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COVID-19 and elite sport: Cardiovascular implications and return-to-play

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ABSTRACT

Curtailing elite sports during the coronavirus disease 2019 (COVID-19) pandemic was necessary to prevent widespread viral transmission. Now that elite sport and international competitions have been largely restored, there is still a need to devise appropriate screening and management pathways for athletes with a history of, or current, COVID-19 infection. These approaches should support the decision-making process of coaches, sports medicine practitioners and the athlete about the suitability to return to training and competition activities. In the absence of longitudinal data sets from athlete populations, the incidence of developing prolonged and debilitating symptoms (i.e., Long COVID) that affects a return to training and competition remains a challenge to sports and exercise scientists, sports medicine practitioners and clinical groups. As the world attempts to adjust toward 'living with COVID-19' the very nature of elite and international sporting competition poses a risk to athlete welfare that must be screened for and managed with bespoke protocols that consider the cardiovascular implications for performance.

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Abbreviations: ACC, American College of Cardiology; AHA, American Heart Association; CMRI, Cardiac magnetic resonance imaging; CPET, Cardiopulmonary exercise testing; CTA, Computed tomography angiography; COVID-19, Coronavirus disease 2019; ECG, Electrocardiogram; FIFA, Federation Internationale de Football Association; GRTP, Graduated return to play; HR, Heart rate; IOC, International Olympic Committee; LGE, Late gadolinium enhancement; NGOs, Nongovernmental organizations; PET, Positron emission tomography; RPE, Rating of perceived exertion; RTP, return-to-play; RV, Right Ventricle; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; WHO, World Health Organization.

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Throughout the coronavirus disease 2019 (COVID-19) pandemic, elite sports and prestigious competitions were either suspended, pos

tponed, or cancelled to reduce the risk of viral transmission and mitigate the threat to public health. Indeed, the postponement of the 2020 Tokyo Olympics and Paralympics was the only instance of its kind since its inception in 1896, which had only been previously impacted by World War I and World War II. When the games were able to go ahead, 12 months later, they took place in the absence of spectators. A global spectacle such as the Olympics which is founded on core values of friendship, respect and excellence also draws the attention of the world's richest international corporations and is broadcasted by powerful media corporations.[1] It is estimated that ticket sales from spectators only contribute 5% of total competition revenue, which explains why the games proceeded as planned in 2021, without spectators and despite strong opposition from national and international bodies. Another instance where powerful corporate and commercial entities appear to have influenced decisions that are driven by financial implications rather than public health occurred during the height of the pandemic in the United Kingdom. Football competitions and leagues were curtailed and most leagues in Europe were cancelled in March 2020, but the pressure to complete the Premier League season from the media and commercial partners was at the heart of key decisions to restore and complete unfinished competitions.[2]

Football and specifically the English Premier League is a global market and is arguably the highest-earning and most commercialized football league in Europe, if not the world[3] In football, media and commercial investment has forged a way for external bodies to be an integral part of the football ecosystem[4] and associated revenue represent a large proportion of income streams which can be as high as 59%.[5] This pressure led to drastic action being taken from governing bodies and clubs to develop protocols that allowed players to return to training and complete all outstanding fixtures. Strict protocols for training and competition were developed by governing bodies including regular COVID-19 testing of players and coaching and regular cleaning and quarantining of facilities and equipment[6] to allow completion of the 2019–20 season, this period and the subsequent 2020–21 season was completed without spectators. Despite the measures taken to complete international leagues, fixtures and competitions, the football world governing body, Federation Internationale de Football Association (FIFA), estimates that $14 billion of revenue and income were lost in that period. Whilst football has a monumental commercial foundation, it is also a powerful vehicle in communities globally and plays a key citizenship role in community settings,[7] which was likely important at a time when morale and well-being were adversely affected by imposed restrictions and lockdowns that limited social interaction.[8]

During a time of international crisis where global health was in the most precarious state in modern history where the health inequality gap was becoming increasingly worse, the pressure and sporadic approaches that were taken to reinstate elite sporting competitions prematurely might have been considered a risk to athlete welfare. Even as the pandemic progressed and global steps to restore social and economic activities, including the re-introduction of elite sports schedules and international competitions, the risk of infection due to sustained transmission remained a very real threat. As is the case with all acute illnesses, prevention is the preferred solution. However, with the removal of all social distancing restrictions, free testing and mandatory wearing of personal protective equipment and a rise in variants of concern, infection rates have and will continue to increase.[9] The risk associated with long-term disability and cardiovascular sequelae following infection with COVID-19 represents a real challenge to practitioners and sports medicine professionals to determine when it is appropriate for athletes to return to training and competition activities.[10] Whilst the knowledge about acute and chronic implications is still developing, there is a need to devise appropriate assessment and management strategies that prioritize athlete health, well-being, and welfare.

