*Case Series*

*Journal of* INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
49(10) 1–8

DOI: 10.1177/03000605211053280
journals.sagepub.com/home/imr
SAGE

# Increased number of electrocardiogram findings requiring additional cardiac examination in young athletes during the coronavirus disease 2019 pandemic: a case series

**Zoran Šarčević[1,2] and Andreja Tepavčević[2,3,4]**

**Abstract**

We aimed to compare the results of electrocardiogram (ECG) examinations in young athletes from 2017 to 2020, which includes a period during the coronavirus disease 2019 (COVID-19) pandemic, with special attention to T-wave inversion that might be a sign of myocarditis. This was a retrospective observational study. We reviewed data of ECG examinations among 640 young athletes aged 10 to 14 years (160 in each year from 2017–2020). The setting was Novi Sad Sports Medicine Center in Serbia. We hypothesized that most young athletes with changes on ECG had asymptomatic COVID-19. In the group from 2020, there were significantly more ECG findings requiring additional cardiac examination, according to modern sports cardiology, compared with previous years. We describe one case of documented asymptomatic COVID-19 infection and with T-wave inversion in V4 and V5. The number of schoolchildren with asymptomatic COVID-19 infection might be high because most classes in Novi Sad were conducted face-to-face during 2020. Because a serious risk of myocarditis exists in young athletes, especially in relation to COVID-19 infection, a careful sports preparticipation examination is important to identify athletes possibly requiring additional testing and medical care prior to a return to sports.

[1]Novi Sad Health Care Centre, Sports Medicine Centre, Novi Sad, Serbia
[2]Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia
[3]Faculty of Sciences, University of Novi Sad, Novi Sad, Serbia
[4]Mathematical Institute SANU, Belgrade, Serbia

**Corresponding author:**
Andreja Tepavčević, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovića 4, 21000 Novi Sad, Serbia.
Email: andreja@dmi.uns.ac.rs

**Keywords**
Coronavirus disease 2019, young athlete, sports preparticipation screening, electrocardiogram, myocarditis, case series

Date received: 11 May 2021; accepted: 22 September 2021

## Introduction

More than a year has passed since the initial report of an outbreak of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the cause of coronavirus disease 2019 (COVID-19) and the global pandemic caused by rapid transmission of the virus. COVID-19 is associated with high morbidity and mortality, mostly among patients with advanced age, male sex, and previous medical conditions.[1] Although it is widely confirmed that most infections are mild, especially in young patients, it is important for physicians to recognize the possibility of severe presentations in pediatric patients, especially with cardiovascular involvement.[2–4] One possible mechanism is that SARS-CoV-2 may directly infect myocardial cells, leading to myocarditis with acute impairment of cardiac muscle function and potential residual chronic scarring, leading to increased vulnerability to malignant ventricular arrhythmias.[2,5] Therefore, further studies are needed of cardiac involvement in COVID-19 infection among children, as well as studies comparing the clinical profiles of children with COVID-19, with and without cardiac injury.[6]

Because there is a risk of myocarditis among young athletes, it is important to conduct careful preparticipation screening to identify those who may require additional testing and medical care prior to returning to sports.[7] Independently of the COVID-19 pandemic, ECG examination is one of the most important aspects of preparticipation examinations or periodic health examinations in which young athletes are regularly screened prior to their participation in sports.[8,9] A variety of cardiac disorders are associated with sudden cardiac death in young athletes, most of which can be identified or suggested by abnormalities on a resting 12-lead electrocardiogram (ECG).[10]

To prevent sports-related sudden cardiac death in young athletes, the following aspects of ECG should be considered and additional cardiac examinations should be performed in cases of the following: abnormalities in the P wave, QRS complex, ST segment, T-waves, and QT interval as well as cardiac rhythm and conduction abnormalities.[9] In addition to using ECG in preparticipation examinations to screen for rare genetic and congenital conditions, cardiovascular sequelae of COVID-19 should be checked, particularly patterns indicative of myocardial inflammation, such as T-wave inversions and new ST segment changes.[7] In 33% of all cases with abnormal ST or T waves, later endomyocardial biopsy specimens reveal histologic evidence of myocarditis.[11]

