



Special Article

COVID-19—Myocarditis and Return to Play: Reflections and Recommendations From a Canadian Working Group

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ABSTRACT

The COVID-19–related pandemic has resulted in profound health, financial, and societal impacts. Organized sporting events, from recreational to the Olympic level, have been cancelled to both mitigate the spread of COVID-19 and protect athletes and highly active individuals from potential acute and long-term infection-associated harms. COVID-19 infection has been associated with increased cardiac morbidity and mortality. Myocarditis and late gadolinium

RÉSUMÉ

La pandémie de COVID-19 causée par le virus SRAS-CoV-2 a eu de profondes répercussions sanitaires, financières et sociétales. Les événements sportifs organisés, depuis les sports de loisir jusqu'aux Jeux olympiques, ont été annulés afin de limiter la propagation de la COVID-19 et de protéger les athlètes et les personnes très actives des torts potentiels à court et à long terme liés à la maladie. La COVID-19 a été associée à une hausse de la morbidité et de la mortalité d'origine

Preamble

The COVID-19 pandemic has resulted in major changes to all activities, including sport. These are the consequence of recommendations from health and government authorities and individual restraint due to health concerns. With care, some Canadian jurisdictions are now cautiously easing restrictions to permit the resumption of sport, and organizations and individuals are seeking direction on how best to address

the health of athletes or highly active individuals. Specifically, guidance is required on how to evaluate those who have been infected or possibly infected with COVID-19 to ensure both safe sport reintegration and their individual well-being.

Questions regarding return to play include:

- (1) What, if any, screening above and beyond current public health recommendations should be performed to assess exposure or possible infection with COVID-19?
- (2) What testing recommendations should be pursued in athletes and highly active individuals with previously confirmed COVID-19 infection wishing to return to play?
- (3) How can a shared decision-making approach be implemented in the context of a return-to-play decision?

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enhancement as a result of COVID-19 infection have been confirmed. Correspondingly, myocarditis has been implicated in sudden cardiac death of athletes. A pragmatic approach is required to guide those who care for athletes and highly active persons with COVID-19 infection. Members of the Community and Athletic Cardiovascular Health Network (CATCHNet) and the writing group for the Canadian Cardiovascular Society/Canadian Heart Rhythm Society Joint Position Statement on the Cardiovascular Screening of Competitive Athletes recommend that highly active persons with suspected or confirmed COVID-19 infection refrain from exercise for 7 days after resolution of viral symptoms before gradual return to exercise. We do not recommend routine troponin testing, resting 12-lead electrocardiography, echocardiography, or cardiac magnetic resonance imaging before return to play. However, medical assessment including history and physical examination with consideration of resting electrocardiography and troponin can be considered in the athlete manifesting new active cardiac symptoms or a marked reduction in fitness. If concerning abnormalities are encountered at the initial medical assessment, then referral to a cardiologist who cares for athletes is recommended.

Members of the Community and Athletic Cardiovascular Health Network (CATCHNet) and writing group for the Canadian Cardiovascular Society/Canadian Heart Rhythm Society Joint Position Statement on the Cardiovascular Screening of Competitive Athletes have summarized their approach to these important considerations during this time of transition. The focus is on return to play of athletes (defined as highly active persons who exercise or compete regularly at either a recreational or a competitive level) with suspected or confirmed COVID-19 infection. This document is intended to supplement the Canadian Cardiovascular Society/Canadian Heart Rhythm Society Joint Position Statement on the Cardiovascular Screening of Competitive Athletes to provide further direction for active individuals who may not be under the umbrella of a cardiovascular (CV) screening program.

Background

The COVID-19 pandemic has had profound worldwide health, economic, and societal impacts, including substantial impact on the sporting world. Gymnasiums, recreation centres, and arenas were shuttered, and collegiate sports and the Olympics were postponed to both mitigate the spread of COVID-19 and protect exercisers and athletes. Despite the cessation of organized sports and restrictions placed on the use of venues to perform exercise, athletes (from recreational to highly competitive individuals) may contract COVID-19. In addition to the deleterious cardiac and respiratory effects imposed by the virus, the cessation of sports and implementation of health authority—mandated quarantine to prevent the spread of the virus may pose additional negative consequences on an

cardiaque. On sait déjà que la COVID-19 peut provoquer une myocardite et un rehaussement tardif au gadolinium, et on sait aussi que la myocardite peut entraîner une mort cardiaque subite chez les athlètes. Une approche pragmatique s'impose afin d'aider les praticiens qui traitent des athlètes et des personnes très actives ayant contracté la COVID-19. Les membres du réseau CATCHNet (*Community and Athletic Cardiovascular Health Network*) et les auteurs de l'énoncé de position émis conjointement par la Société canadienne de cardiologie et la Société canadienne de rythmologie sur le dépistage cardiovasculaire des athlètes de compétition recommandent aux personnes très actives ayant une infection au virus de la COVID-19 soupçonnée ou confirmée de s'abstenir de faire des activités physiques pendant 7 jours après la disparition des symptômes de l'infection virale et de reprendre ensuite graduellement leurs activités. Nous ne recommandons pas systématiquement la mesure de la troponine, l'obtention d'un électrocardiogramme à 12 dérivations au repos, ni la réalisation d'une échocardiographie ou d'un examen d'imagerie cardiaque par résonance magnétique avant la reprise de l'activité physique. Une évaluation médicale comprenant une anamnèse et un examen physique incluant possiblement une électrocardiographie au repos et la mesure de la troponine peut toutefois être envisagée dans le cas d'un athlète présentant de nouveaux symptômes cardiaques évolutifs ou une diminution marquée de sa condition physique. Si des anomalies préoccupantes sont détectées à l'évaluation médicale initiale, il est recommandé d'orienter le patient vers un cardiologue spécialisé dans le traitement des athlètes.

individual's well-being by affecting one's psychosocial health (increased anxiety, depression, weight gain, social deprivation, fear of seeking medical help, and school dropout).

