</sup>	Sinus bradycardia with sinus arrhythmia. Right bundle branch block	Echo, troponin	No cardiac pathology
12	2 <sup>c</sup>	Sinus bradycardia. T-wave abnormality, consider inferior ischemia	Echo, $\dot{V}O_2$ , troponin	No cardiac pathology
13	3	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms during exertion with return to activity and questionable family cardiac history	Echo, $\dot{V}O_2$ , Holter monitor, troponin, cardiac MRI	Effusive viral pericarditis
14	3	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms during exertion with return to activity	Echo, troponin, chest CT, spirometry	Hyperinflation, asthma No cardiac pathology

*Continued on next page*

TABLE 3. Continued

Patient	Symptom severity <sup>b</sup>	ECG findings	Follow-up tests	Final findings
15	3	Normal sinus rhythm, normal ECG Referred to cardiology due to symptoms reported	Echo, troponin	Mitral valve thickening; mild MR No other cardiac pathology pertinent to COVID-19
16	3 <sup>c</sup>	Normal sinus rhythm. Nonspecific ST abnormality.	Echo, $\dot{V}O_2$ , troponin, cardiac MRI, chest CT	Effusive viral pericarditis

<sup>a</sup>COVID-19, coronavirus disease 2019; CT, computed tomography; ECG, electrocardiography; Echo, echocardiography; ST, ST segment of ECG rhythm; MR, mitral regurgitation; MRI, magnetic resonance imaging;  $\dot{V}O_2$ , volume of oxygen consumption test.

<sup>b</sup>Based on a scale of 1 to 4: 1 = asymptomatic; 2 = mild (nonspecific and self-limited fatigue, anosmia or ageusia, nausea, vomiting, and/or diarrhea, headache, cough, sore throat, and nasopharyngeal congestion); 3 = moderate (persistent fever [temperature >38 °C] or chills, myalgias, severe lethargy, hypoxia, or pneumonia, and/or cardiovascular symptoms [dyspnea and chest pain, tightness or pressure at rest or during exertion]); and 4 = severe (hospitalized) using previously described categories.

<sup>c</sup>Abnormal ECG based on International consensus criteria.

categorized as having moderate symptoms compared with men. These findings are contradictory to those of previous reports indicating that men typically experience more severe outcomes and have a higher case fatality rate than women, albeit in older populations.<sup>11-13</sup> Loss of smell, loss of taste, headache, and fatigue were the most prevalent symptoms in our study, with 38.8%, 36.5%, 32.9%, and 25.3%, respectively, of athletes reporting each symptom. These symptoms are in alignment with those commonly reported in adults with mild to moderate disease.<sup>14,15</sup> The current study findings are unique in that in otherwise healthy adults who are asymptomatic or present with mild symptoms of COVID-19, ECG would typically not be warranted; rather, patients would be instructed to manage their symptoms at home unless further testing or care would be needed. However, the use of ECG in sports to screen athletes for cardiac abnormalities is not unprecedented because some sports medicine professionals often recommend it for all athletes prior to competing, despite a lack of any cardiovascular symptoms. The primary focus of such a surveillance strategy tends to be on detecting cardiac myopathy in an effort to prevent sudden cardiac death in athletes during high levels of exertion. For reference, over a 5-year surveillance period using widespread ECG screening, an abnormal occurrence rate of 6.6% was reported when using the Stanford criteria.<sup>16</sup> More recently, among a cohort of 1686 NCAA Division I athletes, a

surveillance screening period identified an abnormal ECG rate of 1.8% when using the international consensus criteria.<sup>17</sup> In the current study, which had a smaller sample size, we found a slightly higher abnormal ECG rate of 3.5%, compared with the 1.8% using widespread surveillance and the international consensus criteria. It is unclear if COVID-19 infection contributed to the ECG abnormalities reported in the current study vs expected abnormality rates with mass screenings among an athletic population. This issue underscores the need for future study with an age-matched control group and larger sample sizes. Currently, limited data are available regarding the prevalence of myocarditis in otherwise healthy young adults. Although viral myocarditis was not documented in any athlete referred for cardiology assessment in our study, 2 patients experienced post-COVID effusive viral pericarditis—to our knowledge, the first such cases reported in the literature among athletes. We question if further study with greater power may yield similar findings in patients with moderate or more severe symptoms. Both patients with pericarditis were restricted from any form of exercise for 4 weeks while monitoring symptoms and treatment with the nonsteroidal anti-inflammatory drug indomethacin for 2 weeks. Both patients became completely asymptomatic and were gradually returned to exercise with no adverse events.