The aim of our study was to compare the results of ECG examinations among young athletes in sports preparticipation screening from 2017 to 2019 with ECG findings from 2020. Special attention was paid to young athletes with T-wave inversion, which might be a sign of myocarditis. These patients should be placed under permanent observation because even asymptomatic myocarditis might result in permanent heart damage.[11]

## Methods

This was a retrospective observational study involving a case series, with detailed

description of one particular case. Together with data from 2020, we reviewed the data of young athletes with a previous history and family history and previous ECG data of those who underwent sports preparticipation screening in previous years.

We analyzed ECG data according to criteria defined in the IOC Manual of Sports Cardiology[12] and also in a consensus statement,[10] with updated contemporary standards for ECG interpretation among athletes. ECG examinations were conducted using the HeartScreen 60-IKO (Innomed, Inc., Savannah GA, USA).

We analyzed the data using MedCalc version 18.2.1 (MedCalc Software Ltd., Ostend, Belgium). Comparisons of proportions were made using the chi-squared test. The reporting of this study conforms to the CARE guidelines.[13]

## Results

### *Analysis of sports preparticipation ECG examination data*

We reviewed the data of sports preparticipation ECG examinations in 640 young athletes aged 10 to 14 years (160 from September to November in each year during 2017–2020). For 2017, we identified ECG findings from 7 athletes requiring further examination, out of 160 athletes. Four athletes had terminal activation delay of QRS $\geq$55 ms in the right precordial leads (TAD); one had isolated ventricular extrasystoles (VES); one had a saddleback-shaped ST segment pattern in V2 (suspicious for Brugada syndrome); and one athlete had QRS duration >140 ms.

In 2018, ECG findings for 7 of 160 athletes required additional examination. Four athletes had TAD; one had QTc <0.33 s; one had Wolff–Parkinson–White syndrome; and one athlete had signs of a right bundle branch block and left atrial hypertrophy. In 2019, we identified abnormal findings in 10 of 160 athletes. Five athletes had TAD; one had depression of the ST segment in D2 and D3; one had QTc $\geq$0.48 s; one had T-wave inversion in V4; one had depression of the ST segment in V5 and V6; and one athlete had a saddleback-shaped ST segment pattern in V2 (suspicious for Brugada syndrome).

In 2020, we found ECG findings requiring additional examination for 31 of 160 ECG examinations. Sixteen athletes had T-wave inversion in V4 (among which two also had T-wave inversion in V5); two athletes had a saddleback-shaped ST segment in V2 (suspicious for Brugada syndrome); six had TAD; six had VES; and one athlete had depression of the ST segment in D2 and D3.

The frequency of ECG findings requiring additional examination in 2020 was significantly higher than those in the other years (2017–2019), with $p < 0.001$. At the same time, no significant difference appeared between the frequency of ECG findings requiring additional examination among the years 2017, 2018, and 2019. The incidence rate of the observed findings was approximately three times higher in 2020 than the average number of such findings in previous years. In particular, the incidence rate of ECG findings that might be related to myocarditis (abnormal ST and T waves) was significantly higher than those in previous years.

### *Incidence of ECG abnormalities during the COVID-19 pandemic*

Our hypothesis was that a significant number of young athletes with ECG findings requiring additional examination had asymptomatic COVID-19. However, this hypothesis was not directly proven because only a small percentage of athletes underwent screening (Table 1). However, when considering the number of athletes whose family members tested positive for COVID-19 and who (or whose family

**Table 1.** Data related to COVID-19 testing and symptoms.

| | Positive test result for COVID-19 | Family members tested positive for COVID-19 | Mild symptoms of COVID-19 but not tested | Family members had symptoms of COVID-19 but not tested | Unknown | Total |
|---|---|---|---|---|---|---|
| Boys | 2 | 3 | 2 | 2 | 2 | 11 |
| Girls | 2 | 1 | 0 | 1 | 1 | 5 |

Note: If a case is counted in a column to the left, it is not counted again in another column.

