



ORIGINAL ARTICLE

Cardiovascular involvement among collegiate athletes following COVID-19 infection

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ABSTRACT

Background: Recent studies suggest that the prevalence of cardiac involvement in young competitive athletes with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection appears to be low.

Aim: This study aimed to determine the prevalence of cardiovascular involvement in young competitive athletes.

Methods: In this single-center retrospective cohort study from one Division I university; we assessed the prevalence of cardiovascular involvement among collegiate athletes who tested positive for SARS-CoV-2 by polymerase chain reaction testing. Data were collected from June 25, 2020, to May 15, 2021. The primary outcome was the prevalence of cardiac involvement based on a comparison of pre- and post-infection electrocardiogram (ECGs). The secondary outcome was to evaluate for any association between ethnicity and the presence or absence of symptoms.

Results: Among 99 athletes who tested positive for the SARS-CoV-2 virus (mean age 19.9 years [standard deviation 1.7 years]; 31% female), baseline ECG changes suggestive of cardiovascular involvement post-infection were detected in two athletes (2/99; 2%). There was a statistically significant association between ethnicity and the presence or absence of symptoms, $\chi^2 (3, n = 99) = 10.61, P = 0.01$.

Conclusions: The prevalence of cardiovascular involvement among collegiate athletes following SARS-CoV-2 infection in this cohort is low. Afro-American and Caucasian athletes are more likely to experience symptoms following SARS-CoV-2 infection in comparison to Hispanic and Pacific Islander athletes; however, there is no association between ethnicity and symptom severity.

Relevance for Patients: These data add to the growing body of the literature and agree with larger cohorts that the risk of cardiac involvement post-infection appears to be low among elite athletic and semi-professional athletic populations.

1. Introduction

The coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first identified on December 31, 2019, and declared a pandemic on March 11, 2020, by the World Health Organization. To date, over 173 million people have been infected with the SARS-CoV-2 virus with over 3.7 million deaths [1]. While these data are staggering, it is important to understand the potential health implications of this virus across infected individuals.

A significant fraction of hospitalized and critically ill patients with coronavirus disease has exhibited multiple cardiovascular complications, including acute myocardial injury, heart failure, myocarditis, arrhythmias, venous thromboembolism, and cardiogenic shock [2-4]. While the majority of hospitalized patients have prior existing conditions [5,6] which could lead to or be a precursor of cardiovascular complications, it is unclear what cardiac risk exists for asymptomatic or mildly symptomatic cases. This is important given that the majority of young adults or physically active individuals, specifically NCAA Division I athletes, have little to no symptoms of COVID-19. Viral myocarditis is a known cause of sudden cardiac death in athletes and physically active individuals [7-10]. The evolving understanding of the risk of cardiovascular sequelae in athletes following SARS-CoV-2 infection is currently being reflected in the ongoing updating of return-to-play guidelines for athletes and active individuals [11-19].

Abnormal cardiac magnetic resonance (CMR) imaging in middle-aged, ambulatory adults recovering from COVID-19 has been reported to be as high as 78%, sparking concern about COVID-19 myocarditis in athletes [20]. One of the earliest cohort studies investigating professional soccer players noted no cardiac involvement after undergoing return-to-play (RTP) cardiac testing [21]. Further studies examining professional athletes undergoing RTP cardiac testing reported a low prevalence of cardiac involvement (0.6%) [22]. Single-center observational cohort studies of collegiate athletes report varying degrees of cardiac involvement following RTP cardiac testing (1.4–56%); however, the prevalence of myocarditis is much less so (0–15%) [23-26]. The largest to date multicenter observational cohort study involving over 3000 collegiate athletes with SARS-CoV-2 infection undergoing RTP cardiac testing reported a low prevalence of cardiac involvement (0.5–3%) [27]. The most recent observational cohort study of collegiate athletes reported a low prevalence of abnormal cardiac testing (3.6%), with no evidence of myocarditis after further workup by CMR [28]. These findings have provided a critical foundation for understanding the risk of myocarditis among athletes but more data are needed which include pre-infection health status. These important data can aid clinical decisions regarding RTP and may rule out the possibility of expensive time-intensive procedures.

The purpose of this retrospective cohort study was to evaluate the prevalence of cardiac involvement in collegiate athletes recovering from COVID-19 infection based on a comparison of pre- and post-infection electrocardiogram (ECGs). It was hypothesized that those with positive pre-infection cardiac involvement would demonstrate exaggerated or worse outcomes following a positive COVID-19 diagnosis.

