

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)

European Journal of Preventive

Cardiology

0(0) 1–10

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Cardiology 2020

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DOI: 10.1177/2047487320930596

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Abstract

Regular exercise has multiple benefits for physical and mental health, including the body's ability to combat infections. The current COVID-19 pandemic and the social distancing measures employed to curtail the impact of the infection are likely to reduce the amount of usual physical activity being performed by most individuals, including habitual exercisers. The uncertainties relating to the impact of the SARS-CoV-2 virus on the heart may cause increased anxiety, particularly in athletes who need to sustain a vigorous exercise regime in order to maintain their skills and fitness in preparation for return to competition after a short re-training period. The aim of this document is to provide practical answers to pertinent questions being posed by the sporting community, in an attempt to offer reassurance, promote safe participation in exercise during as well as after the COVID-19 pandemic and provide a framework of management for physicians caring for athletes.

Keywords

COVID-19, athlete, exercise, sports cardiology, screening

Received 24 April 2020; accepted 10 May 2020

The current SARS-CoV-2 virus is responsible for COVID-19 infection, which has resulted in a pandemic. Cardiac involvement is a recognised complication of the infection and has potential implications for athletes, who push their cardiovascular system to the limits on a regular basis to maintain skill and fitness for competition, but also for physicians and coaches worldwide involved in their care. This document aims to provide practical answers to pertinent questions being posed by the sporting community. The article is divided into three parts: Part 1 provides a brief overview of the COVID-19 infection; Part 2 is a 'question and answer' section aimed specifically at exercising

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individuals and athletes; and Part 3 is a 'question and answer' section to guide doctors and coaches to manage and support athletes during the pandemic.

Part I: General information pertaining to COVID-19 infection and its impact on the heart

COVID-19 infection is transmitted via droplets from the respiratory tract. Common symptoms include fever (89%), a dry cough (68%), fatigue (38%), sore throat, myalgia and headache.¹ Nausea or diarrhoea is also recognised and up to 30% report anosmia and ageusia.² Most affected individuals (80%) experience a mild illness although a significant proportion (15%) will develop a severe illness and become debilitated for several days, or even require hospital admission. Critical illness occurs in 4.7%, which necessitates hospital admission, often for advanced life support.³ Mortality figures, though evolving, currently sit at around 2% worldwide, and are considerably higher in older individuals

(>70 years) and those with pre-existing co-morbidities affecting the cardiovascular and respiratory systems.⁴ Although several drug trials are in progress, there are no proven therapies to combat the virus and a vaccine is unlikely to be available for several months. Current public health preventive strategies to reduce viral transmission include promotion of personal hygiene, and social distancing. Public health authorities offer extensive advice, including information for exposed, suspected or confirmed individuals.⁵

What is known about the impact of SARS-CoV-2 virus on the heart?

The effect of SARS-CoV-2 virus on the cardiovascular system is still evolving (Figure 1). Reports from China revealed that between 12% and 30% of patients admitted to hospital with SARS-CoV-2 had a raised troponin above the 99th percentile.⁶ Patients with raised troponin experienced more severe disease and were more likely to require mechanical ventilation and