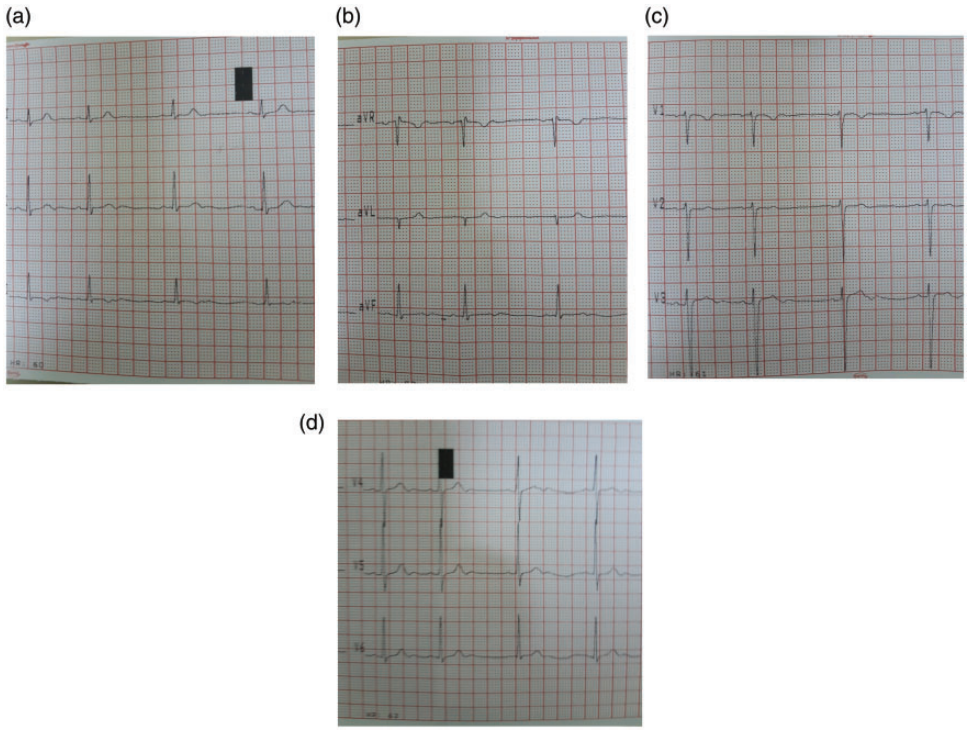


**Figure 1.** ECG findings from February 2020 before COVID-19 infection. (a) Leads I, II, and III before COVID-19 infection. (b) Leads aVL, aVR, and aVF before COVID-19 infection. (c) Leads v1, v2, and v3 before COVID-19 infection. (d) Leads v4, v5, and v6 before COVID-19 infection.

members) had symptoms related to COVID-19, it might be indirectly proven that most of these athletes had COVID-19 infection. Moreover, the number of asymptomatic schoolchildren with COVID-19 in the study area might be high because most classes in Novi Sad were conducted face-to-face during the 2020/21 school year.

A characteristic case is presented below.

A 13-year-old girl (height 168 cm and weight 56 kg) with no symptoms underwent sports preparticipation examination in September 2020. She had trained in volleyball for 5 years, three times weekly for 1 hour each time. Her ECG findings from February 2020 were completely normal