Myocarditis is a concerning potential consequence of COVID-19 infection.¹ Myocarditis has been demonstrated to cause heart failure and sudden cardiac arrest/death.² Those who care for athletes or highly active individuals are faced with making "return-to-play" recommendations for those who have suffered a COVID-19 infection. A pragmatic contextual approach that considers available health resources is required. In Canada, and many other jurisdictions with resource-limited public health systems that are stressed, particular considerations apply that form the background for the present document. The desire to investigate and to potentially increase safety in this area of clinical uncertainty must be balanced by thoughtful resource utilization and the risks and consequences of overinvestigation given the potential risks of unduly alarming athletes and restricting sport participation.

COVID-19 Cardiovascular Effects

COVID-19 infection can result in CV morbidity and mortality in hospitalised adult patients.^{3,4} Myocardial injury (elevation in cardiac troponin) is common in severe COVID-19 infection (38% of hospitalised patients) and if present is associated with a marked increased mortality compared with those without myocardial injury (51.2% vs 4.5%).³ The degree and magnitude of myocardial injury in nonhospitalised persons with COVID-19 infection (including asymptomatic COVID-19 persons) is unknown, because evaluation for markers of myocardial injury is not routinely carried out. The etiology of the myocardial injury is presumably multifactorial,

Table 1. Comparison of return-to-play recommendations after COVID-19 infection

Factor	Proposed Canadian recommendations	<i>British Journal of Sports Medicine</i> ²⁸	<i>JAMA Cardiology</i> ¹²	<i>European Journal of Preventative Cardiology</i> ²⁷	Canadian Olympic and Paralympic Sport Institute Network ²⁹
Time before return to sport after infection (positive test)	7 days after resolution of viral symptoms	Not specified	14 days from positive test result	Symptom free for 7 days	Symptom free for 10 days
RTP evaluation stratified by symptoms	No	Yes	Yes	Yes/no	Yes
Asymptomatic (COVID-19—positive test, no COVID-19 symptoms)	Focused cardiac symptom history. If cardiac symptoms are present or a new reduction in fitness is present, then medical assessment is recommended.	Focused medical history and physical examination. Consider 12-lead ECG. If ECG is abnormal or shows new repolarization changes compared with a prior ECG, then additional evaluation with at minimum echocardiography and exercise test is warranted in conjunction with a sports cardiologist.	Rest/no exercise for 2 weeks from positive test result. Close monitoring for symptom onset or late deterioration. Slow resumption of activity 2 weeks after positive test result under guidance of health care team.	Refrain from exercise for 7 days, gradual return to exercise if remaining symptom free, can consider repeated COVID-19 testing.	Consultation with a physician for a history of physical examination. Based on clinical assessment and if prior cardiac history, the following could be ordered: CRP, troponin, and ECG (consider ECG if athlete has preexisting ECG). If ECG is abnormal proceed to echocardiogram. If abnormal investigations refer to (sports) cardiologist.
Symptomatic (COVID-19—positive test, COVID-19 symptoms present)	After resolution of viral symptoms, address presence of cardiac symptoms. The absence or presence and severity of COVID-19 viral symptoms affects cardiac evaluation framework. Focused cardiac symptom history. If cardiac symptoms are present or a new reduction in fitness is present, then medical assessment is recommended.	Mild symptoms, not hospitalised. Focused medical history and physical examination to screen for persistent or new postinfectious findings following COVID-19 infection. Perform 12-lead ECG. If ECG is abnormal or shows new repolarization changes compared with an earlier ECG, then additional individualized evaluation is warranted, including at minimum echocardiography and exercise testing, in conjunction with a sports cardiologist.	Mild symptoms, not hospitalised: <ul style="list-style-type: none"> • Rest/recovery with no exercise. Consider further cardiac testing and/or hospitalisation if development of cardiac symptoms. Evaluation by a medical professional for consideration of return to activity: <ul style="list-style-type: none"> • hsTn • ECG • Echocardiography • Consider additional symptom-guided testing. If normal, slow return to activity and follow for clinical deterioration. If troponin elevated or abnormal cardiac study, follow myocarditis guidelines. ^{1,2}	Consider clinical assessment including troponin and CRP. If troponin is positive, then consider 12-lead ECG, echocardiography, CMR, and long-term ECG monitoring. If no evidence of cardiac involvement and symptom free, consider gradual RTP after an additional 7 days.	Consultation with a physician for a history and physical examination. Based on clinical assessment and if prior cardiac history, the following could be ordered: CRP, troponin, and ECG (consider ECG if athlete has preexisting ECG). If ECG is abnormal proceed to echocardiogram. If abnormal investigations, refer to (sports) cardiologist.

Continued

Table 1. Continued.