Sports cardiology and COVID-19

The significance of myocarditis in athletes

Observations of cardiac injury provoked by COVID-19 in the general population prompted healthcare providers to turn their attention toward the effect of the disease on the hearts of competitive athletes.[10] The chief concern was the dangerous prospect of myocarditis. A robust line of evidence links exercise-induced sudden cardiac death to myocarditis in otherwise healthy young individuals.[11] Studies in United States Military recruits yielded an association between myocarditis and rare incidents of exercise-induced sudden cardiac death.[12,13] Analysis of young competitive athletes corroborated this association, mostly in males.[14] As a result, the American College of Cardiology (ACC) and American Heart Association (AHA) recommend a thorough evaluation of competitive athletes presenting with myocarditis, with restrictions on exertion in individuals showing evidence of active myocardial inflammation.[15]

Strategies for screening and risk stratification in the general population of adolescent and young adult athletes require an accurate assessment of the incidence of the disease, which in turn requires adherence to a workable definition of cases. The spectrum of presentation of myocarditis in the general population can vary from a mild syndrome of dyspnea and/or chest discomfort to a rare but fulminant life-threatening emergency characterized by malignant arrhythmias and cardiogenic shock.[16] Most cases are mild and self-limited without lasting sequelae.[17] The gold standard for diagnosis of acute myocarditis is histopathological, with endomyocardial biopsy demonstrating lymphocytic infiltrate.[18] However, an endomyocardial biopsy is rarely performed in practice outside of life-threatening presentations because of sampling error in patchy disease, procedural complication risks, and availability of safer testing strategies which offer excellent specificity and sensitivity.[19] Electrocardiography, echocardiography, and serum biomarkers of inflammation and cardiac injury are vital components for the diagnosis but can also be normal in some cases.

Cardiac magnetic resonance imaging (CMRI) with gadolinium contrast has become central to the diagnosis of myocarditis with the use of the Lake Louise Criteria, which in 2018 underwent an update to include T1 and T2 mapping to the framework.[20,21] In addition to its ability to show focal wall motion abnormalities, CMRI's capacity for tissue characterization enables visualization of intramyocardial oedema, a hallmark of cellular injury. A non-coronary anatomic distribution of edematous segments, early gadolinium enhancement suggesting capillary leak and hyperemia, and late mid-myocardial or sub-epicardial gadolinium enhancement (LGE) characteristic of necrosis and/or scar can all be evidence of myocarditis. In a study of 40 patients with myocarditis compared to 26 controls, the updated 2018 Lake Louise Criteria yielded a sensitivity and specificity of 87.5% and 96.2%, respectively; notably this study was conducted in a population with a high pre-test probability for myocarditis.[22] However, while CMR findings can demonstrate myocardial inflammation, in isolation they are insufficient to secure a diagnosis of myocarditis. The European Society of Cardiology proposed diagnostic criteria for myocarditis in 2013.[23] A typical clinical presentation, in combination with at least one of four corroborative abnormal testing features (electrocardiography, echocardiography, serum biomarkers, and CMR), in the absence of an alternative explanation for the syndrome, are necessary for a diagnosis of myocarditis. Diagnosing an asymptomatic patient with myocarditis requires that at least two of these testing features be present.