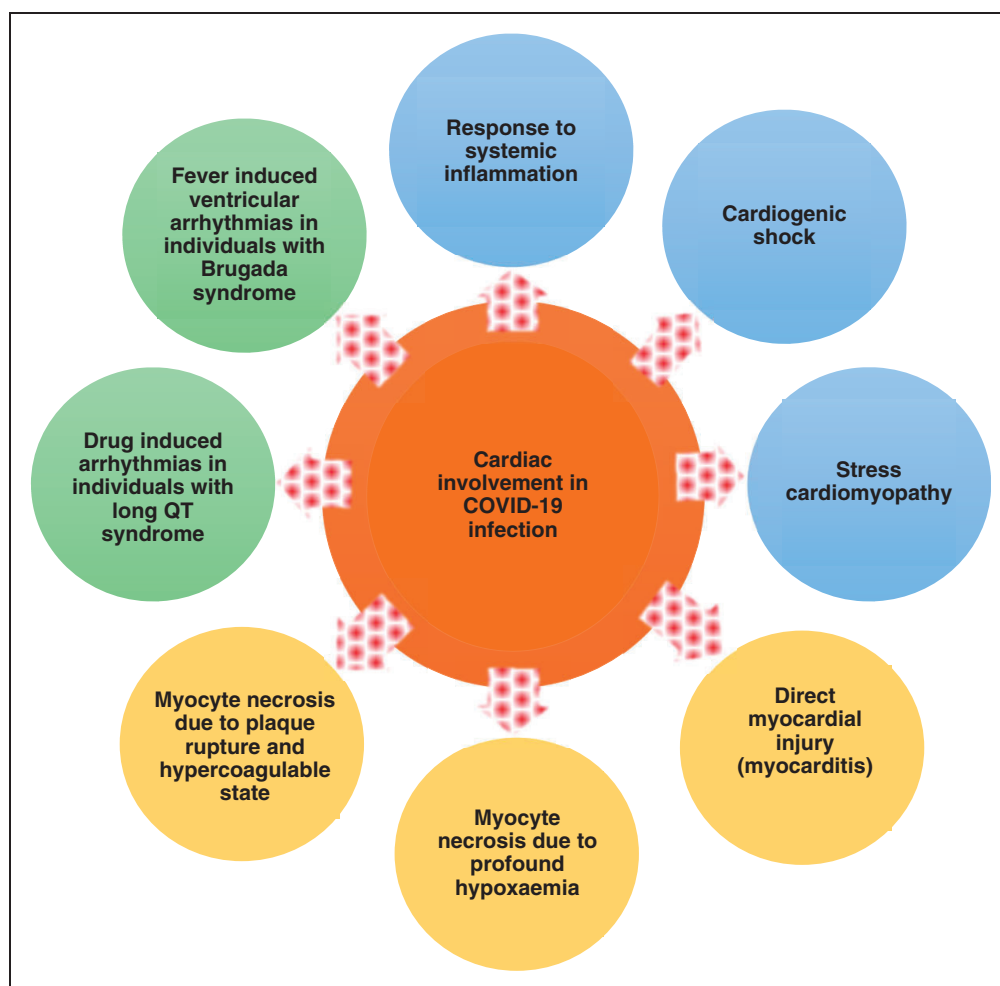


Figure 1. Possible mechanisms of cardiac involvement in COVID-19 infection.

die.^{7,8} The precise cause of the raised troponin concentrations is unclear and likely multifactorial. Amongst non-survivors serum troponin concentrations continued to rise beyond day 4, suggesting that elevated serum troponin concentration may be a consequence of the systemic inflammatory response or cytokine storm.⁸ Myocyte necrosis could be a consequence of right ventricular strain resulting from profound hypoxaemia secondary to the respiratory illness and/or pulmonary embolism.⁹ Among individuals with chronic coronary syndromes or subclinical coronary artery disease, plaque rupture, acute thrombosis and distal embolisation may complicate the acute inflammatory and hypercoagulable state. In the context of a severe systemic reaction the possibility of a stress induced cardiomyopathy cannot be excluded.¹⁰

Although a diagnosis of myocarditis cannot be confirmed in the absence of endomyocardial biopsies or cardiovascular magnetic resonance (CMR) imaging scans, there are several case reports implicating myocarditis as an additional cause of cardiac damage.^{10,11} SARS-CoV-2 virus binds to angiotensin converting enzyme 2 (ACE2) in the upper airways and lungs after the protein spike on the virus is activated by transmembrane protease serine 2.¹² The myocardium also contains a high concentration of ACE2 receptors, activation of which may exert direct toxic effects within the myocardium.¹² A proportion of patients diagnosed with COVID-19 infection have presented with chest pain and palpitations rather than symptoms due to the respiratory tract involvement.¹³

Part 2: Question and Answer session for exercising individuals and athletes

Have there been many athletes affected by COVID-19?