Factor	Proposed Canadian recommendations	British Journal of Sports Medicine ²⁸	JAMA Cardiology ¹²	European Journal of Preventive Cardiology ²⁷	Canadian Olympic and Paralympic Sport Institute Network ²⁹
Severe/hospitalised	We do not recommend stratifying based on severity of COVID-19 symptoms. On discharge from hospital, cardiac history should be implemented before return to exercise. If significant cardiac diagnoses (myocarditis) are diagnosed during hospitalisation, then follow myocarditis return-to-play guidelines. Focused cardiac symptom history: If cardiac symptoms are present or a new reduction in fitness is present then medical assessment is recommended.	Comprehensive evaluation before return to sport, in conjunction with a sports cardiologist, to include blood biomarker assessment (hs-Tn and BNP), 12-lead ECG, echocardiography, exercise testing, and ambulatory rhythm monitoring. If an athlete has documented myocardial injury (ECG changes, elevated troponin or BNP, arrhythmia or impaired cardiac function), regardless of symptom severity, require comprehensive evaluation by sports cardiologist with CMR before RTP, and longitudinal follow-up if abnormal cardiac function.	During hospitalisation: • hsTn. • Consider cardiac imaging per local protocols. If normal, gradual RTP after 2 weeks and close monitoring for clinical deterioration. If troponin elevated or abnormal cardiac study, follow myocarditis guidelines. ¹²	—	If systemic symptoms > 10 days, physician assessment with history and physical examination, troponin, CRP, ECG, echocardiography, and spirometry. If abnormal investigations, refer to (sports) cardiologist.

BNP, B-type natriuretic peptide; CMR, cardiac magnetic resonance; CRP, C-reactive protein; ECG, 12-lead electrocardiography; hs-Tn, high-sensitivity troponin; RTP, return to play.

and it is unclear what proportion of it represents direct viral or inflammatory myocardial damage (myocarditis) vs myocardial injury from hemodynamic or hypoxic stress following serious COVID-19 respiratory illness. Therefore, the proportion with, the etiology of, and prognostic value of elevated troponin levels in nonhospitalised COVID-19 patients remains unclear.

Myocarditis

Myocarditis is an inflammatory disease of the heart characterised by inflammatory infiltrates and myocardial injury of heterogeneous etiology not from an ischemic cause.⁵ The acute phase (1-3 days) of viral myocarditis is characterized by pathognomonic myocyte necrosis induced by virus replication after infection occurs. Exposure of intracellular antigens may lead to the humoral activation and cellular immunologic processes aimed to eliminate the virus from the myocardium. Humoral activation to eliminate the virus from the myocardium follows and may persist for several weeks to months. Immunologic activation, independently from viral genome detection, results in chronic postinfectious autoimmune myocarditis.⁶ Epidemiologic studies have estimated the incidence of viral myocarditis in the pre-COVID-19 era to be 1.0-2.2 per 1,000,000 per year in adults.⁷

Myocarditis can result in scarring of the heart, ventricular dysfunction (transient or permanent), ventricular arrhythmias, cardiogenic shock, and sudden cardiac death (SCD).⁵ Occult myocarditis has been implicated as a cause of SCD among young healthy individuals. Myocarditis was identified to be the third leading cause of SCD, at 6%, after coronary artery abnormalities (17%) and hypertrophic cardiomyopathy (36%), in young competitive American athletes.⁸ It is important to note, however, that the overall incidence of SCD in this population from 1980 to 2006 was estimated to be 0.61 per 100,000 athlete-years. In a contemporary autopsy series of the general population from Australia and New Zealand (ages 1-35 years), myocarditis accounted for 7% of all SCD. In a sudden cardiac arrest (SCA) series of competitive athletes from Ontario, Canada, 1 out of 16 arrests was possibly due to myocarditis; echocardiography and electrocardiography (ECG) were normal, whereas the MRI demonstrated scar. The overall incidence of SCA in that population was 0.76 per 100,000 athlete-years.⁹ Among collegiate athletes in the National Collegiate Athletic Association (NCAA), 10% of SCD was attributed to myocarditis (overall incidence of SCD in this population was 1 per 53,703 athlete-years).¹⁰ To put this into perspective, SCD attributed to myocarditis is 1 in 537,634 athlete-years in the NCAA, 1 in 1,098,901 athlete-years in the general population of young persons in Australia and New Zealand, and 1 in 2,732,240 athlete-years in the study of American young athletes from 1980 to 2006.^{8,10,11} Exercise in individuals with overt myocarditis may result in accelerated viral replication, increased inflammation and cellular necrosis, and a proarrhythmic myocardial substrate.^{12,13} COVID-19 has been implicated in the development of myocarditis, with accumulating pathologic and imaging confirmation.¹⁴⁻¹⁶

Cardiac magnetic resonance (CMR) imaging data in recovered hospitalised and nonhospitalised COVID-19 patients and nonhospitalised asymptomatic or minimally symptomatic collegiate athletes have led to concern about the

Table 2. Diagnostic criteria for clinically suspected myocarditis

Newly abnormal 12-lead electrocardiography, Holter monitoring, and/or stress testing, any of the following:
<ul style="list-style-type: none"> • First- to third-degree atrioventricular block • Bundle branch block • ST/T-wave change (ST-segment elevation or non-ST-segment elevation, T-wave inversion) • Sinus arrest • Ventricular tachycardia or fibrillation and asystole • Atrial fibrillation, supraventricular tachycardia • Low QRS voltage • Frequent premature ventricular contractions
Markers of myocardial injury
<ul style="list-style-type: none"> • Troponin I/troponin T
Functional and structural abnormalities on cardiac imaging
Echocardiography, angiography, and/or CMR:
<ul style="list-style-type: none"> • Regional or global systolic or diastolic dysfunction, with or without left ventricular dilation • Increased wall thickness • Pericardial effusion • Intracavitary thrombi
Tissue characterization by CMR (updated Lake Louise criteria*)
<ul style="list-style-type: none"> • Edema • Hyperemia or capillary leak (early gadolinium enhancement) • Irreversible injury (necrosis, scar; late gadolinium enhancement)

CMR, cardiac magnetic resonance.

Modified from Caforio et al.³⁰ with permission from Oxford University Press.

