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Mini-symposium: COVID 19: The second year

## Covid-19 and the impact on young athletes

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### Educational Aims

The reader will be able to appreciate that:

- Protecting athletes from COVID-19 infection is challenging when training and competing.
- The mental health of athletes is vulnerable as a consequence of COVID-19 restrictions.
- Following COVID-19 infection of any severity, health assessments and graded reintroduction to training and competition are advised.
- Implementing effective simple strategies to mitigate against the risk of acquiring COVID-19 at a community level is crucial for ongoing participation in organized sport.

### ARTICLE INFO

#### Keywords:

Covid-19  
Athletes  
Sport participation  
Harm minimization  
Return to training

### SUMMARY

The Covid-19 pandemic has disrupted organised sport in the community as authorities cancelled, greatly modified or postponed sporting participation as part of a strategy to reduce transmission of the virus. This had a significant impact on young athletes and their families in relation to their psycho-social, physical and career progression considerations. The disruption is likely to continue for some years, considering the constraints of lockdowns, the need to overcome dysfunctional national logistics for delivery of medical care, fund and implement an efficacious vaccine programme locally, nationally and worldwide, develop sufficient herd immunity and create an environment of confidence in the safety of returning to sports for participants, coaches, umpires, administrators and observers. This article will consider the interim challenges regarding the physical and psychosocial importance of maintaining an active sporting programme for young athletes, reflect on safety measures for modifying sporting equipment and environmental protections to allow safest participation in training and competition and provide advice on protocols for a gradual return to sport for the young athlete after infection with Covid-19.

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### INTRODUCTION

The young athlete thrives on the opportunity to train, improve their skills, and compete. Juxtaposing the physical and emotional

benefits that competing in sport brings has been the enforcement of lockdowns, closing of sporting venues and schools, and minimising public gatherings by authorities to decrease the spread of SARS-CoV-2 [1,2]. The interruption of organised sport for the last 18 months has been challenging for the young athlete, coaches and institutions as they navigate altered routines, uncertainty regarding training and competitions, and for the most elite, their professional sporting careers.

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## PSYCHOSOCIAL AND PHYSICAL IMPORTANCE OF MAINTAINING SPORTS IN A PANDEMIC

### *Mental health*

Isolation can challenge an athlete's ability to maintain performance levels, healthy nutrition and quality sleep [3]. Athletes, used to a high caloric intake, may maintain the same eating programmes despite less exercise and evolving mood-related drivers of comfort eating occurring with boredom and stress [4]. Reduced sleep quality has been linked to loneliness [5]. This may decrease an athlete's ability to recover and train [6]. Returning to training and competition after poor sleep quality can hinder performance. Healthy sleep practices may be reinforced through the use of apps for the psychological and physical health of the athlete [7,8].

Isolation inhibits abilities to form relationships as a result of cancelled social events, classes, and sporting competitions. Whilst people can remain in contact through social media platforms, there are fewer opportunities to develop deeper friendships. Not surprisingly, reliance on online communication has been linked to greater rates of loneliness and depression in the general population [9].

There are fears about contracting and transmitting COVID-19 among athletes especially in older female athletes, those engaged in team sports, and those from lower socioeconomic backgrounds [10]. Athletes may have reservations about returning to group training and competition without adequate health and safety provisions in place as discussed later in this article.

### *Physical health*

A lack of regular physical activity is associated with an increase in body fat and muscular atrophy, resulting in a reduced muscular contractile capacity [11]. Aerobic capacity [VO<sub>2</sub> max] declines markedly in elite athletes with major injuries, as seen in professional soccer players for up to 6 months after anterior cruciate ligament tears requiring surgery [12]. Some of the adaptations observed from regimented physical activity occurring in training, and graded programmes for recovery from injury, include increases in blood and blood plasma volume, cardiac output and stroke volume during maximal efforts, and muscular hypertrophy [13]. Deconditioning will reverse these training induced adaptations [14]. The decline in athletic performance can be limited with the adaptation of home-based workouts or outdoor aerobic activities, where permitted. Undertaking consistent physical activity to limit deconditioning will be beneficial before returning to training and competition.