Several high-profile athletes have been affected. News media outlets, including social media platforms, have reported on athletes who have volunteered to describe their experience with the diagnosis. In the USA, this has included athletes across all major professional sporting teams in basketball, baseball and American football.¹⁴ There is no international registry data available to quote accurate statistics, although collaboration between national and international sporting organisations to develop a registry of athletes who have been affected by COVID-19 could aid our understanding of the epidemiology and acute and long-term outcomes in athletes.

What measures should one take to reduce the risk of contracting COVID-19?

Everyone should adhere to government advice, including diligent hand hygiene and social distancing guidelines and limit their time in public spaces to protect themselves from contracting COVID-19 infection.^{3,5} Consultations with coaches, physiotherapists, team colleagues and doctors should be via audio or video calls although mutual use of surgical masks and respecting a 2 meter distance will become possible as the pandemic begins to resolve. In addition, it is important to conform to recommendations supporting a healthy lifestyle such as maintaining a healthy diet, adequate hydration, good quality sleep, adherence to a routine, social contact with family and friends over instant messaging or video conferences and continuing to engage in some form of exercise for physical and mental well-being.

Can an individual continue to exercise during this pandemic?

Individuals are encouraged to continue exercising provided they are well and asymptomatic. There is evidence that moderate exercise performed for 20–30 min 3–4 times per week may strengthen the immune system and reduce the risk of viral infection.¹⁵ Studies have also shown that regular moderate exercise prior to developing a potentially serious viral infection such as flu may be associated with better outcomes.^{16,17} People who continued to remain active during the 1998 Hong Kong flu were more likely to survive compared with sedentary people.^{16,17} The current pandemic means that exercising in gyms and other communal exercising areas or performing team sports is no longer possible, therefore, training needs to be adjusted based on public health advice and restrictions. In some countries one outdoor exercise activity per day is permitted while in others, all outdoor activity has been prohibited. Individuals who have exercising facilities at home such as treadmills, static bicycles or rowing machines should be encouraged to use them to stay physically fit. Callisthenic exercises such as press-ups and sit-ups, yoga, strength training or high intensity exercise can be performed indoors or in the garden. There are also many on-line programmes and applications to allow individuals to follow a systematic exercise programme. Furthermore, regular exercise has been shown to have a relevant psychological impact, which should not be underestimated in times of ‘social distancing’ and ‘self-isolation’.¹⁸ Athletes who are used to regular training may suffer from psychological problems due to sudden withdrawal of a training stimulus and should particularly be encouraged to maintain their exercise level.^{19,20}

How should athletes or professional athletes keep fit?

The uncertainty surrounding the current situation must be a source of anxiety and frustration for athletes. Individuals participating in sport at a competitive level (professional athletes) need to maintain fitness to return to competition in the foreseeable future. Many elite athletes will have static exercise machines at home and may have been provided with remotely supervised training schedules or even have virtual training sessions, whereas others may have developed their own exercise programme. Some athletes from the highest echelons of sport will also have provided wearable Global Positioning System devices to monitor physical activity remotely. In the current situation, the exercise programmes recommended may not fully reflect some sports. The key is to remain as fit as possible for when the season resumes. It is essential to maintain close dialogue with team coaches and medical staff as well as sports fans to keep morale up during this difficult time.

What is the advice for individuals who had trained for a marathon, which has been postponed for several months? Can they continue training during this pandemic?

Most individuals who were planning to run a marathon over this period will have trained for several months and will be reaching peak performance. Such individuals would usually rest after the event. It is highly unlikely that any marathon events will take place in Europe for at least five months. The duration of this pandemic is uncertain and therefore runners should pace themselves and prevent the risk of over training and reducing their immunity.²¹ It is advised that individuals train as if the event is 4–5 months away and, depending on their level of competitiveness, take an appropriate number of rest days per week. Given the limitations for adequate training, we would advise amateur athletes not to try to attempt a personal best this year and focus on running for a good cause and in celebration of the end of the pandemic.