* Clinically suspected myocarditis if > 1 clinical presentation and > 1 diagnostic criteria from different categories, in the absence of (1) angiographically detectable coronary artery disease (coronary stenosis > 50%) and (2) known preexisting cardiovascular disease or extracardiac causes that could explain the syndrome (eg, valve disease, congenital heart disease, hyperthyroidism). Suspicion is higher with higher number of fulfilled criteria. If the patient is asymptomatic, > 2 diagnostic criteria should be met.

prevalence of late gadolinium enhancement (LGE) given its potential to represent subclinical or minimally symptomatic myocarditis.^{4,5,17} Results from a much critiqued German study demonstrated some degree of CMR imaging abnormalities in 78% of recovered hospitalised and nonhospitalised COVID-19 general population patients (median age 49 years) who underwent non-clinically indicated CMR; CMR was for research purposes and not for the intention of diagnosing suspected myocarditis. Sixty percent of patients had evidence of ongoing inflammation (edema) and 32% had evidence of LGE at a median 71 days after infection. There was an increased prevalence of LGE in the COVID-19 patients compared with healthy and risk factor-matched control groups. However, ventricular size and biventricular function were within normal limits.⁴ The impact of the CMR abnormalities on ventricular arrhythmias, ECG, and echocardiographic findings was not reported in the study.

In a population of COVID-19-positive American collegiate athletes (mean age 20.2 years) who underwent a CMR at a median 52 days after infection, LGE was found in 9%, with 1 athlete (5%) meeting the diagnosis of myocarditis.⁶ None of the age-matched healthy control subjects and COVID-19-negative athletes had evidence of LGE or myocarditis.¹⁸ Most relevant to the return-to-play discussion from the findings of this small study is that among the COVID-19-positive athletes who had ECG (20/22), troponin (18/22), or echocardiographic (21/22) testing, all had normal results. The 2 COVID-19-positive athletes who demonstrated inferoseptal LGE on CMR had normal ECGs, negative troponin I, and normal echocardiograms with normal strain imaging. The only athlete diagnosed with myocarditis

endorsed symptoms consistent with acute pericarditis and exertional chest tightness.¹⁸

In a separate study, 26 competitive collegiate athletes from Ohio with confirmed COVID-19 (46% mildly symptomatic, 54% asymptomatic) underwent ECG, troponin testing, and echocardiography on the same day as CMR.¹⁷ No diagnostic ST/T-wave changes on ECG were reported. Echocardiography-derived ventricular volumes and function were within normal limits. Troponin I was not elevated in any athlete. Nearly half of the athletes (46%) had evidence of LGE. Four athletes (15%) had CMR findings consistent with myocarditis based on the updated Lake Louise criteria.⁶ Two athletes with CMR evidence of myocarditis had coexisting pericardial effusions. Of the 4 athletes with myocardial inflammation, 2 were asymptomatic and 2 had mild symptoms (shortness of breath).¹⁷ There was no COVID-19-negative control group in this study.

When considering return-to-play decisions for athletes with prior COVID-19 infection, interpretation of the results of the studies published thus far^{17,18} warrants careful consideration. These exploratory observations include a total of 48 elite collegiate-level athletes, where 5 athletes (10%) met criteria for myocarditis and 29% demonstrated LGE. Whether the degree of myocardial injury can be extrapolated to other active populations is unknown.

LGE from non-COVID-19 symptomatic myocarditis has been associated with ventricular arrhythmias and SCD in athletes.¹⁹ Furthermore, persisting LGE after biopsy-proven myocarditis is independently associated with an increased risk of SCD and overall mortality.²⁰ However, the long-term prognoses of incidentally detected CMR abnormalities, particularly in those not meeting diagnostic criteria for myocarditis, and in a predominantly asymptomatic post-COVID-19 population remain unknown. In a study of patients fulfilling diagnostic criteria of myocarditis (non-COVID-19 in origin), the majority (50%) had regression in the amount of LGE at 3 months, and some (17%) experienced complete resolution of LGE by that time.^{6,21} Regarding COVID-19 myocarditis and presumed COVID-19 infection-mediated LGE (some athletes may have had preexisting LGE from non-COVID causes), we do not yet know the magnitude of change in LGE with time, because follow-up imaging studies have yet to be reported. Another unknown factor is the magnitude of potential increased SCD risk that exercise poses in a person with subclinical LGE. Even if the subclinical LGE is determined to be secondary to COVID-19 infection and represents a potential arrhythmic substrate, the extent of risk exercise poses remains uncertain.

How the results from CMR studies in athletes fit into contemporary expert return-to-play recommendations for myocarditis is unclear. In both studies, the athletes with LGE had normal troponin levels, normal ECGs, and normal biventricular function on echocardiography; therefore, athletes with subclinical LGE would not be expected to be identified via conventional return-to-play testing modalities.^{17,18} In the absence of significant persistent symptoms or concerning ECG abnormalities on prolonged ECG monitoring and stress testing, the majority of these patients would have been cleared to return to play (European Society of Cardiology 2020; American Heart Association/American College of Cardiology 2015).²²⁻²⁵ The presence of LGE, in and of itself, does not currently represent a rationale for ongoing exercise restriction beyond the acute inflammatory period, provided that no other