### *Social dynamics*

Physical activity and sport at all levels of competition provides an opportunity for social interactions among athletes, coaches and families. The social interactions at these training or sporting fixtures can provide an outlet for emotional stresses. The Covid-19 pandemic has greatly affected young people globally with forced isolation and varying degrees of restriction, resulting in the rescheduling and cancellation of many sporting competitions and social sporting events which may have lasting impacts on psychosocial functioning [15].

## CONSIDERATIONS FOR ATHLETES AND THEIR TEAMS

### *Considerations for the team*

The team's organisation must provide a safe environment for its members to train and compete. It involves an awareness of symp-

toms of Covid-19 infection, wearing masks, physical distancing, not sharing drink bottles, foods and utensils, towels, clothing, protective sports gear and hand hygiene remain essential at training and when competing. Screening of temperatures and questioning about contact with potentially infectious cases at Covid-19 "hot spots" within the community are helpful. The use of Quick Response [QR] codes [two-dimensional bar-codes] via mobile phones apps is proving useful for tracing peoples' movements, enabling efficient contact tracing which has been the hallmark of successful virus suppression/eradication strategies in countries such as Australia.

Athletes should maintain their own labelled sporting equipment and clothing. Where training involves gym work, this needs to allow for physical distancing protocols. Segregation of travel and accommodation for team members attending training and competition is essential to minimise the risk of acquiring Covid-19 [16]. The UK government has provided useful guidelines for phased return to sport involving the screening of coaching staff, spectators and providing practical advice for travel logistics [17].

### *Considerations for athletes*

#### *Staying well during the pandemic*

An athlete needs to remain active and adjust their training to maintain fitness and wellbeing when communal training and competition are restricted. Non-contact activity such as conditioning work, skill development, wearing of cloth masks and drills where physical distance can be maintained in training should be prioritised [18]. Athletes need to adhere to government restrictions when training, but should be actively supported in continuing to exercise, continue their educational requirements, set realistic goals for training and realign expectations for participation in competition in line with the impact of Covid-19 on their sport within their community.

#### *Likely or proven Covid-19 infection in athletes*

Athletes with symptoms consistent with Covid-19 should seek testing and obtain medical review if needed. They should undertake appropriate quarantine and contact tracing to minimise the spread of the infection to others. Diagnosis may involve a positive polymerase chain reaction [PCR] for Covid-19 on a nasal or oronasal swab or, less commonly, serological testing for the presence of antibodies. A negative test does not exclude infection and so athletes with persisting symptoms should be retested. When a positive test is obtained, it should be repeated before returning to training to confirm that the athlete is no longer infectious. However, not all athletes will have access to reliable and expedited testing [19]. Many diagnoses may be considered on clinical grounds and treated similarly. Basic management should include maintaining hydration, adequate and appropriate diet, isolation within the household, separate toilet, bathing and laundry facilities for clothes and bedding where possible as well as ample rest. If symptoms persist beyond a week, further medical assessment should be sought [20].

#### *Graded return to activity*

After Covid-19 infection there are physical and psychological considerations for athletes as they return to sporting activity. The guidelines for return to training and competition are based upon expert recommendations rather than being evidence-based. They will demonstrate variability between countries. The American Academy of Pediatrics has stratified patients into those with mild, moderate and severe symptoms and made recommendations on return to sporting activity [Table 1].

Recommendations for those athletes who have recovered from Covid-19 without hospitalisation needing a graded return to play

**Table 1**  
Return to sporting activity based on severity of Covid-19 illness, adapted from American Academy of Pediatrics. COVID-19 Interim Guidance: Return to Sports 2020 [18].