Is it true that exercising excessively increases the chances of getting the infection?

Although regular moderate exercise is beneficial for the immune system, there are suggestions that regular, high intensity exercise, especially in unaccustomed individuals, can impair immunity and increase risk of a subclinical infection.^{21–23} There is currently no evidence to suggest that athletes are particularly susceptible to COVID-19 infection. A pragmatic approach for an

athlete is not to exceed their usual training programme during this period of uncertainty.

There are reports that the virus can affect the heart. Should athletes be worried that exercise may pose a serious risk?

A proportion of individuals who develop the infection will be bedridden for a few days or even require hospital admission (15%) and others will have very serious or life-threatening disease (4%). There is evidence from China that almost one in five people who were sufficiently seriously ill to require hospital admission had a raised serum cardiac troponin level to indicate some level of heart damage.⁹

It is less likely that the heart is affected in individuals with mild symptoms similar to a common cold. Athletes should be advised to seek a medical opinion if they experience chest pain made worse with inspiration, increasing breathlessness and palpitations. Importantly, athletes are strongly advised not to exercise if they experience any of these symptoms until a doctor has made an assessment. Animal studies have shown that exercising with an infection can increase viral replication and inflammation within the heart, resulting in permanent damage or occasionally sudden death.²⁴

Some athletes have been diagnosed with heart disease but have no symptoms and have continued to play sport following discussion with their sport cardiologist. Until now, these athletes were being closely monitored by team doctors. How much unsupervised exercise can these athletes perform safely during the pandemic?

This is a difficult question to answer with certainty. The fact that a cardiologist has permitted an athlete to continue training under supervision implies that the risk was perceived to be relatively low. It is recommended that a cardiologist is consulted as advice will depend on a case by case basis. As a general rule it is advised that athletes with recognised heart disease should not increase their heart rate above 80% of the maximal predicted for their age in the absence of supervision. Athletes are advised to stop immediately if they experience chest pain, breathlessness that is disproportionate to the amount of exercise being performed, palpitations, dizziness or loss of consciousness and consult their doctor.

Should athletes be concerned about detraining?

Individuals might unintentionally detrain as a result of illness and/or lack of facilities to maintain their fitness. Regimes prescribed by coaches may not be able to maintain the same level of fitness and performance as if they

were training under normal circumstances. However, many athletes around the world are in a similar situation and it is important to emphasise that athletes should adhere to the prescribed exercise programme, or their own training schedule, without breaching government advice. Athletes who are not fortunate enough to benefit from a comprehensive health care infrastructure, training equipment and/or facilities which support social distancing and good hygiene might not have much choice but to detrain. These plausible scenarios will undoubtedly need to be considered when current public health measures are lifted. It is anticipated that a period of retraining and risk assessments will be performed in most sports prior to recommencing competition. During this period, team doctors and sport cardiologists will need to monitor for possible cardiovascular sequelae of COVID-19. It is likely that almost all athletes will be able to regain their previous fitness and engage in performing at the highest level again after the pandemic is declared over.

Part 3: Question and Answer session for physicians and coaches caring for athletes

Should all elite athletes be tested for COVID-19 infection?

Recommendations will differ between countries, based predominantly on a balance between the feasibility of testing and its impact on the management of the athlete. Current guidance, in most countries, suggests that COVID-19 testing should be reserved for individuals with symptoms compatible with infection. Testing individuals who have been exposed to somebody that may have had COVID-19 infection would also be appropriate.²⁵ This situation is fluid and once comprehensive widespread testing does become available in the near future, it is possible that elite sporting organisations will consider testing all their players with nucleic acid tests for the presence of viral RNA or check prior exposure through serological tests.

How can we perform investigations on an athlete with symptoms that are highly suggestive of COVID-19 infection?