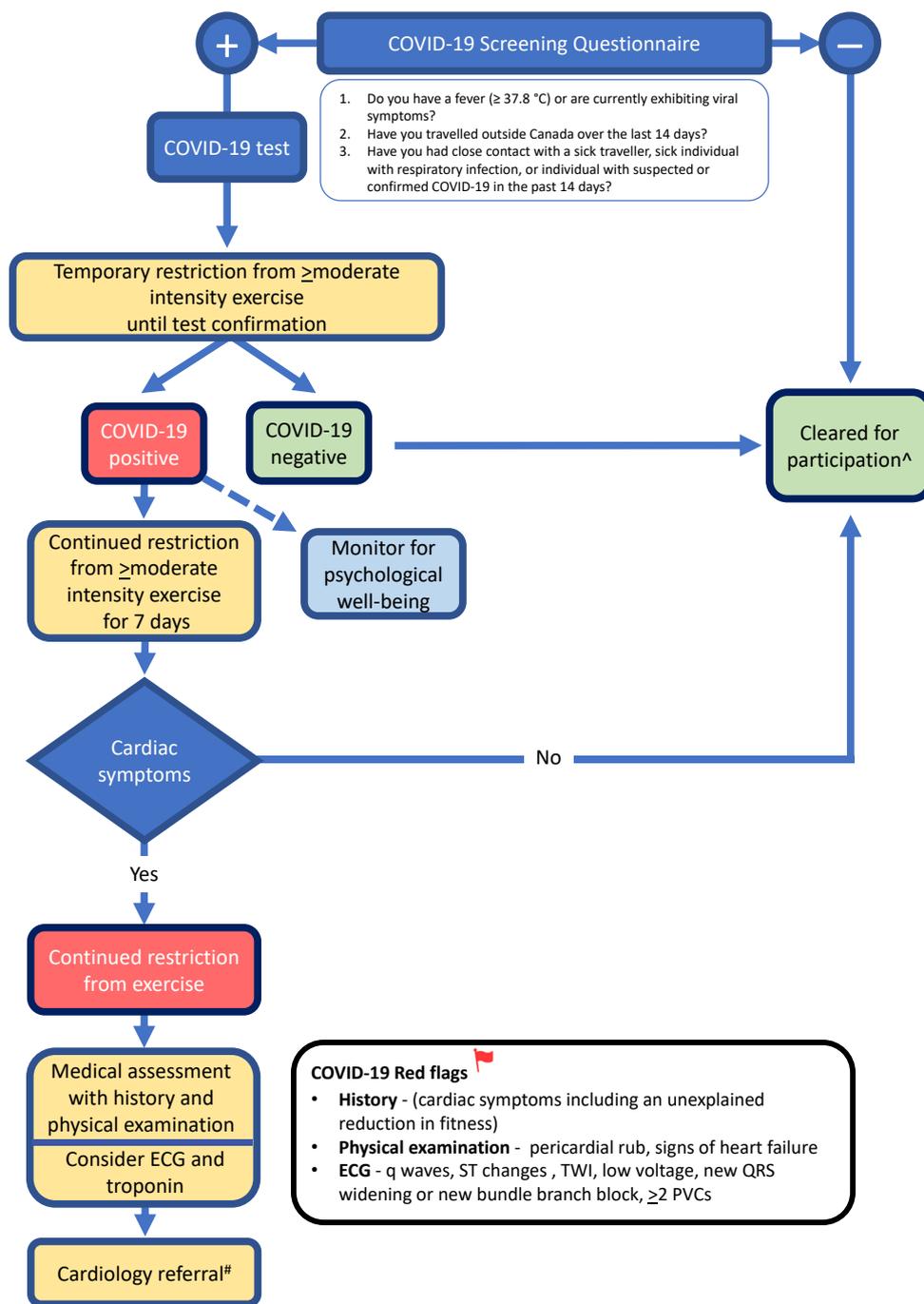


Figure 1. Suggested return to play for athletes and highly active persons in the context of COVID-19 considerations. Medical assessment should include a detailed cardiac history and physical examination. It may also include resting 12-lead electrocardiography (ECG) and troponin. If an active person develops new cardiac symptoms regardless of COVID-19 status, clinically indicated evaluation is recommended. #If red flags are identified, then cardiology referral is recommended. PVC, premature ventricular contraction; TWI, T-wave inversion.

abnormalities are present at return-to-play testing (symptoms, abnormal exercise stress testing, or abnormal prolonged ECG monitoring).²²⁻²⁵ Per the European Society of Cardiology guidelines, an athlete is permitted to resume sport in the presence of LGE if there is an absence of left ventricular (LV) dysfunction and ventricular arrhythmias and a normalization of biomarkers.²⁰ To be clear, we are not advocating that CMR

should never be performed in the context of COVID-19—suspected myocarditis, but we are recommending against the routine use of CMR in athletes with suspected or confirmed COVID-19 in the absence of other concerning clinical or diagnostic findings. CMR may be used to help confirm clinically suspicious myocarditis, as well as to guide prognosis.^{6,20} Regarding resource utilization and stewardship, it

Table 3. COVID-19 return-to-play questionnaire

Since confirmed or suspected COVID-19 infection, have you experienced any of the following:
a. Fainting or sudden loss of consciousness
b. Chest pain, chest pressure, sharp pain in the heart or lungs when breathing or lying down
c. Shortness of breath at rest or with exertion
d. Increase in resting heart rate by > 20 beats per minute
e. Palpitations (heart racing, heart skipping or dropping beats)
f. Marked reduction in fitness.

should be noted that if LGE is discovered, follow-up clinical consultation and CMR is recommended.²⁶

Differing approaches to return-to-play

Differing return-to-play guidelines for patients with either asymptomatic or mildly symptomatic COVID-19 infections exist, reflecting an area of substantial clinical uncertainty. A number of approaches have been proposed.^{12,27,28} All recommendations propose that the extent of evaluation be stratified by the severity of symptoms.