COVID-19 and myocarditis: initial observations

A complex narrative intertwines COVID-19 with the cardiovascular care of competitive athletes. Initial observations in patients hospitalized with COVID-19 in Wuhan, China suggested a 12.5–20% incidence of biomarker-evident cardiac injury in that population.[24,25] Given the possibility of nonspecific troponin elevation in patients hospitalized with severe viral infections, a number of investigators further explored the possibility of COVID-19 myocarditis with CMRI. In one such study including 100 German patients recovering from COVID-19, 78 had abnormal CMRI findings.[26] Two patients in this cohort with high-risk findings were referred for endomyocardial biopsy, which revealed lymphocytic infiltration with no viral genome. However, in the absence of a correlation between imaging findings and symptoms, it was not possible to determine the incidence of true myocarditis from this study. An autopsy study demonstrated active severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) replication within the myocardium in 24 of 39 consecutive cases, suggesting a high incidence of COVID-19 related myocarditis.[27] However, subsequent pathologic studies have since called into question the incidence of myocarditis associated with COVID-19, showing that viral replication within cardiac myocytes is rare.[28] Data from patients who died of fulminant infection also may not be generalizable. A later epidemiologic study using more stringent criteria for COVID-19-associated myocarditis in hospitalized patients suggests that it is rarer than initially suspected, on the order of 1 case per 1000 hospitalizations.[29] The incidence of myocarditis among all comers infected with SARS-CoV-2, including those not requiring hospitalization, has not been determined.

CMRI and COVID-19 in athletes

Findings from CMRI in patients recovering from hospitalization prompted healthcare providers involved in the care of competitive athletes to direct their attention to the possibility of an increased risk of exercise-related sudden cardiac arrest driven by COVID-19 myocarditis. Early in the pandemic, data informing a risk stratification strategy for return-to-play (RTP) in athletes convalescing from COVID-19 were lacking. One key question was the incidence of post-COVID-19 myocarditis in athletes. Between June and August 2020, Rajpal et al. performed comprehensive CMRI on 26 competitive collegiate athletes who presented to the Ohio State University sports medicine clinic after testing positive for COVID-19.[30] Twelve athletes had LGE; four had findings suggestive of myocarditis, two of which had mild symptoms of dyspnea; however, it is difficult to discern whether the dyspnea was attributable to myocarditis or COVID-19. No athlete had abnormal serum cardiac biomarkers and follow-up for clinical events was unavailable. The high reported prevalence of cardiac involvement in this study was concerning during the initial stages of the pandemic. However, since athletic remodeling can result in characteristic changes in CMRI, including LGE at the right ventricle (RV) insertion point into the septum, it is difficult to interpret the clinical significance of the abnormalities discovered in this small cohort lacking a control group of healthy athletes.[31] The lack of follow-up outcome data, as well as the overlap between symptoms of COVID-19 and symptoms of heart disease, make risk stratification more challenging. Conflicting concurrent reports also made the available data difficult to interpret; in July 2020, when a cohort of COVID-19-positive student-athletes at the University of West Virginia underwent CMRI, none reportedly showed features of myocarditis, though almost a third showed pericardial involvement.[32] Nonetheless, at the time of publication of these data, organizations at the collegiate and professional athletic levels had cancelled competition in the interest of protecting athletes from complications of infection. This brought significant public and academic attention to the important and unclear issue of viral myocarditis in the pandemic.[33]

With concern about potential COVID-19 myocarditis developing, investigators embarked on larger and more robust investigations. The COMPETE CMR study enrolled 59 COVID-19-positive athletes, 60 athletic controls, and 27 healthy non-athletes, all of whom underwent comprehensive evaluation including CMRI.[34] Two asymptomatic athletes had CMRI findings consistent with myocardial inflammation, one of whom went on to develop dyspnea and left ventricular systolic dysfunction consistent with myocarditis. Approximately one-fifth of each group of athletes demonstrated focal LGE isolated to the inferoseptal RV insertion point, a finding that the authors emphasized should not be conflated with myocarditis. The authors also made a point to encourage the use of clinical judgment when contextualizing abnormal CMRI findings and called for longer-term follow-up studies to determine the rates of complications. Soon after the publication of the COMPLETE CMR study, the University of Wisconsin published data on 145 student-athletes recovering from COVID-19, all of whom underwent cardiac MRI.[35] Only two athletes had imaging evidence of myocardial inflammation, neither of whom was symptomatic.