Currently most countries suggest that such athletes should monitor their symptoms and self-isolate for 7–14 days from the onset of symptoms or until symptoms resolve.^{3,5} Urgent testing is not necessary for the majority of athletes who have improved after a short illness but if there are concerns, then the team doctor may decide on a case-by-case basis. Tests may be performed via designated centres or arranging remote individual tests for COVID-19 infection.

Doctors should only perform these investigations personally if they are equipped with satisfactory personal protection equipment. If such facilities and equipment are available, it is reasonable to also perform a serum cardiac troponin level at the same time to check for myocyte necrosis as this may inform decisions about the amount of period of rest that is required before training intensively.

What is the management of an athlete who has a temperature and a cough but has a negative test for COVID-19?

In the current era, all athletes who have symptoms suggestive of a viral infection should be considered to suffer from COVID-19 and self-isolate for 7–14 days or until their symptoms have resolved, irrespective of test results. Coryzal illnesses, however, are common especially in spring; therefore it is possible that the athlete has a ‘common cold’. It is also possible that the COVID-19 test is falsely negative. Hence it is recommended to repeat the test if possible in athletes with persistent symptoms. Athletes who have negative tests may continue to exercise after resolution of symptoms (Table 1).²⁶

What is the management of an athlete who has tested positive for COVID-19 after presenting with coryzal symptoms?

The athlete should be advised to self-isolate for 7–14 days and not to engage in systematic exercise until they have been symptom free for a minimum of seven days. During that period, it is reasonable to engage in 20–30 min of gentle physical activity that does not put any strain on the heart and lungs, such as walking and stretching. Professional athletes should monitor symptoms through virtual consultations with their team doctor or equivalent.

Athletes with mild symptoms which resolve may return to graduated training when they have been symptom free for seven days and can progress gradually to the normal training regime and/or play after an additional seven days. Repeat COVID-19 testing to ensure conversion to negative may be considered prior to return to training. Assessment of symptoms by telephone consultations and monitoring for arrhythmias through a heart rate monitor (if possible) is pragmatic. Any concerns should be discussed with their team doctor.

For athletes with a debilitating illness and/or symptoms compatible with myocarditis/pericarditis such as chest pain, severe breathlessness or palpitations, it is reasonable to check the serum cardiac troponin concentration and C-reactive protein (CRP) at the time of the diagnostic testing. This is particularly pertinent for

Table 1. Recommendations for exercise in athletes based on symptoms and COVID-19 (viral RNA) test result.

COVID-19 symptoms	COVID-19 test result	Recommendations
Positive	Positive	<ul style="list-style-type: none"> • Self-isolate for 7–14 days. • Refrain from exercise until symptom free for seven days. • Consider clinical assessment in appropriate environment including blood tests (troponin and CRP). • If troponin positive, consider 12-lead ECG, echocardiogram, CMR and ECG monitor. If evidence of peri/myocarditis treat accordingly.²⁶ • If no evidence of cardiac involvement reassess after symptom free for seven days and consider graduated return to training for an additional seven days and return to normal training and/or play if asymptomatic and progressing well. • Repeat COVID-19 testing to ensure conversion to negative may be considered prior to return to training.
Negative	Positive	<ul style="list-style-type: none"> • Refrain from all exercise for seven days from the test result. • If still symptom free after this period, consider graduated return to training and return to normal training and/or play if asymptomatic and progressing well. • Repeat COVID-19 testing to ensure conversion to negative may be considered prior to return to training.
Positive	Negative	<ul style="list-style-type: none"> • Manage as coryzal illness according to usual policy. • If there is a high index of suspicion, consider repeat COVID-19 testing or adhering to the COVID-19 test positive recommendations.
Negative	Negative	<ul style="list-style-type: none"> • Maintain high standards of hand hygiene and social distancing.