Covid-19 illness severity	Manifestations	Further assessment	Return to activity
Mild	<4 days of fever above 100.4°F	Review by doctor	If screening and examination are normal, may return to play after 10 days from the positive test and >24 h symptom free off fever reducing medication
	Short duration of myalgia, chills and lethargy	Full focussed history with emphasis on cardiac symptoms	
		Physical examination	
Moderate	≥4 days of fever above 100.4°F	If symptoms or signs elicited, needs ECG and referral to a paediatric cardiologist for further assessment	Exercise should not resume until cleared by a cardiologist
	Myalgia, chills or lethargy	ECG and Cardiology assessment after symptom resolution and minimum of 10 days past the date of the last positive Covid-19 test result	
		Non-ICU hospital stay	
	No evidence of Multiple Inflammatory Syndrome in children [MIS-C]	Further tests may include a cardiac troponin test, echocardiogram, 24-hour Holter monitor, exercise stress test or cardiac magnetic resonance imaging (MRI)	
Severe	ICU admission MIS-C	Cardiac troponin test, echocardiogram, 24-hour Holter monitor, exercise stress test or cardiac magnetic resonance imaging (MRI)	No exercise for 3–6 months
			Return to exercise guided by cardiologist

[GRTP] programme have been suggested [21]. Fundamental aspects of the GRTP programme relating to cardio-respiratory aspects are listed in Table 2. Those athletes who have required hospitalisation or have co-morbidities such as diabetes, cardiovascular or renal disease will need specialist medical assessments, further testing and a more measured return to sporting activity.

*Specific testing for cardiovascular disease in athletes*

Cardiovascular involvement with Covid-19 is not uncommon, even in previously well young athletes. Symptoms may include chest pain, shortness of breath, palpitations or syncope [18]. Cardiac involvement may manifest with myocarditis, arrhythmias and heart failure [22]. One meta-analysis suggested 8% of patients suffered an acute cardiac injury; with this being 13 times higher in critically unwell patients admitted to the intensive care setting [23]. Yet, some asymptomatic patients may manifest signs of sub-clinical cardiac damage presumably mediated by the pro-inflammatory state with endothelialitis, immunological factors, ACE2 -related signalling pathways, hypoxia and direct myocardial damage [22,24].

Some cardiologists advocate that all athletes should have an echocardiogram, maximal exercise test and a 24-hour Holter mon-

itor to exclude subclinical disease before returning to training [24]. A cardiac troponin > 99th percentile of the reference range has been demonstrated in 15% of patients hospitalised with Covid-19 [22]. Extrapolating these concerns to mildly affected people, other authors have suggested that any cardiac symptoms in an athlete should prompt cardiac troponin testing before training is resumed [25]. Furthermore, as Covid-19 specific concerns for athletes may involve undiagnosed channelopathies, such as the long QT syndrome, an electrocardiograph and Holter monitoring have been recommended [25]. Other authors have a more pragmatic approach for most young athletes, suggesting that asymptomatic athletes who had a focussed medical history taken and demonstrated no abnormal clinical signs are at the lowest risk of complications when returning to competition and should be allowed to return to play with further assessment limited to a 12 lead ECG [26].

*Considerations for families and observers*

The presence of families to support young athletes is important. The psychological aspect of sport with the “feel-good” factor for families and friends serves to help the athlete perform and brings communities together [27]. Covid-19 restrictions on sporting programmes may have a disproportionate impact on young athletes from economically disadvantaged backgrounds [27]. These limitations provide additional challenges for maintaining the physical and emotional wellbeing of young athletes and are often under-appreciated in advice for Covid-19 modifications to sporting protocols.