The Big 10 COVID-19 Cardiac Registry enrolled 9255 collegiate athletes in the United States Big Ten Athletic Conference, representing the largest cohort to date at the time.[30] 2810 (30.4%) individuals tested positive for COVID-19, of which 1597 underwent comprehensive CMRI evaluation. Thirty-seven athletes, of whom twenty-seven were male, were diagnosed with myocarditis according to the study definition. Only nine of them reported symptoms, whereas the remainder of the cases were asymptomatic and defined as "subclinical myocarditis." The authors estimated a prevalence of study-defined overt or subclinical myocarditis of 2.1% among athletes testing positive for COVID-19 and proposed that CMRI increases the sensitivity of screening for myocarditis in this population. However, CMRI has not been studied for screening a population with a low pre-test probability of myocarditis. If the true prevalence of myocarditis is assumed to be 1% in this population, provided a sensitivity of 87.5% and a specificity of 96.2%, the positive predictive value of a CMRI suggestive of myocardial inflammation for myocarditis is only 18%. In the absence of a compatible clinical syndrome, these abnormal test results are more likely to represent false positives than "subclinical" cases. The nine symptomatic athletes with compatible CMRI findings who were diagnosed with myocarditis represent only 0.5% of the tested cohort, a figure that is comparable to results from other studies discussed below. Indeed, the authors acknowledged the lack of clinical outcome data available to guide care in asymptomatic athletes with isolated CMRI abnormalities. Nonetheless, this study raised the question of universal CMRI screening in all athletes testing positive for COVID-19. This contrasted with guideline documents and published expert opinion available at the time, which suggested cardiovascular testing before RTP was unnecessary in asymptomatic and mildly symptomatic athletes.[36,37]

Later in 2021, data with clinical outcomes began surfacing to better inform screening recommendations. Professional North American athletic leagues implemented mandatory cardiovascular screening before RTP, and their data included crucial documentation of clinical cardiac events. 789 COVID-19-positive symptomatic and asymptomatic professional athletes were included in an analysis of RTP screening.[38] All COVID-19 cases in this study, including asymptomatic individuals, underwent screening, including serum cardiac troponin levels, a resting electrocardiogram, and a resting echocardiogram. No athlete had severe symptoms, but thirty athletes (3.8%) were sent for additional testing after abnormalities were detected upon screening, and twenty-seven of them underwent CMRI. Five CMRIs showed evidence of myocarditis, and 2 showed evidence of pericarditis; these athletes were held from returning to play according to published guidelines.[15] Critically, throughout competition throughout the year 2020, no cardiac events were reported in this cohort, corroborating a conservative screening strategy using CMRI as a selective downstream test appropriate for symptomatic athletes. The authors also emphasized the low prevalence of COVID-19 myocarditis in this cohort. A similarly low prevalence of myocarditis and a low clinical event rate were demonstrated in a large cohort of 19,378 collegiate athletes, 3018 of whom tested positive. 21 (0.7%) of cases demonstrated evidence of myocarditis.[39] Selective use of CMRI, compared to primary screening CMRI, showed better positive predictive value in this latter study. Only one cardiac event was recorded, which was felt to be unlikely related to SARS-CoV-2 infection. Considering this low event rate, the authors proposed that asymptomatic or mildly symptomatic athletes without cardiopulmonary

Table 1
Published case series and registries to date evaluating athletes recovering from infection with SARS-CoV-2. CMRI, cardiac magnetic resonance imaging. Triad testing includes an electrocardiogram (EKG), serum cardiac troponin measurement, and a transthoracic echocardiogram (TTE).