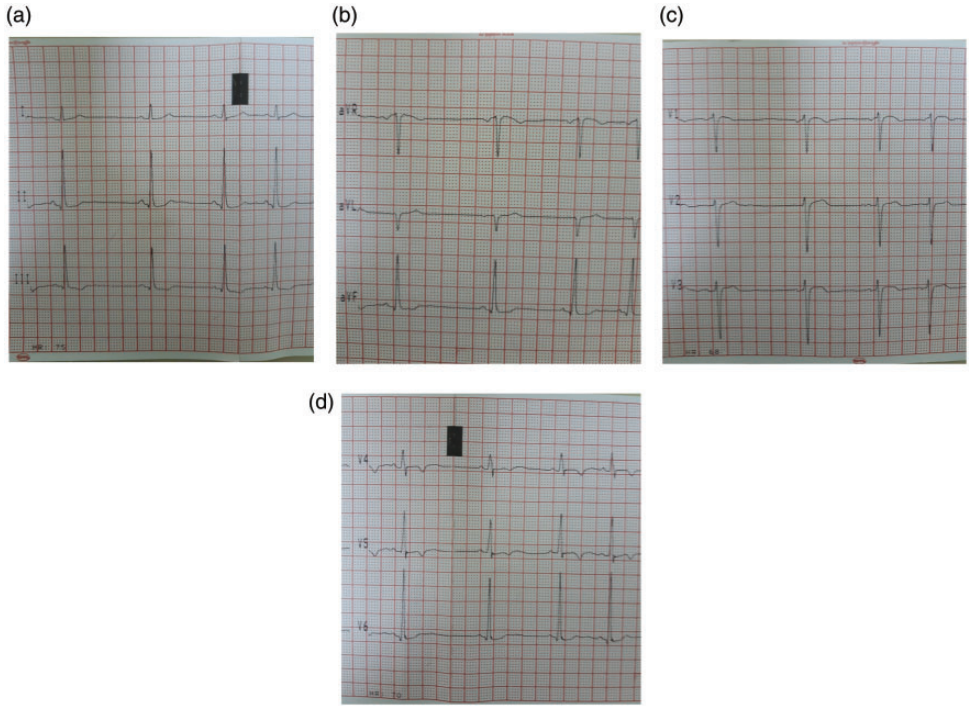


**Figure 2.** ECG findings from September 2020 after COVID-19 infection. (a) Leads I, II, and III after COVID-19 infection. (b) Leads aVL, aVR, and aVF after COVID-19 infection. (c) Leads v1, v2, and v3 after COVID-19 infection. (d) Leads v4, v5, and v6 after COVID-19 infection (T-wave inversion in V4 and V5).

(Figure 1a–1d). On her ECG findings from September 2020 after COVID-19 infection (Figure 2a–2d), T-wave inversion was observed in V4 and V5 (Figure 2d).

Because this young athlete underwent preparticipation screening in previous years, we were able to confirm that her ECG findings in 2017, 2018, and 2019 were completely normal. This girl underwent testing for COVID-19 because her parents were diagnosed with COVID-19, although she was asymptomatic. The girl tested positive for COVID-19. This case shows that young athletes may have asymptomatic COVID-19 infection, which may lead to serious effects on their health.

Among athletes with T-wave inversions in V4 (and V5), 11 were boys and 5 were girls, with mean age $10.19 \pm 2.10$ years. The included athletes trained in different sports: volleyball (4), soccer (3), basketball (3), swimming (3), and others (3). The median duration of training was 3 years, and the median training time per week was 3 hours.

Only one case is described here, together with the ECG findings. However, nearly all other cases with T-wave inversion in V4 (and V5) had either a positive COVID-19 test result, one or more family members with a positive COVID-19 test result, or one or more family members with mild symptoms of COVID-19 infection but who did not undergo testing (Table 1).

Athletes in our study with ECG abnormalities underwent further investigations in the cardiology department. Echocardiography was performed in all athletes; however, all results were normal. Diagnosis of myocarditis might only be detectable using cardiac magnetic

resonance imaging (MRI) or biopsy, which were not carried out in these patients, according to the cardiology protocol in Serbia. Instead, all young athletes in this study remain under permanent observation.

## Discussion

In our study, we found that the number of ECG findings requiring additional cardiac examination, according to modern sports cardiology, was significantly higher in 2020 than in the 3 previous years. Our study is compatible with the results of previous studies. A case–control study[7] investigated the effects of asymptomatic or mild COVID-19 infection on transmyocardial repolarization parameters in children without treatment. The findings showed that QTd, QTcd, Tp-e, Tp-e dispersion, Tp-e/QT ratio, and Tp-e/QTc ratio were significantly higher in the COVID-19 group than in the control group. Moreover, ventricular repolarization was impaired, even in children with asymptomatic COVID-19 infection.[7] Another study[14] described the association of COVID-19 and T-wave inversion in a large case series among older patients (mean age $66 \pm 7$ years). Our study indicated a possibility that T-wave inversion might be a manifestation of COVID-19 in young athletes.