CMR: cardiovascular magnetic resonance; CRP: C-reactive protein; ECG: electrocardiogram

athletes who require a high level of regular training to maintain their fitness. Intensive exercise is associated with raised serum troponin concentration, therefore we recommend that serum troponin measurements should be performed 48 hours after a rest period to reduce the risk of a false positive result. Athletes with normal troponin levels should be managed as above. Athletes with a raised troponin (>99th percentile) should be considered to have myocarditis and should be investigated with a 12-lead electrocardiogram (ECG), echocardiogram, CMR imaging scan and ECG monitor to help confirm the diagnosis and assess risk of arrhythmias (Table 1).²⁶ Athletes with convincing features of myocarditis should be managed according to established guidelines for myocarditis, which recommend a minimum of three months' rest from intensive exercise.²⁶

Will there be a mandate to perform comprehensive cardiac evaluations for elite athletes prior to return to competitions as a consequence of the pandemic and the lack of testing in the early phases of the disease?

It is recommended that all athletes returning back to competition after prolonged abstinence should undergo

a comprehensive clinical assessment including detailed history and examination, which can be performed by the team doctor (if applicable).

Assuming that sufficient and reliable testing is available, it may be reasonable for sporting organisations to identify players who are silent carriers through throat and nose swabs (nucleic acid tests for the presence of viral RNA) and check for previous exposure to the virus through serological tests. IgM antibodies appear to most likely develop between three and six days after the onset of symptoms and IgG antibodies develop 8–20 days after the onset of symptoms.^{27,28} This is particularly relevant for team sports where players would not be able to observe social distancing during training and games, especially if games resume while the SARS-CoV-2 virus pandemic is beginning to subside but has not resolved. It is also relevant for preventing infection of ancillary personnel working with athletes, including their medical staff. Such a proposal already exists for professional athletes from the Italian Sports Medicine Federation.²⁹

The consensus panel believes that for most athletes, who never experienced symptoms of viral infection, an assessment by their team doctor is sufficient.

For the minority of athletes who experienced debilitating symptoms (bedridden for several days) or

required hospital admission with confirmed COVID-19 infection, comprehensive re-evaluation by a team physician and sports cardiologist would be advisable prior to return to play, particularly if there was a documented rise in cardiac troponin and/or ventricular dysfunction and/or arrhythmia noted during the admission (Figure 2).

Athletes with mild to moderate symptoms who have managed their condition at home pose a greater challenge. Few will have been tested for COVID-19 infection and most will simply suspect they had the infection. In the near future serological testing is likely to become more readily available to test for previous COVID-19 infection. There is a rationale to advise cardiac re-evaluation in some of these athletes from a cardiovascular perspective prior to returning to sport. This includes:

1. Athletes who are currently asymptomatic but had a debilitating illness lasting > 7 days and/or experienced symptoms compatible with myocarditis/pericarditis such as chest pain, breathlessness, palpitations, exertional dizziness or syncope.
2. Athletes who are experiencing persistent cardiac symptoms even after the acute infection has resolved.
3. Athletes with reduced performance despite an appropriate re-training regime.

Asymptomatic athletes with a prior history of debilitating illness and those who experienced symptoms compatible with myocarditis/pericarditis should have at least a 12-lead ECG and echocardiogram. If these are normal, proceed to a maximal exercise stress test and clear to train if normal. A CMR scan may be considered to check for myocardial fibrosis in those with symptoms highly suggestive of myocarditis.

Athletes with on-going symptoms should have additional blood tests, including cardiac troponin, CRP and full blood count and a CMR scan to check for myocardial inflammation or fibrosis. If these preliminary investigations are normal, proceed to a maximal exercise stress test and ECG monitor. Additional investigations and advice relating to return to normal training will depend on the symptoms and results of the investigations (Figure 2). It is important to emphasise that personnel performing cardiac investigations should wear personal protective equipment and clean diagnostic tools such as ECG, echocardiography and exercise stress testing machines with a mild detergent or anti-septic wipes after each procedure.