Authors	Study Type	COVID+ Athletes Included	Competition Level	Findings
Rajpal, et al.[30]	Case Series	26	Collegiate	No abnormal biomarkers, EKG, or TTE. All underwent CMRI. 4 (15%) had abnormal CMRI, and two had dyspnea.
Brito, et al[32]	Case Series	60	Collegiate	54/60 had echocardiography, serum cardiac troponin measurement, and EKG. Forty-six underwent CMRI for symptoms and/or abnormal triad testing. 27/46 (56%) had abnormal CMRI findings. 19 (40%) had pericardial late enhancement with associated pericardial effusion. No specific imaging features of myocardial inflammation were identified.
Vago, et al[72]	Case Series	12	Professional	All asymptomatic. All had normal serum cardiac troponin and CMRI compared to healthy controls.
Clark, et al.[34]	Case Series	59	Collegiate	All had normal EKG, serum cardiac troponin, and TTE. All underwent CMRI. Two COVID+ athletes (3%) had CMRI features of myocardial inflammation. One (2%) developed clinically evident myocarditis. Notable CMRI findings were documented in healthy and COVID+ athletes which were absent in non-athletes, such as RV insertion point LGE.
Starekova, et al.[35]	Case Series	145	Collegiate	All underwent CMRI. 81% had symptoms. Two had evidence of myocardial inflammation on CMRI, one was minimally symptomatic; the other had mild-moderate symptoms.
Malek, et al.[37,36]	Case Series	26	Professional	All underwent CMRI. 4 (15%) had abnormal serum troponin. CMRI revealed abnormalities in five, none met updated criteria for myocarditis.
Martinez, et al[38]	Registry	789	Professional	All underwent triad testing; thirty screened abnormal. Twenty-seven underwent CMRI; five had findings of myocardial inflammation. No deaths or cardiac events were recorded.
Moulson, et al.,[33]	Registry	3018	Collegiate	Selective triad testing followed by CMRI if clinically indicated. 21/2999 had abnormal EKG; 24/2719 had abnormal troponin; 24/2556 had abnormal TTE. 198 underwent CMRI with three showing cardiac involvement. One cardiac event was recorded, unrelated to COVID-19.
Hendrickson, et al.[74]	Case Series	137	Collegiate	All underwent triad testing. CMRI was done when clinically indicated. Five athletes had CMRI, and none were abnormal.
Daniels, et al.[75]	Registry	2810	Collegiate	All recommended CMRI, 1597 completed. 37 (2.3%) had abnormal CMRI, 9 (0.5%) of which had symptoms consistent with myocarditis. Twenty-eight were asymptomatic.
Hwang, et al.[76]	Case Series	55	Collegiate	All underwent triad testing; CMRI was used selectively. One case of pericarditis. No cases of myocarditis. No cardiac events were reported.

RV, right ventricle; LGE, late gadolinium enhancement.

complaints may return to play without further cardiac testing after recovery from their initial infection. Table 1 summarizes the available case series and registries evaluating the prevalence of cardiac involvement in athletes following SARS-CoV2 infection.

In summary, while initial reports regarding prevalence and risk of myocarditis in athletes recovering from COVID-19 were concerning, thorough subsequent investigations of imaging and outcomes in large cohorts have been reassuring. Screening recommendations have continued to be conservative, suggesting that asymptomatic or minimally symptomatic athletes can return to play without further testing once symptoms resolve[40]; the latest update to RTP guidelines, published in May of 2022, suggests CMRI is reserved for athletes with symptoms highly suggestive of myocarditis as well as abnormal initial testing. Individuals with no symptoms, or mild or moderate non-cardiopulmonary symptoms, following SARS-CoV2 infection may resume training after three days of abstinence without additional testing. This can be done while continuing to self-isolate for the CDC-recommended period, which is currently five days. Those with cardiopulmonary symptoms should undergo triad testing consisting of serum cardiac troponin measurement, electrocardiogram (ECG), and echocardiography. Only those with abnormal triad testing, or persistent symptoms prompting high suspicion of myocarditis, should undergo CMRI. Synthesis of clinical, biochemical, electrocardiographic, and imaging findings is crucial for the accurate diagnosis of myocarditis in a young competitive athlete.

Management of the athlete with myocarditis

Once the true diagnosis of myocarditis has been established in an athlete, there is insufficient evidence to suggest the management should differ based on the underlying infectious agent. Thus, current guideline recommendations for myocarditis in athletes apply to COVID-19-associated myocarditis.[15] Left ventricular systolic dysfunction and cardiac arrhythmias should be managed according to current ACC/AHA guidelines.[41] Athletes with myocarditis should abstain from training while symptomatic and for at least 3–6 months following symptom resolution. They should also undergo repeat testing before RTP. Testing in this setting should include a resting echocardiogram, measurement of serum cardiac troponin and inflammatory markers, a 24-h Holter monitor, and an exercise ECG with attention to arrhythmic burden. Repeat CMRI can be considered as well. Complete resolution of all evidence of cardiac inflammation is reassuring, but some athletes may manifest persistent LGE even after other abnormalities have resolved. While the presence of LGE indicating scar may convey a heightened risk for arrhythmias, it is not clear whether the presence of isolated LGE after an episode of myocarditis should preclude an athlete from participating in competitive sport; an informed risk-benefit discussion with the athlete is important in these cases.[42]