2. Materials and Methods

De-identified retrospective data were collected from June 20, 2020, to May 15, 2021, through chart review from a single NCAA Division I school. This study was granted exempt status by the University of Nevada Las Vegas Institutional Review Board (Protocol #1632049-4). Data will be made available on reasonable request.

All NCAA student-athletes at the University of Nevada Las Vegas who had an ECG done as part of their pre-participation evaluation and tested positive for SARS-CoV-2 by polymerase chain reaction (PCR) were eligible to participate. Written informed consent was obtained for each participant. Athletes were excluded from the study if they were unable to be contacted to provide written informed consent, declined informed consent, had a positive SARS-CoV-2 test that was not medically documented, did not have a pre-participation ECG on file, only had a clinical assessment with no additional cardiac testing, or have yet to complete their cardiac evaluation by the end of the collection date. Student-athletes or the public were not involved in the design, conduct, reporting, or dissemination plans of this cohort study.

Athletes were required to complete a mandatory daily symptom screener and any positive symptoms were flagged and recorded by an athletic trainer. Symptom severity was categorized based on the reported symptoms from the initial infection or during their mandatory isolation period as initially proposed for collegiate athletes [29]. Symptoms were categorized as follows: Asymptomatic, mild, and moderate. Mild symptoms were defined as cough, fatigue, headache, anosmia, ageusia, rhinorrhea, sore throat, nasopharyngeal congestion, nausea, vomiting, or diarrhea. Moderate symptoms included cardiopulmonary symptoms and were defined as fever, chills, myalgias, chest pain, shortness of breath, palpitations, or exercise intolerance. If an athlete had symptoms in multiple categories, they were assigned to the most severe category. Post-infection evaluations included both a clinical assessment and a 12-lead ECG no sooner than 10 days after the positive test. All ECGs were interpreted using the International Criteria for ECG Interpretation in Athletes [30]. Each ECG post-infection was compared to the athlete's pre-participation ECG. Further cardiac testing was determined by the severity of symptoms and included a cardiac troponin T assay (Quest Diagnostics; cutoff range 0.01 ng/mL), TTE, CMR, and/or clinical assessment by a sports cardiologist [12]. Athletes with a normal clinical evaluation and negative cardiac testing were cleared to start a graduated return to play program as previously described [14].

Every athlete had a 12-lead ECG as part of their pre-participation evaluation. Each ECG was interpreted using the International Criteria for ECG Interpretation in Athletes [30]. Any pre-season ECG abnormalities were documented and had follow-up assessments through a sports cardiologist which included exertional testing to rule out any potential complications from sports participation.

Patient demographics, ECG changes, and SARS-CoV-2 symptom categories were described using basic descriptive methods. Associations between ethnic groups and symptom categories were calculated using the Chi-square test of independence. In addition, Chi-square tests were used to determine any associations between type of sport participation and the reporting of symptoms and severity of symptoms. Statistical analyses were performed using JASP (Version 0.14.1, University of Amsterdam, Amsterdam, Netherlands).

3. Results

Of the 120 athletes enrolled during the study period, 99 met the study inclusion criteria. Baseline characteristics for the cohort are

shown in Table 1. Athletes were young adults (mean age 19.9 years; standard deviation 1.7 years). The median time between COVID-19 diagnosis and ECG test was 15 days (interquartile range 11 and 18 days). Athletes from ten different sports were represented: Football, soccer, baseball, softball, basketball, volleyball, track and field, cross country, swimming and diving, and tennis. Three athletes had abnormal pre-season ECGs that were referred to cardiology for further evaluation and were cleared to participate in sport. Cardiac return-to-play testing is also described below.

Of all athletes testing positive, there was a significant association between ethnicity and symptom development ($\chi^2 = 11.27$, $df = 3$, $n = 99$, and $P = 0.01$). Individuals of Afro-American and Caucasian ethnicity were more likely to develop symptoms (79% and 74%, respectively) compared with individuals of Hispanic or Pacific Islander ethnicity (33% and 58%, respectively). However, in terms of symptom severity, there was no association between mild or moderate symptom development with ethnicity (Afro-American = 35% moderate, Caucasian = 17% moderate, Hispanic = 25% moderate, and Pacific Islander = 29% moderate) with a $\chi^2 = 2.63$, $df = 3$, and $P = 0.45$. In addition, there was no significant association between gender and symptom development ($\chi^2 = 0.27$ and $P = 0.61$) nor between gender and symptom severity ($\chi^2 = 0.20$ and $P = 0.66$).