The results of the current study add to the growing body of literature regarding the

TABLE 4. Categorization of Symptom Severity and Frequency of COVID-19 Symptoms by Sex<sup>a,b</sup>

Variable	Men (n=91)	Women (n=79)	Total (N=170)	$\chi^2$ test	P value
Symptom severity				14.136	.001
Asymptomatic	20 (22.0)	2 (2.5)	22 (12.9)		
Mild	57 (62.6)	59 (74.7)	116 (68.2)		
Moderate	14 (15.4)	17 (21.5)	31 (18.2)		
Data missing	0 (0.0)	1 (1.3)	1 (0.5)		
Abnormal ECG	2 (2.2)	4 (5.1)	6 (3.5)	NA	.418 <sup>c</sup>
Symptom category					
Head/nasal/throat					
Cough	20 (22.0)	15 (19.0)	35 (20.6)	0.231	.631
Congestion	9 (9.9)	14 (17.7)	23 (13.5)	2.217	.137
Runny nose	15 (16.5)	19 (24.1)	34 (20.0)	1.513	.219
Sore throat	15 (16.5)	21 (26.6)	36 (21.2)	2.730	.098
Light-headedness	2 (2.2)	0 (0.0)	2 (1.2)	NA	.500 <sup>c</sup>
Headache	20 (22.0)	36 (45.6)	56 (32.9)	10.655	.001
Red eyes	2 (2.2)	1 (1.3)	3 (1.8)	NA	.402 <sup>c</sup>
Gastrointestinal tract					
Loss of smell	31 (34.1)	35 (44.3)	66 (38.8)	1.866	.172
Loss of taste	28 (30.8)	34 (43.0)	62 (36.5)	2.747	.097
Nausea	1 (1.1)	1 (1.3)	2 (1.2)	NA	>.99 <sup>c</sup>
GI upset	1 (1.1)	0 (0.0)	1 (0.6)	NA	>.99 <sup>c</sup>
Loss of appetite	1 (1.1)	3 (3.8)	4 (2.4)	NA	.339 <sup>c</sup>
Diarrhea	1 (1.1)	1 (1.3)	2 (1.2)	NA	>.99 <sup>c</sup>
Cardiorespiratory					
Chest pain/tightness	7 (7.7)	5 (6.3)	12 (7.1)	NA	.773 <sup>c</sup>
Variable heart rate/palpitations	1 (1.1)	2 (2.5)	3 (1.8)	NA	.598 <sup>c</sup>
Shortness of breath	11 (12.1)	14 (17.7)	25 (14.7)	1.070	.301
Whole body					
Body aches	13 (14.3)	10 (12.7)	23 (13.5)	0.096	.757
Chills	7 (7.7)	7 (8.9)	14 (8.2)	0.076	.782
Fatigue	15 (16.5)	28 (35.4)	43 (25.3)	8.045	.005
Fever	7 (7.7)	4 (5.1)	11 (6.5)	NA	.547 <sup>c</sup>

<sup>a</sup>COVID-19, coronavirus disease 2019; ECG, electrocardiography; GI, gastrointestinal tract; NA, not applicable.

<sup>b</sup>Data are presented as No. (percentage) of patients.

<sup>c</sup>Fisher exact test.

pathophysiologic effects of COVID-19 in young, otherwise healthy adult athletes. In this small cohort of athletes, there was an ECG abnormality rate of 3.5%, with follow-up diagnostics also indicating low rates of myocardial injury secondary to COVID-19 infection for those requiring a cardiology consultation. It is important to note that even some patients with mild symptoms (n=5) exhibited abnormal cardiac rhythms. No patients in our study classified as asymptomatic or having mild symptoms were found to have evidence of myocardial injury if they completed further diagnostic cardiovascular testing based on an initial abnormal ECG result. This finding would align with new

evidence<sup>3</sup> against cardiovascular risk stratification in less than moderately symptomatic young healthy athletes.

Overall, adults between the ages of 15 and 24 years represent approximately 0.18% of all COVID-19 related deaths.<sup>2</sup> The low death rate, in conjunction with preliminary findings indicating a low degree of symptom severity and low rate of abnormal ECG findings reported in the current study, suggests that the overall risk for young adult athletes is likely low; however, the long-term physiologic effects secondary to COVID-19 infection are still unknown. The findings from the current study are in alignment with those described in the review by Kim et al,<sup>3</sup> adding further support



that cardiovascular risk stratification should be considered only in athletes with persistent moderate symptoms. Therefore, athletes should take every precaution to avoid COVID-19 and if infected, use a gradual progression when returning to physical activity while closely monitoring symptoms. Additionally, athletes with comorbid medical conditions such as asthma, dyslipidemia, sickle cell trait, and diabetes may want to exercise caution when making decisions regarding a return to play because there is currently limited evidence on how these subpopulations may be affected by COVID-19, despite being regularly active.<sup>18</sup> The Centers for Disease Control and Prevention also provides a summary of medical conditions that may predispose individuals to more severe symptoms following COVID-19 infection.<sup>19</sup> Further, if athletes continue to experience symptoms more than 2 weeks postinfection, follow-up is recommended to determine if additional testing is warranted.