Asymptomatic athletes. COVID-19—positive individuals who are asymptomatic are recommended to abstain from activity for a 2-week period before a graded return to exercise.²⁸ Recommendations by the Sports Cardiology and Exercise Section of the European Association of Preventive Cardiology²⁷ and those appearing in *JAMA Cardiology*¹² suggest no cardiac evaluation, whereas recommendations set forward in the *British Journal of Sports Medicine*²⁸ suggest consideration of resting 12-lead ECG.²⁸

Symptomatic athletes. For symptomatic athletes with documented COVID-19 infection who do not require hospitalisation, medical evaluation recommendations also vary. The Sports Cardiology and Exercise Section of the European Association of Preventive Cardiology suggest consideration of troponin and C-reactive protein testing. If troponin is abnormal, then further testing with ECG, echocardiography, CMR, and ECG monitoring (Holter) are recommended.²⁷ Conversely, the *British Journal of Sports Medicine* recommendations suggest starting with resting 12-lead ECG for symptomatic nonhospitalised individuals. If the ECG is abnormal or shows new repolarization changes compared to a prior ECG, then echocardiography (at a minimum) and cardiology consultation is recommended.²⁸ The Canadian Olympic and Paralympic Sport Institute Network also have developed recommendations for Canada's elite athletes.²⁹ A summary of the different recommendations is presented in [Table 1](#). If testing results in a diagnosis of myocarditis ([Table 2](#)), then formal guidelines for sport participation should be followed.^{24,25} According to guidelines, for confirmed cases of myocarditis, it is recommended that athletes refrain from exercise programs for a period of 3-6 months to help ensure biological and clinical resolution of the disease.^{24,25} Current expert consensus recommended approaches to return to play after COVID-19 infection agree that patients with confirmed myocarditis be treated in keeping with previously established guidelines. At present, there is no evidence that COVID-19—associated myocarditis is substantially clinically different from other forms of myocarditis that might justify alternative approaches to care.

Resumption of training is permitted after the period of restriction, provided that LV function and serum biomarkers have normalized, and there is an absence of symptoms and clinically significant arrhythmia on ECG exercise stress testing and ECG ambulatory monitoring.^{24,25} In some cases, normalization of parameters may be faster than 3-6 months. This recommendation (3-6 months) is arbitrary, and there are instances where earlier return to play may be considered.

Proposed return-to-play recommendations

The absolute numbers of highly active persons engaging in sporting activity with potential COVID-19 diagnosis is not insignificant (and may increase if virus spread increases), so a pragmatic approach to return-to-play screening is required, reflecting the clinical uncertainty regarding risk and the virtual impossibility of conducting mass CV testing of large segments of the population. We are only now developing an understanding of the prevalence and magnitude of cardiac involvement following COVID-19 infection. The long-term cardiac implications of COVID-19 infection are unknown. A cautious approach regarding the return to high-intensity exercise (> 70% VO_{2max}; > 75% maximum heart rate) must meet the challenge of reducing SCD risk for athletes while minimizing the likelihood of inappropriate restriction. It is difficult to overlook the growing number of reports describing lingering CMR abnormalities in COVID-19 patients despite the mild severity of their illness. However, it is not feasible, nor practical, to perform CMR on every COVID-19—positive exerciser, nor do we fully understand the implications of CMR findings in this context. In the small studies of collegiate COVID-19—positive athletes, for example, evaluation with ECG, troponin, and echocardiography were all reported as being within normal limits and would not have identified the athletes with LGE on CMR.^{17,18} Based on currently available evidence, and in the context of the uncertain prognostic implications, our group has recommended against routine troponin, ECG, echocardiography, and CMR in asymptomatic athletes with confirmed or suspected COVID-19 infection before exercise resumption.

Nevertheless, in concordance with the Canadian Cardiology Society position statement,³¹ when considering return-to-play evaluation, a shared decision-making approach with the patient/athlete is strongly recommended.³² In this respect, a COVID-19—positive athlete who has recovered from acute infection should be made aware of the limitations of the investigations for myocarditis, and the implications of a myocarditis diagnosis, which would lead to the recommendation of restriction from sport for 3-6 months and potentially longer, in association with ongoing follow-up. The health of the individual who is found to have significant cardiac abnormalities that may increase the risk of SCD is still of paramount focus for the physician. Within the Canadian system, the role of the physician is to diagnose, treat, and provide recommendations to the athlete while acknowledging limitations in prediction and prognostication, not to “disqualify” the athlete, unless the physician is under contract by a third party and not acting on behalf of the athlete but that of his or her employer or institution. Athletes and health care providers should also be educated about

symptoms and recommended to exercise caution when gradually returning to high-intensity exercise. In addition, it is imperative that an athlete's mental well-being is not neglected. A COVID-19 diagnosis in itself, let alone referral for cardiology evaluation with possible restriction from sport, may have potential deleterious effects on one's psychologic well-being. Given the global mental health crisis that has accompanied this pandemic, competitive and student athletes are among the many subpopulations that may present with heightened levels of anxiety, depression, and worry.³³⁻³⁵ A properly executed shared decision-making process, as well as the integration of psychologic follow-up and intervention when necessary (particularly for COVID positive athletes who are restricted from participation), is recommended to reduce the overall mental health burden to athletes returning to play.