Managing COVID-19 infections in athletes

The management of COVID-19 infections and the return to play is a unique challenge to sports scientists and sports medicine practitioners, which resulted in the sporadic approaches across sports worldwide.[43] Despite evolving knowledge and understanding to inform the development of safe and athlete-centered approaches, there remains a lack of consistency. Most recently, Rafał Majka tested positive during the 2022 Tour de France cycling event, however, continued to compete as the medical team deemed it 'safe' to ride due to a 'low viral load.' This decision was taken despite existing knowledge of acute respiratory infections and decreased exercise performance due to neural (impaired coordination and speed in the performance of motor skills, reductions in submaximal force generation), physical (cardiorespiratory capacities, and reflecting muscle protein catabolism), cognition (decreased attention and vigilance) challenges.[44,45] Conversely and at a similar time, Matteo Berrettini was forced to withdraw from the Wimbledon tennis championships due to a positive COVID-19 test. Whilst the details of the infection and progression is not public knowledge, it appears at first glance that approaches to managing performance and wellbeing are disparate and disease specific scientific protocols and consensus is needed to manage acute infection, recovery and re-introduction to training and competition. The disparity is also in part due to nongovernmental organizations (NGOs) and event organizers who in the absence of international guidelines have been able to implement their own approaches with dealing with COVID-19 infected athletes. Guidelines have also been adapted multiple times by NGOs and governments throughout the pandemic with variable testing regimes and protocols for isolation. This is surprising given there are multiple protocols offered by experts in the field, such as the graduated return to play (GRTP) protocol,[46,47] in respect of assisting an athlete return to play in a manner to protect athlete welfare and the support staff around them.

Initial response protocols to a positive COVID-19 infection in athletes focused on myocarditis and myocardial injury (i.e., heart inflammation), due to the concern that athletes undertaking a high load of training/exercise may exacerbate the myocardial injury and precipitate malignant ventricular arrhythmias with viral myocarditis following infection.[36] The authors suggest that ECG, CMRI, Computed Tomography Angiography (CTA), cardiopulmonary exercise testing (CPET), and nuclear positron emission tomography (PET) could all be part of a screening process. Whilst this has clinical merit in these approaches,[48,49] it may be difficult to implement this across the board due to budget constraints, considering a recent article suggested the cost per athlete for similar screening procedures could be between $632 ± 651 and $1357 ± 757 per athlete.[49,50] More importantly, Kim et al.[51] suggested these procedures are not merited, due to the incidence of myocardial issues was as low as 0.6–0.7% within a large study of professional ($n = 789$) and collegiate ($n = 3018$) athletes following a COVID-19 infection.[38,39] It is logical therefore to suggest that the handling of athletes with a COVID-19 infection should be based on a priori clinical probability based on symptoms presented and not a universal screening approach of costly measures.

To determine clinical probability, it is advised that the traditional 'above the neck' and 'below neck' symptoms should be identified, and this should guide the next procedure to follow, which is also in line with the GRTP protocol, highlighted in Table 2. Generally, athletes require around 10 days to be back to normal training based on the median duration for players to report no symptoms, although as many as 14% could still be unavailable for 28 days later and beyond.[52] However, athletes with 'above neck' symptoms will typically recover faster than those with 'below neck' symptoms,[53] and the GRTP reflects this, as the latter has an additional 5-day rest period to allow for longer recovery and greater monitoring (Table 2). Using the GRTP will produce consistency among athlete treatment and care, and therefore reduce the confusion currently surrounding when athletes should/should not compete with a recent COVID-19 infection. This approach also is cost-effective and can be conducted by most athletes and sport science support teams globally. A caveat to this approach, however, is if clinical symptoms of COVID-19 re-appear or become more severe. In this case, athletes should cease the GRTP protocol and seek medical advice. These 'red flag' symptoms, as termed by the GRTP, are typically chest pains, unusual high rating of perceived exertion (RPE) and heart rate (HR) during exercise, mental health concerns, syncope, fatigue and/or dyspnea. This is where invasive scanning and biochemical blood measures, such as those proposed by Phelen et al.,[36] could be employed. These more invasive procedures may also be necessary for athletes that have unvaccinated status due to the likelihood of the illness being more severe. Finally, if athletes have any concomitant medical conditions (e.g., cardiovascular or respiratory or renal disease) then medical evaluation should be conducted before completing the GRTP.[54]