A limitation of the current study was the questionnaire used to document self-reported symptoms of the athletes. The questionnaire included symptoms at any point and for any duration no matter how brief after testing positive for COVID-19 or any underlying context. Given institutional policies for evaluation of recently COVID-19–positive patients, we were not able to see these athletes in the clinic until a minimum of 10 days from symptom onset. Several of the athletes who reported moderate symptoms had symptoms completely resolve by the time of their evaluation. In these cases, if their ECG revealed no abnormalities, they were managed on the basis of their symptoms at the time of evaluation, which were almost always less severe than during initial onset. Current recommendations on categorizing symptom severity do not explicitly define duration of symptoms for every category because we do not have concrete evidence. In this cohort of athletes, we determined management on the basis of symptoms present at their evaluation. All athletes in the current cohort were followed up during their return to play progression using an interdisciplinary continuum of care and supervision. To date, there have been no adverse events with their return. Another limitation of the current study was the omission of

data on preexisting medical conditions of the athletes included in this cohort. As previously discussed, certain underlying medical conditions may influence symptom severity following COVID-19 infection. There were also a small number of athletes who had abnormal ECG results, which did not allow us to adjust for covariates in the statistical model. Further studies should be conducted to ascertain the effect of possible confounders and the association of sex in abnormal ECG results.

## CONCLUSION

Findings from the current study indicate a low degree of symptom severity and low rate of abnormal ECG findings in a cohort of athletes, suggesting the overall risk for young adult athletes is likely low; however, the long-term physiologic effects secondary to COVID-19 infection are still unknown. Loss of smell, loss of taste, headache, and fatigue were the most prevalent symptoms, with 38.8%, 36.5%, 32.9%, and 25.3%, respectively, of athletes reporting each symptom. Further study on categorizing symptom severity should take into account the duration of symptoms. Limited data from the current study would suggest the symptom of shortness of breath, for example, in and of itself may not be enough to classify someone as having moderate symptoms. More research is needed to determine whether an athlete who has shortness of breath that resolves by day 10 is at a lower risk for myocardial injury than an athlete who continues experiencing shortness of breath at the time of medical evaluation after self-isolation. Further, elucidating the duration of symptoms to more accurately classify symptom severity could prove useful and become an important indicator for which athletes require further testing. All athletes from the current study who were asymptomatic or mildly symptomatic and presented with an abnormal ECG result that prompted further cardiovascular testing were able to return to activity without complication. This finding further supports the limited value of widespread cardiovascular testing in athletes with less than moderate symptoms and symptoms that resolve in less than 10 days. These findings can help guide prognostic



information and policy development for clearing athletes for a return to sports. Further work is needed using prospective study designs to understand the relationship between COVID-19 symptom severity, confounding factors, and advanced cardiovascular diagnostic testing to determine the frequency of COVID-19—related myocardial disease among a larger sample of athletes. Additionally, long-term surveillance data are needed to examine long-term physiologic effects following COVID-19 infection in athletes.

**Abbreviations and Acronyms:** BMI = body mass index; COVID-19 = coronavirus disease 2019; ECG = electrocardiography; NCAA = National Collegiate Athletic Association

**Affiliations (Continued from the first page of this article.):** of Biomedical Statistics and Informatics, Department of Health Sciences Research (K.M.F.), Mayo Clinic, Rochester, MN; Athletics Department, University of Wisconsin La Crosse (J.L.); and Saint Mary's University, Winona, MN (J.C.).

**Potential Competing Interests:** Dr Jagim has consulted with and received external funding from companies that sell or work with certain dietary ingredient manufacturers (Increnovo, LLC, Alzchem) and has written for online (Prosource) and other media outlets on topics related to exercise and nutrition. The other authors report no competing interests.

**Correspondence:** Address to Andrew R. Jagim, PhD, CSCS\*D, CISSN, Sports Medicine, Mayo Clinic Health System, 191 Theater Rd, Onalaska, WI 54650 (jagim.andrew@mayo.edu; Twitter: @AJagim).