As knowledge of the impact of SARS-CoV-2 on the heart continues to evolve, the proposed protocol for cardiac evaluation of athletes prior to resuming training and competitive sports is based on expert opinion. As such, the protocol may be viewed as very conservative by some or too aggressive by others. The authors

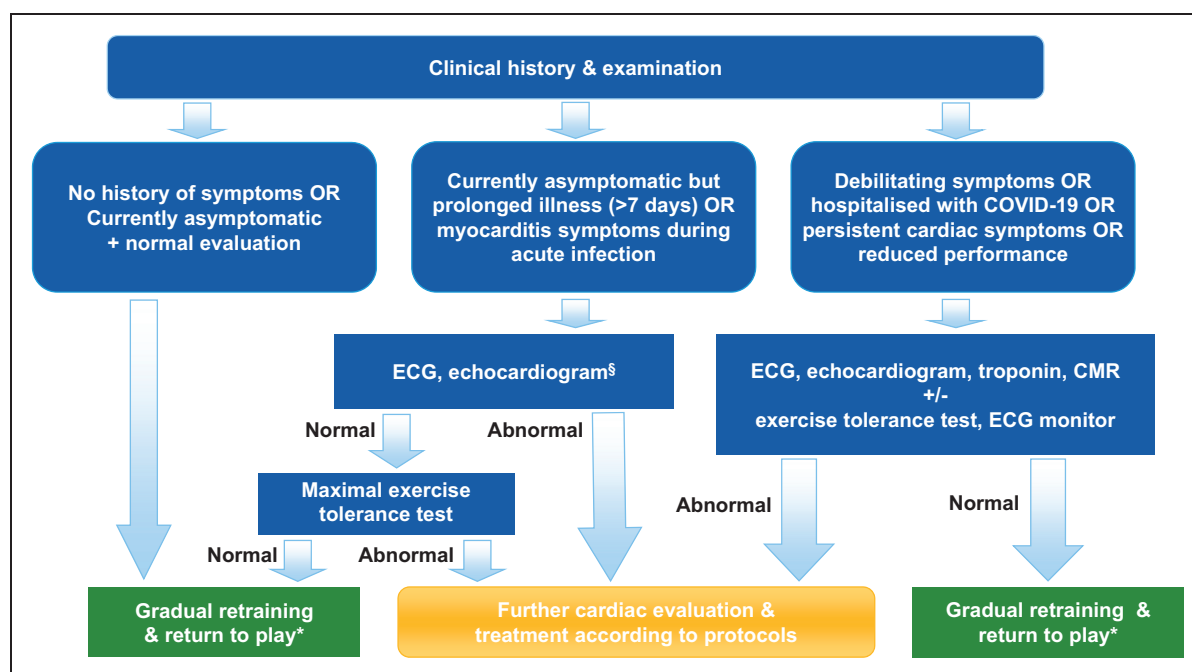


Figure 2. Proposed cardiac evaluation of elite athletes prior to return to competitions.

§Depending on the nature of past symptoms a CMR scan may be considered to check for myocardial fibrosis in those with symptoms highly suggestive of myocarditis.

*If any cardiac symptoms during re-training assessment by the team doctor and/or sports cardiologist as necessary.

ECG: electrocardiogram; CMR: cardiovascular magnetic resonance.