The International Olympic Committee (IOC) recently published a two-part consensus statement that covers acute respiratory infections[55] and non-infective acute respiratory illness. The drive behind these statements is to provide guidance to sport and exercise science/medicine practitioners working with athletes and to uphold the Medical and Scientific Commission's value of protecting athletes, whilst focusing on prevention and management and enabling the development of effective return to sport protocols following acute illness. Data from the report highlights that almost half of all athlete's medical consultations at international events such as the Olympics and Para Olympics relate to acute respiratory illness (4.2 per 1000 athlete days).[55] Whilst the work of the IOC task force began before the COVID-19 pandemic, there are clear lessons that have been incorporated into the report by the authors which broadly cover acute respiratory infection, but these apply directly to COVID-19. One of these is to highlight the importance of symptom recognition and the implementation of early and precise viral pathogen identification so that athletes can be quarantined to prevent the spread of further spread of infection. This will be of particular importance when travel and 'athlete villages' are common practice, such as during the Olympic games.

Mitigating risks

COVID-19 and some variants (e.g., Omicron, B.1.1.529) are highly transmissible, and the severity of acute infection is also variable ranging from asymptomatic to a mild-severe clinical presentation. Whilst the development and administration of current vaccinations have been effective against emerging variants, it is well established that immunity is timebound and there is a need for regular boosters.[57] Recent data highlights that 20 to 30% of SARS-CoV-2 infections in athletes are asymptomatic, which creates additional considerations for sports medicine practitioners as screening, testing and quarantine protocols will be

Table 2
The Graduated Return to Play Protocol. Redrawn from Elliot et al. (2022).

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Activity description	Minimum rest period	Light activity	Frequency of training increases	Duration of training increases	Intensity of training increases	Resume normal training	RETURN TO COMPETITION *IN SPORT SPECIFIC TIMELINES*
Exercise allowed	Walking, activities of daily living	Walking, light jogging, stationary cycle. No resistance training	Simple movement activities e.g., running drills	Progression to more complex training activities	Normal training activities	Resume normal training progressions	
% Heart rate max		<70%	<80%	<80%	<80%	Resume normal training progressions	
Duration	10 days	<15 mins	<30 mins	<45 mins	<60 mins	Resume normal training progressions	
Objective	Allow recovery time, protect cardio-respiratory system	Increase heart rate	Increase load gradually, manage any post viral fatigue symptoms	Exercise, coordination, and skills/tactics	Restore confidence and assess functional skills	Resume normal training progressions	
Monitoring	Subjective symptoms, resting HR, I-PRRS	Subjective symptoms, resting HR, I-PRRS, RPE	Subjective symptoms, resting HR, I-PRRS, RPE	Subjective symptoms, resting HR, I-PRRS, RPE	Subjective symptoms, resting HR, I-PRRS, RPE	Subjective symptoms, resting HR, I-PRRS, RPE	

I-PRRS, Injury – Psychological Readiness to Return to Sport; RPE, Rated Perceived Exertion Scale. Note: This guidance is specific to sports with an aerobic component.