#### ORCID

Andrew R. Jagim:  <https://orcid.org/0000-0002-6651-5096>

#### REFERENCES

- Jorstad HT, van den Aardweg JG. Balancing act: when is an elite athlete who has had COVID-19 safe to return to play? when does prudent investigation go offside into overmedicalising [editorial]? *Br J Sports Med*. 2020;54(19):1134-1135.
- Centers for Disease Control and Prevention. COVID Data Tracker: Demographic trends of COVID-19 cases and deaths in the US reported to CDC. Updated February 25, 2021. <https://covid.cdc.gov/covid-data-tracker/#demographics>. Accessed November 17, 2020.
- Kim JH, Levine BD, Phelan D, et al. Coronavirus disease 2019 and the athletic heart: emerging perspectives on pathology, risks, and return to play. *JAMA Cardiol*. 2021;6(2):219-227.
- Halle M, Binzenhöfer L, Mahrholdt H, Schindler M, Esefeld K, Tschöpe C. Myocarditis in athletes: a clinical perspective [published online ahead of print March 3, 2020]. *Eur J Prev Cardiol*. <https://doi.org/10.1177/2047487320909670>.
- Rajpal S, Tong MS, Borchers J, et al. Cardiovascular magnetic resonance findings in competitive athletes recovering from COVID-19 infection. *JAMA Cardiol*. 2021;6(1):116-118.
- Phelan D, Kim JH, Chung EH. A game plan for the resumption of sport and exercise after coronavirus disease 2019 (COVID-19) infection [published online ahead of print May 13, 2020]. *JAMA Cardiol*. <https://doi.org/10.1001/jamacardio.2020.2136>.
- Gandhi RT, Lynch JB, Del Rio C. Mild or moderate Covid-19. *N Engl J Med*. 2020;383(18):1757-1766.
- Drezner JA, Sharma S, Baggish A, et al. International criteria for electrocardiographic interpretation in athletes: consensus statement. *Br J Sports Med*. 2017;51(9):704-731.
- Bertini M, Ferrari R, Guardigli G, et al. Electrocardiographic features of 431 consecutive, critically ill COVID-19 patients: an insight into the mechanisms of cardiac involvement. *Europace*. 2020;22(12):1848-1854.
- Barman HA, Atici A, Alici G, et al. The effect of the severity COVID-19 infection on electrocardiography [published online ahead of print October 7, 2020]. *Am J Emerg Med*. <https://doi.org/10.1016/j.ajem.2020.10.005>.
- Gebhard C, Regitz-Zagrosek V, Neuhauser HK, Morgan R, Klein SL. Impact of sex and gender on COVID-19 outcomes in Europe. *Biol Sex Differ*. 2020;11(1):29.
- Meng Y, Wu P, Lu W, et al. Sex-specific clinical characteristics and prognosis of coronavirus disease-19 infection in Wuhan, China: a retrospective study of 168 severe patients. *PLoS Pathog*. 2020;16(4):e1008520.
- Takahashi T, Ellingson MK, Wong P, et al. Sex differences in immune responses that underlie COVID-19 disease outcomes. *Nature*. 2020;588(7837):315-320.
- Lovato A, de Filippis C. Clinical presentation of COVID-19: a systematic review focusing on upper airway symptoms. *Ear Nose Throat J*. 2020;99(9):569-576.
- Wise J. Covid-19: symptoms are common after acute phase of disease, Italian study shows. *BMJ*. 2020;370:m2804.
- Fuller C, Scott C, Hug-English C, Yang W, Pasternak A. Five-year experience with screening electrocardiograms in National Collegiate Athletic Association Division I athletes. *Clin J Sport Med*. 2016;26(5):369-375.
- Conway JJ, Krystofiak J, Quirolgico K, Como B, Altobelli A, Putukian M. Evaluation of a preparticipation cardiovascular screening program among 1,686 National Collegiate Athletic Association Division I athletes: comparison of the Seattle, Refined, and International Electrocardiogram Screening criteria [published online ahead of print June 10, 2020]. *Clin J Sport Med*. <https://doi.org/10.1097/JSM.0000000000000858>.
- Harmon KG, Pottinger PS, Baggish AL, et al. Comorbid medical conditions in young athletes: considerations for preparticipation guidance during the COVID-19 pandemic. *Sports Health*. 2020;12(5):456-458.
- Centers for Disease Control and Prevention. People with certain medical conditions. Updated February 22, 2021. [https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html?CDC\\_AA\\_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fneed-extra-precautions%2Fgroups-at-higher-risk.html](https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fneed-extra-precautions%2Fgroups-at-higher-risk.html). Accessed November 20, 2020.