Cardiac evaluation of a highly active person with cardiac symptoms is clinically indicated and far more likely to identify persons at a higher SCD risk as opposed to mass screening of a population merely presumed to be at risk. A stratified approach based on new cardiac symptoms or diminished exercise performance is recommended. The stratification of COVID symptoms as mild, moderate, and severe can be ambiguous, and there is no strong correlation between the severity of COVID-19 symptoms and associated degree of myocardial injury and cardiac involvement. For all athletes returning to play, it is recommended that they be surveyed for current and prior or suspected COVID-19 infection in addition to new cardiac symptoms (Fig. 1). In the setting of organized systematic CV screening for competitive athletes as outlined in the Canadian Cardiovascular Society Position Statement on the Cardiovascular Screening of the Young Athlete, it is essential that the presence of high-quality emergency protocols (cardiopulmonary resuscitation training, automated external defibrillator accessibility, emergency action plan preparedness), remains the foundational element on which the safety of athletes rests, as potential long-term outcomes in terms of COVID-19 and SCA remain unknown.³⁶

RECOMMENDATION

Athletes and highly active persons with suspected or confirmed COVID-19 infection and those who have recovered (no active viral symptomatology) with no new active cardiac symptoms and no marked reduction in exercise capacity.

1. (1) Graded return to exercise at least 7 days after complete viral symptom resolution.
- (2) No additional screening testing required.

Practical tips. After complete viral symptom resolution, and if no active cardiac symptoms [palpitations, syncope, chest pain, dyspnea, unexplained increase in heart rate (Table 3)] are present, then a graded return to exercise ≥ 7 days after

complete viral symptom resolution is recommended.³⁷ Continued monitoring for cardiac symptoms and inability to regain fitness or a reduction in exercise capacity or performance is recommended. Routine troponin testing is not recommended in the asymptomatic athlete before return to play. If an athlete is within the context of an established CV screening program (ie, collegiate, competitive sporting league, professional) and the physical examination and ECG are established components of that institutions' cardiac evaluation, the recommendation is to continue as previously. However, if the physical examination is not a component of the CV screening algorithm, we do not recommend implementing it, owing to the low sensitivity of a physical examination to diagnose myocarditis in addition to reducing health care interactions and costs.

RECOMMENDATION

COVID-19—positive or —suspected athletes and highly active persons manifesting with new cardiac symptoms or marked reduction in fitness.

2. (1) Focused history and physical examination.
- (2) Consideration of ECG and troponin.
- (3) If concerning findings on history and physical examination, and/or abnormal troponin and ECG, referral to cardiology and advanced cardiac imaging (echocardiography and/or CMR).

Practical tips. If new or ongoing cardiac symptoms (palpitations, syncope, chest pain, dyspnea, unexplained increase in heart rate) are present after COVID-19 infection, continued restriction from moderate- to high-intensity exercise is recommended. Medical assessment including a detailed cardiac history and physical examination should be performed. Resting 12-lead ECG and troponin testing may be considered as part of the initial evaluation. Cardiology referral is recommended if ECG abnormalities are present (Q waves, ST depression or elevation, T-wave inversion, low voltage, new QRS widening or new bundle branch block, > 2 premature ventricular contractions, > 1 st degree atrioventricular block), troponin is elevated, or there is clinical concern over cardiac symptoms or physical examination. It is reasonable to proceed to CMR in athletes with a clinical diagnosis of myocarditis, overt abnormalities on ECG, echocardiographic abnormalities (wall motion abnormalities, ventricular dysfunction), or clinical deterioration. If myocarditis is diagnosed, strenuous activity should be avoided, and exercise restriction may be considered for 3-6 months.^{23,24} If cardiac investigations are within normal limits but there are ongoing symptoms, longitudinal follow-up may be warranted.