needed to limit the impact within a team and sports environment. Whilst vaccines offer the greatest protection from severe outcomes with COVID-19, vaccine hesitancy in general populations has been widely reported in the general population[58] but with less coverage in athletes.[59] From the available information, it appears that hesitancy is caused by a lack of knowledge on the impact of COVID-19 vaccines upon sports performance and also issues relating to side effects.[59,60] Whilst athletes maintain a right to personal choice, this may create issues regarding international travel in countries where vaccines have been declared mandatory. The most notable case here relates to Novak Djokovic, who was unable to participate in the 2022 Australian Open and was subsequently deported by the Australian Government for not adhering to laws around vaccination. Despite the development and widespread administration of efficacious COVID-19 vaccines,[61] waning immunity,[62] athlete hesitancy,[63] and the risk of sustained transmission and emerging variants[64] will undoubtedly lead to spikes in the transmission that need to be considered with the development and introduction of screening/testing procedures that prioritize athlete welfare over commercial and business needs. Counterintuitively, the relaxing of mandatory social distancing, wearing of face coverings and the removal of access to free testing in western societies means that sports science and medicine practitioners will result in governing bodies and sports organizations having to develop, implement and uphold protocols that protect athletes, coaches, and spectators against the continued risk of infection and long-term sequelae.

Long-COVID

There remains a paucity of data to highlight the prevalence of the longitudinal challenges faced by athletes following a COVID-19 infection and the development of a more long-term illness that prevents a return to pre-COVID-19 activities. Long COVID or post COVID syndrome, is defined by the WHO as a condition that occurs in individuals with a history of probable or confirmed SARS CoV-2 infection, usually 3 months from the onset of COVID-19 with symptoms that last for at least 2 months and cannot be explained by an alternative diagnosis.[65] Presently, there is limited understanding of the prevalence, severity, or impact upon an athlete's long term health and the ability to resume to training and competition schedules.[66] Data from Hull et al highlights in 147 Olympic standard athletes (25 Paralympic and 37% female) that median symptom duration was 10 days but 14% reported symptoms greater than >28 days.[52] Whilst the issues reported in this study highlight lasting issues there is no detail on the full time to recovery/return to training and the timeframe is not covered by the current WHO definition of Long COVID. There is, however, a growing number of reports within the media that highlight longstanding issues that athletes are facing in their attempts to return to training and competition activities.[67–69]

Whilst datasets remain infrequent, it is estimated that >144 million people globally are living with multi-dimensional and episodic symptoms that broadly impact functional status, quality of life and physical and mental wellbeing.[70] Individuals with a history of elevated levels of cardiorespiratory fitness will observe marginal changes in their training and performance capabilities over the long term compared with the functional capacity of those with a history of reduced health status and multiple morbidities. However, more research and surveillance from governing bodies and leading organizations are needed to quantify and understand the longitudinal issues experienced by athletes regarding training, performance and their general health and wellbeing. The acute and chronic implications of COVID-19 will inevitably play a key role in the role of practitioners at least for the near future and further research and support from leading agencies in the governance of sport should direct the development of diligent and comprehensive protocols that support athletes and practitioners to restore pre-COVID-19 status.

Future of elite sport

As highlighted in this article, managing the elite sport environment is confounded by a myriad of complexities that exceeds sports performance and competition. As evidenced by the COVID-19 pandemic, global issues have a direct influence of upon elite sports and consideration of current and future challenges should be met with proactive rather than reactive strategies. The need to assess and manage athletes exposed to COVID-19 and even Long COVID is likely to evolve in respect of increased mechanistic understanding and with the development of efficacious treatments. However, the risk of future variants of concern COVID-19 and future new pandemics is inevitable, posing a sustained challenge to global health.[71] The very nature of the elite sports will continue to change creating new working environments for sport scientists and medics. Therefore, we must take proactive steps to review recent reactive approaches and make considered and informed strategies that manage athlete physical, mental, and emotional wellbeing when future health threats are realized. The authors accept that the magnitude and impact of COVID-19 was and remains unprecedented, but the ability to apply these skills in competition and to train to enhance them is likely to be hampered by any viral infection including COVID-19.

Conclusions

The move to restore sporting competition was primarily due to commercial and contractual agreements, which posed a risk to athlete and sports scientist/medicine experts health and wellbeing. Despite attempts from international and national governing bodies implementing protocols to mitigate against, the absence of knowledge to inform decision making could have resulted in sustained illness for some athletes that have developed long term complication and/or not yet achieved clinical resolution. Whilst the knowledge base to inform decision making is advancing, the risk of sustained transmission and future variants of concern pose a continued risk to athlete and practitioner welfare. Appropriate screening and management guidance and mitigation strategies must be revised regularly and be developed with interdisciplinary collaborative approaches.

Declaration of Competing Interest

None.

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