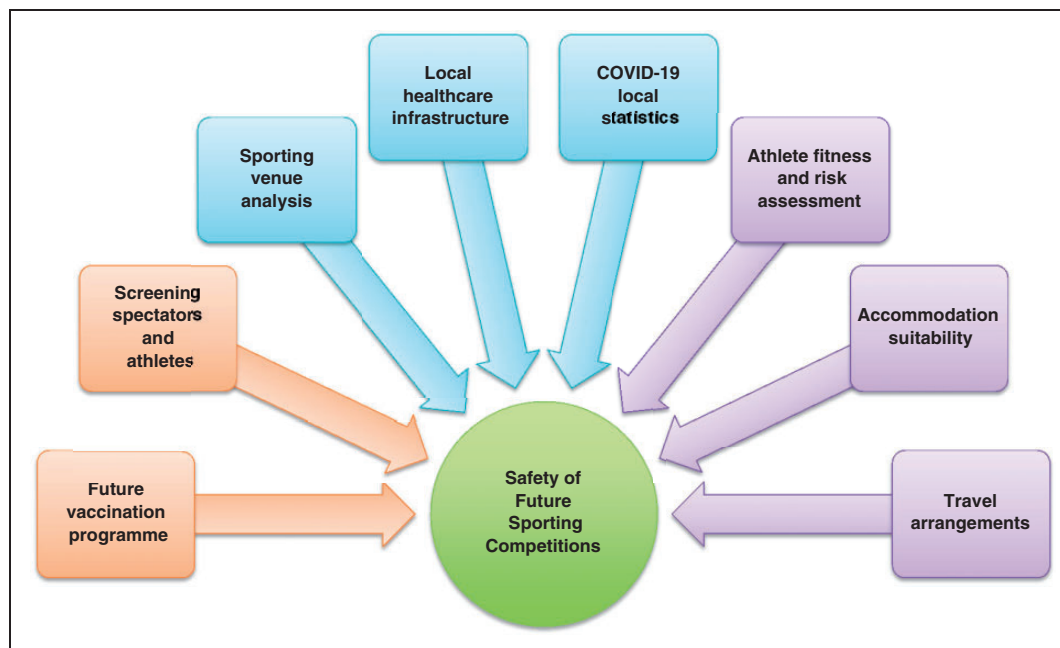


Figure 3. Factors to be considered in the assessment of the safety of future sporting competitions.

believe that this protocol presents a pragmatic approach that safeguards the safety of the athlete and is applicable for most settings. Individual sporting organisations and national societies, however, may decide to implement different protocols depending on availability of testing for the virus as well as cardiovascular testing facilities.

Some athletes had tests pending after their cardiovascular assessments before clearance to train and compete. What is the urgency of performing these investigations and how should these athletes be managed?

In the current climate, all non-urgent diagnostic tests have been postponed. It is recommended that only symptomatic athletes should be investigated urgently. Asymptomatic athletes with ECG or structural abnormalities that would normally require further investigations prior to clearance should be discussed with a sports cardiologist.²⁶ An individualised plan should be devised about diagnostics and management of training schedule based on clinical suspicion and perceived risks.

As a result of the current pandemic, what factors will need to be considered by sporting organisations and public health authorities for the future planning of competitions?

Prior to hosting any sporting competition, relevant health authorities in respective countries will need to

conduct a detailed analysis on the impact of COVID-19 on their own countries whilst simultaneously learning from the global experience. This will include details of disease incidence, prevalence and natural history. Several factors should be considered, including meticulous medical assessments of the athletes, their environment, travel, accommodation and local health care infrastructure (Figure 3). The safety of spectators should also be considered given the highly contagious nature of the virus and close proximity of stadium and arena seating. In addition, as countries ramp up availability for screening and test kits for COVID-19 and the search for a vaccine continues, we postulate that these processes will also have a significant part to play in the safety of any future sporting competitions. We hope in the near future rapid point of care testing for COVID-19 might be possible at sporting venues. Similar testing for influenza viruses during the 2018 Winter Olympic Games in PyeongChang, South Korea allowed timely identification of the aetiology of respiratory infections and in certain cases facilitated treatment.³⁰

Concluding remarks

The COVID-19 pandemic has had a substantial impact on almost all aspects of life. The strict social distancing measures employed to curtail the impact of the infection are likely to considerably reduce the amount of physical activity most individuals perform, from recreational exercisers to elite athletes. Although the

duration of the pandemic is uncertain, the benefits of regular exercise in most aspects of our physical and mental health, including our ability to fight infections, are well documented. We hope that this document will offer reassurance, promote safe participation in exercise in the COVID-19 era and offer a framework of management for physicians caring for athletes.

Author contribution

MP and SS contributed equally to the manuscript as senior authors.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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