A systematic review[15] provided an overview of studies on COVID-19-mediated myocarditis. The results indicated that ECGs showed changes in 90% cases of COVID-19-mediated myocarditis. The frequency and prognostic impact are unknown, but evidence demonstrates myocardial inflammation with or without direct cardiomyocyte damage owing to COVID-19 means that different pathophysiologic mechanisms might be responsible for COVID-mediated myocarditis.[15]

One study[16] including 789 professional athletes with positive COVID-19 test results detected abnormal screening findings in 30 athletes, among which 5 athletes (17%) ultimately had cardiac MRI findings suggesting inflammatory heart disease. Another study[17] among 145 competitive student athletes recovering from COVID-19 reported that after performing cardiac MRI in all patients, 2 patients (1.4%) had MRI findings consistent with myocarditis. In a cohort study[18] of 1597 competitive collegiate athletes in the United States who had been infected with COVID-19, the prevalence of clinical myocarditis was only 0.31% using a symptom-based screening strategy. After screening with cardiovascular MRI, the prevalence of clinical and subclinical myocarditis increased to 2.3% (7.4 times higher).

Because myocarditis can be asymptomatic, sports medicine physicians should pay special attention to athletes who may have had COVID-19 because these individuals are at risk for myocarditis and should have a low threshold for further cardiovascular testing.[19] The currently reported rates of cardiac involvement in COVID-19 indicate a risk of myocarditis. Therefore, physicians who conduct sports preparticipation screening should be well-versed in the diagnosis, management, and criteria for clearance of athletes with suspected myocarditis.[19]

### *Strengths and limitations of the study*

The strength of our study is that all participants were members of a homogeneous group of healthy young athletes. The only change between the 3 previous years and 2020 was the COVID-19 pandemic, so the statistical differences in the data are likely owing to the pandemic. A limitation of this study is that cardiac MRI or biopsy was not done in the diagnosis of myocarditis.

## Conclusion

A serious risk of myocarditis exists in young athletes, so it is important to conduct careful preparticipation screening to identify those athletes who may require additional testing and medical care prior to a return to sports. Because the rate of myocarditis related to abnormal ST or T waves might be high, it is important to perform additional cardiac testing and to place all children with such findings under permanent observation because even asymptomatic myocarditis might result in permanent heart damage and even sudden cardiac death in a worst-case scenario.

### Ethics statement

This research study was conducted retrospectively using data obtained for clinical purposes. The study was approved by the Ethical Committee of the Novi Sad Health Care Centre (approval no. 21/1-1 of 21.1.2021). Informed verbal consent was given by the parents of the child whose case is described in detail.

### Declaration of conflicting interest

The authors declare that there is no conflict of interest.

### Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

### ORCID iDs

Zoran Šarčević https://orcid.org/0000-0001-8115-1430
Andreja Tepavčević https://orcid.org/0000-0002-5716-604X