Table 1. Patient characteristics

Patient characteristics	Total cohort (n=99)
Demographics	
Age, mean (standard deviation)	19.9 (1.7)
Male	68
Female	31
White	42
Afro-American	33
Hispanic	12
Pacific Islander	12
Sport	
Football (American)	44
Soccer	16
Baseball	4
Basketball	5
Softball	2
Tennis	2
Volleyball	11
Track & Field/Cross Country	1
Swim & Dive	14
Symptom Categories	
Asymptomatic	29
Mild	51
Moderate	17
Symptomatic – unknown severity	2
Cardiac Return-to-Play Testing	
Electrocardiogram	99
Transthoracic echocardiography	46
Troponin T	49
Cardiac MRI	2

Finally, there was no significant association between type of sport and the presence of symptoms ($\chi^2 = 11.91$, $df = 10$, and $P = 0.28$), nor between the type of sport and the severity level of any symptoms ($\chi^2 = 8.41$, $df = 9$, and $P = 0.49$). Sport type was not associated with symptom reporting. Tables 1 and 2 provide the specific findings for these athletes relative to symptom rate and severity of symptoms.

Abnormal post-infection ECG changes were detected in two athletes (2% of the sample) and the specifics of these findings are described in Table 3. Both of these athletes had normal troponin T levels and no abnormal findings on CMR with late gadolinium enhancement. One of these athletes (#1) had abnormal ECG findings before the beginning of the athletic season; however, the exercise treadmill stress testing revealed frequent premature ventricular complexes that resolved with exercise. Accounting for the abnormal pre-season ECG, the rate of abnormal ECG values post-infection was 1% while no other markers of myocarditis were observed in the present study. The remainder of the cardiac return-to-play testing in this cohort was normal.

4. Discussion

The purpose of this study was to evaluate the prevalence of cardiac involvement in collegiate athletes recovering from COVID-19 infection based on a comparison of pre- and post-infection ECGs. The hypothesis was not met as the three athletes who had an abnormal pre-participation ECG did not have a positive diagnosis of cardiomyopathy. The main implications of this study are: (1) No clinically diagnosed cases of myocarditis were detected within this cohort of athletes; (2) rate of cardiac involvement was extremely low (1%) even among mild-to-moderate cases of COVID-19, and (3) Afro-American and Caucasian ethnicity were more likely to develop symptoms following a positive diagnosis of COVID-19. This is the first study, to the authors' best knowledge, that used a pre- and post-design in the measurement of cardiac involvement among NCAA athletes and a larger cohort is needed to confirm these findings.

These data add to the growing body of the literature and agree with larger cohorts that the risk of cardiac involvement post-infection is rare (<1–1%) among elite athletic populations [21–28] and 3.3% among semi-professional athletes [31]. These rates are lower than the suggested 78% in ambulatory adults [20], an average incidence of 22 of 100,000 patients according to the Global Burden of Disease Study [32] and following influenza infection (1–10%) [33] among general populations. The potential disease burden of myocarditis appears to be dependent on the health status of the individual while

Table 2. Symptom severity

	Asymptomatic	Mild	Moderate	Symptomatic - unknown severity
Afro-American (n=33)	7	17	9	0
Caucasian (n=42)	9	26	5	2
Hispanic (n=12)	8	3	1	0
Pacific Islander (n=12)	5	5	2	0

Table 3. Athletes with abnormal post-COVID ECG changes

Athlete	Gender	Ethnicity/Race	Symptom severity	Abnormal ECG changes	Troponin T	Transthoracic ECHO	CMR Interpretation
1	Female	Hispanic	Mild (anosmia, ageusia)	New T-wave inversions V1-V4	Negative	Normal	Normal
2	Male	Afro-American	Moderate (headache, fevers, chills, fatigue)	Unifocal frequent PVCs	Negative	Normal	Normal

the risk appears to be lower if you are considered an elite athlete. This is not surprising given the evidence that intense exercise aids in reducing overall cardiac disease risk [34] and enhances immune function [35]. Further research is needed within adolescent athletes and specifically within specific sport types.

The lack of a single consistent site for PCR testing may have inflated the overall positive diagnosis of COVID-19 as each testing facility may have varying cycle thresholds. However, it can be assumed that each PCR testing site followed the CDC's recommendations for cycle thresholds. Furthermore, the total amount of asymptomatic cases was similar to other studies within NCAA athletes.

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Conflict of Interest

Dr. Murray received payments during the project from NIH grant: P20GM103650. All other authors declare no conflict of interest.

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