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References

1. Pirzada A, Mokhtar AT, Moeller AD. COVID-19 and myocarditis: What do we know so far? *CJC Open* 2020;2:278-85.
2. Eckart RE, Shry EA, Burke AP, et al. Sudden death in young adults: an autopsy-based series of a population undergoing active surveillance. *J Am Coll Cardiol* 2011;58:1254-61.
3. Shi S, Qin M, Shen B, et al. Association of cardiac injury with mortality in hospitalized patients with COVID-19 in Wuhan, China. *JAMA Cardiol* 2020;5:802-10.
4. Puntmann VO, Carerj ML, Wieters I, et al. Outcomes of cardiovascular magnetic resonance imaging in patients recently recovered from coronavirus disease 2019 (COVID-19). *JAMA Cardiology* 2020;5:1265-73.
5. Siripanthong B, Nazarian S, Muser D, et al. Recognizing COVID-19—related myocarditis: the possible pathophysiology and proposed guideline for diagnosis and management. *Heart Rhythm* 2020;17:1463-71.
6. Ferreira VM, Schulz-Menger J, Holmvang G, et al. Cardiovascular magnetic resonance in nonischemic myocardial inflammation: expert recommendations. *J Am Coll Cardiol* 2018;72:3158-76.
7. Global Burden of Disease Study 2013 Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2015;386(9995):743-800.
8. Maron BJ, Doerer JJ, Haas TS, Tierney DM, Mueller FO. Sudden deaths in young competitive athletes: analysis of 1866 deaths in the United States 1980-2006. *Circulation* 2009;119:1085-92.
9. Landry CH, Allan KS, Connelly KA, et al. Sudden cardiac arrest during participation in competitive sports. *N Engl J Med* 2017;377:1943-53.
10. Harmon KG, Asif IM, Maleszewski JJ, et al. Incidence, cause, and comparative frequency of sudden cardiac death in National Collegiate Athletic Association athletes: a decade in review. *Circulation* 2015;132:10-9.
11. Bagnall RD, Weintraub RG, Ingles J, et al. A prospective study of sudden cardiac death among children and young adults. *N Engl J Med* 2016;374:2441-52.
12. Phelan D, Kim JH, Chung EH. A game plan for the resumption of sport and exercise after coronavirus disease 2019 (COVID-19) infection. *JAMA Cardiol* 2020;5:1085-6.
13. Peretto G, Sala S, Rizzo S, et al. Arrhythmias in myocarditis: State of the art. *Heart Rhythm* 2019;16:793-801.
14. Inciardi RM, Lupi L, Zaccone G, et al. Cardiac involvement in a patient with coronavirus disease 2019 (COVID-19). *JAMA Cardiol* 2020;5:819-24.
15. Tavazzi G, Pellegrini C, Maurelli M, et al. Myocardial localization of coronavirus in COVID-19 cardiogenic shock. *Eur J Heart Fail* 2020;22:911-5.
16. Dolhnikoff M, Ferreira Ferranti J, de Almeida Monteiro RA, et al. SARS-CoV-2 in cardiac tissue of a child with COVID-19—related multisystem inflammatory syndrome. *Lancet Child Adolesc Health* 2020;4:790-4.
17. Rajpal S, Tong MS, Borchers J, et al. Cardiovascular magnetic resonance findings in competitive athletes recovering from COVID-19 infection. *JAMA Cardiol* 2021;6:116-8.
18. Clark DE, Parikh A, Dendy JM, et al. COVID-19 Myocardial Pathology Evaluated Through Screening Cardiac Magnetic Resonance (COMPETE CMR) [preprint]. medRxiv 2020. <https://doi.org/10.1101/2020.2008.2031.20185140>.
19. Zorzi A, Perazzolo Marra M, Rigato I, et al. Nonischemic left ventricular scar as a substrate of life-threatening ventricular arrhythmias and sudden cardiac death in competitive athletes. *Circ Arrhythm Electrophysiol* 2016;9:e004229.
20. Grün S, Schumm J, Greulich S, et al. Long-term follow-up of biopsy-proven viral myocarditis: predictors of mortality and incomplete recovery. *J Am Coll Cardiol* 2012;59:1604-15.
21. Berg J, Kottwitz J, Baltensperger N, et al. Cardiac magnetic resonance imaging in myocarditis reveals persistent disease activity despite normalization of cardiac enzymes and inflammatory parameters at 3-month follow-up. *Circ Heart Fail* 2017;10:e004262.
22. Aquaro GD, Ghebru Habtemicael Y, Camastra G, et al. Prognostic value of repeating cardiac magnetic resonance in patients with acute myocarditis. *J Am Coll Cardiol* 2019;74:2439-48.
23. Pelliccia A, Sharma S, Gati S, et al; ESC Scientific Document Group. 2020 ESC Guidelines on sports cardiology and exercise in patients with cardiovascular disease. *Eur Heart J* 2021;42:17-96.
24. Maron BJ, Udelson JE, Bonow RO, et al. Eligibility and disqualification recommendations for competitive athletes with cardiovascular abnormalities: Task Force 3: hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy and other cardiomyopathies, and myocarditis: a scientific statement from the American Heart Association and American College of Cardiology. *J Am Coll Cardiol* 2015;66:2362-71.
25. Pelliccia A, Solberg EE, Papadakis M, et al. Recommendations for participation in competitive and leisure time sport in athletes with cardiomyopathies, myocarditis, and pericarditis: position statement of the Sport Cardiology Section of the European Association of Preventive Cardiology (EAPC). *Eur Heart J* 2019;40:19-33.
26. Gati S, Sharma S, Pennell D. The role of cardiovascular magnetic resonance imaging in the assessment of highly trained athletes. *JACC Cardiovasc Imaging* 2018;11:247-59.
27. Bhatia RT, Marwaha S, Malhotra A, et al. Exercise in the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) era: a question and answer session with the experts endorsed by the Section of Sports Cardiology & Exercise of the European Association of Preventive Cardiology (EAPC). *Eur J Prev Cardiol* 2020;27:1242-51.

28. Baggish A, Drezner JA, Kim J, Martinez M, Prutkin JM. The resurgence of sport in the wake of COVID-19: cardiac considerations in competitive athletes. *Br J Sports Med* 2020;54:1130-1.
29. Canadian Olympic and Paralympic Sport Institute Network. Return to health and performance following COVID-19 infection. Toronto: Canadian Sport Institute Ontario, 2020.
30. Caforio AL, Pankuweit S, Arbustini E, et al. Current state of knowledge on aetiology, diagnosis, management, and therapy of myocarditis: a position statement of the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. *Eur Heart J* 2013;34:2636-48.
31. Johri AM, Poirier P, Dorian P, et al. Canadian Cardiovascular Society/Canadian Heart Rhythm Society joint position statement on the cardiovascular screening of competitive athletes. *Can J Cardiol* 2019;35:1-11.
32. Moulson N, Dorian P, Krahn A, et al. Shared decision making and the cardiovascular care of athletes: is it time to get back in the game? *Can J Cardiol* 2020;36:941-4.
33. Grubic N, Badovinac S, Johri AM. Student mental health in the midst of the COVID-19 pandemic: a call for further research and immediate solutions. *Int J Soc Psychiatry* 2020;66:517-8.
34. Pillay L, Janse van Rensburg DCC, Jansen van Rensburg A, et al. No-where to hide: the significant impact of coronavirus disease 2019 (COVID-19) measures on elite and semi-elite South African athletes. *J Sci Med Sport* 2020;23:670-9.
35. Torales J, O'Higgins M, Castaldelli-Maia JM, Ventriglio A. The outbreak of COVID-19 coronavirus and its impact on global mental health. *Int J Soc Psychiatry* 2020;66:317-20.
36. Reagan J, Moulson N, Velghe J, et al. Automated external defibrillator and emergency action plan preparedness amongst canadian university athletics. *Can J Cardiol* 2019;35:92-5.
37. Elliott N, Martin R, Heron N, et al. Infographic. Graduated return to play guidance following COVID-19 infection. *Br J Sports Med* 2020;54:1174-5.