### References

1. Grasselli G, Zangrillo A, Zanella A, et al. Baseline characteristics and outcomes of 1591 patients infected with SARS-CoV-2 admitted to ICUs of the Lombardy region, Italy. *JAMA* 2020; 323: 1574–1581. doi:10.1001/jama.2020.5394.
2. Chiu JS, Lahoud-Rahme M, Schaffer D, et al. Kawasaki disease features and myocarditis in a patient with COVID-19. *Pediatr Cardiol* 2020; 41: 1526–1528. doi: 10.1007/s00246-020-02393-0.
3. Ece İ, Koçoğlu M, Kavurt AV, et al. Assessment of cardiac arrhythmic risk in children with Covid-19 infection. *Pediatr Cardiol*. 2021; 42: 264–268. doi: 10.1007/s00246-020-02474-0.
4. Niaz T, Hope K, Fremed M, et al. Role of a pediatric cardiologist in the COVID-19 pandemic. *Pediatr Cardiol* 2021; 42: 19–35. doi:10.1007/s00246-020-02476-y.
5. Baggish A, Drezner JA, Kim J, et al. Resurgence of sport in the wake of COVID-19: Cardiac considerations in competitive athletes. *Br J Sports Med* 2020; 54: 1130–1131. doi: 10.1136/bjsports-2020-102516.
6. Spencer R, Ch NH, Potter K, et al. COVID-19 and the young heart: What are we missing? *World J Pediatr* 2020; 16: 553–555. doi:10.1007/s12519-020-00391-z.
7. 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: 219–227. doi: 10.1001/jamacardio.2020.5890.
8. Harmon KG, Zigman M and Drezner JA. The effectiveness of screening history, physical exam, and ECG to detect potentially lethal cardiac disorders in athletes: A systematic review/meta-analysis. *J Electrocardiol* 2015; 48: 329–338. doi: 1016/j.jelectrocard.2015.02.001.
9. Corrado D, Pelliccia A, Bjørnstad HH, et al.; Study Group of Sport Cardiology of the Working Group of Cardiac Rehabilitation and Exercise Physiology and the Working Group of Myocardial and Pericardial Diseases of the European Society of Cardiology. Cardiovascular preparticipation screening of young competitive athletes for prevention of sudden death: Proposal for a common European protocol. Consensus Statement of the Study Group of Sport Cardiology of the Working Group of

Cardiac Rehabilitation and Exercise Physiology and the Working Group of Myocardial and Pericardial Diseases of the European Society of Cardiology. *Eur Heart J* 2005; 26: 516–524. doi: 10.1093/eurheartj/ehi108.
10. Drezner JA, Sharma S, Baggish A, et al. International criteria for electrocardiographic interpretation in athletes: Consensus statement. *Br J Sports Med* 2017; 51: 704–731. doi: 10.1136/bjsports-2016-097331.
11. Nakagawa M, Sato A, Okagawa H, et al. Detection and evaluation of asymptomatic myocarditis in schoolchildren: Report of four cases. *Chest* 1999; 116: 340–345. doi: 10.1378/chest.116.2.340.
12. IOC Manual of Sports Cardiology, Wilson MG, Drezner JA, Sharma S, eds. Wiley Blackwell 2017. doi: 10.1002/9781119046899.
13. Gagnier JJ, Kienle G, Altman DG, et al.; CARE Group. The CARE guidelines: Consensus-based clinical case reporting guideline development. *Headache* 2013; 53: 1541–1547.
14. Romero, J, Alviz, I, Parides, M et al. T-wave inversion as a manifestation of COVID-19 infection: A case series. *J Interv Card Electrophysiol* 2020; 59: 485–493. doi: 10.1007/s10840-020-00896-7.
15. Castiello T, Georgiopoulos G, Finocchiaro G, et al. COVID-19 and myocarditis: A systematic review and overview of current challenges. *Heart Fail Rev* 2021 24: 1–11. doi: 10.1007/s10741-021-10087-9.
16. Martinez MW, Tucker AM, Bloom OJ, et al. Prevalence of inflammatory heart disease among professional athletes with prior COVID-19 infection who received systematic return-to-play cardiac screening. *JAMA Cardiol* 2021; 6: 745–752. doi:10.1001/jamacardio.2021.0565.
17. Starekova J, Bluemke DA, Bradham WS, et al. Evaluation for myocarditis in competitive student athletes recovering from coronavirus disease 2019 with cardiac magnetic resonance imaging. *JAMA Cardiol* 2021; 6: 945–950. doi:10.1001/jamacardio.2020.7444.
18. Daniels CJ, Rajpal S, Greenshields JT, et al. Prevalence of clinical and subclinical myocarditis in competitive athletes with recent SARS-CoV-2 infection: Results from the Big Ten COVID-19 Cardiac Registry. *JAMA Cardiol* 2021; 6: 1078–1087. doi:10.1001/jamacardio.2021.2065.
19. Raukar NP and Cooper LT. Implications of SARS-CoV-2-associated myocarditis in the medical evaluation of athletes. *Sports Health* 2021; 13: 145–148. doi: 10.1177/1941738120974747.