**MINIMIZING THE RISK TO ATHLETES**

*Environmental considerations*

For training and competition to proceed, a safe sporting environment for participants, coaches and observers is needed. Until herd immunity is achieved through widespread vaccine uptake and previous infection, limitations on sporting participation will continue. Appreciating that young people may be asymptomatic or minimally symptomatic yet infectious, the basic tenants of social distancing, masking, and appropriate hand hygiene must be followed to minimise the risk of disease transmission. The sporting environment must allow observers safe entry to and egress from sporting facilities as well as limits on the numbers of observers congregating within the allocated viewing spaces. Risks of disease transmission will vary with the facility and the sport in question. An indoor sporting complex (Basketball arena or indoor swimming pool) with many tiers of tightly arranged seats poses a different level of risk compared to an open-air stadium with dispersed team seating and limited observers. Swimming poses additional risks as there are usually additional indoor facilities such as changing and shower rooms, locker rooms, office(s), and rest areas in the same building. Although the direct risk of infection from contaminated water is very low, swimmers cannot wear a cloth face mask while in the water and some may be uncomfortable using a full-face snorkel mask as an alternative [28].

*Sports stratification by risk*

The risk of acquiring Covid-19 can be stratified into low, medium and higher risk based on the sport undertaken is presented in Table 3, based on a recent article [https://clickondetroit.com/sports/2020/06/05/heres-how-25-sports-have-been-divided-into-high-moderate-low-covid-19-risk-categories]. Furthermore, risk may vary among players depending upon their position and associated risk factors [29]. As an example, the linemen in American

**Table 2**  
The key aspects of the GRTP programme, derived from Elliott et al. 2020 [21].

- Have had 10 days of rest
- Been symptom free for 7 days to minimise risk of infecting others
- Demonstrated ability to complete activities of daily living
- Walk on level ground over 500 metres without excessive fatigue or breathlessness
- Basic monitoring of heart rate, perceived exertion, muscle fatigue and soreness, sleep and stress levels
- Estimation of injury-psychological readiness to return to sport

**Table 3**  
Relative risk of Covid-19 related to sport played.

Level of risk	Sport
Low	Home based
	Individual skill based:
	Golf
	Tennis [singles],
	Cricket
Medium	Skiing
	Track and field with staggered starts
	Gymnastics
	Field hockey
	Volleyball,
	Netball
	Baseball
Soccer/football	
High	Swimming and diving competitions
	American football
	Rugby Union, Rugby League, Australian Rules Football
	Basketball
	Wrestling
	Lacrosse
	Competitive cheerleading
	Ice hockey

football and Japanese sumo are deliberately very overweight or obese, a known risk factor for severe disease, and are expected to have close contact with opposing players. The football quarterback, on the other hand, tends to be thin, agile, and protected from direct contact by the offensive line.

*Individual considerations*

Decreasing the risk of exposure to the virus is the first step in mitigating risk. The likelihood of contact with the virus increases with the number of persons (players, coaches, etc.) a player is exposed to and the frequency of exposure, the closeness of contact, the duration of exposure, air circulation, the use of personal protective equipment (PPE) such as masks and hand sanitizer and avoiding the use of shared equipment. In sports, exposure to persons with the virus is related to the size of the team including coaches and other personnel both on and off the field of play. At one extreme, American football has a large number of players and coaches in close proximity to the sidelines during the game, during training, and during travel to games while other sports, such as golf, entail much less exposure. The measures to consider in decreasing exposure to COVID-19 are suggested by the Centers for Disease Control [<https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/youth-sports.html>] and are summarised in Table 4.

Sport competitions pose additional risks with travel and housing of athletes and coaching staff, shared equipment and locker facilities. Competitions can only proceed when authorities consider it safe for participants, with local competitions affording less risk than with travel.

*Virus testing to decrease exposure risk*

It is recommended that all players be tested just before the start of the sports season and at regular intervals based on risk and testing availability. The PCR test is specific and fairly sensitive if an adequate nasal swab specimen is obtained, but this test is generally more expensive than antibody-based tests and the results can take up to several days to receive. Moreover, if an athlete has been very recently exposed then tests may not be accurate. Athletes should be tested by using a certified lab and should be retested whenever there is a possible exposure (e.g. after a competition) and periodically between competitions. Athletes must be tested whenever they have symptoms but recognizing the risk of a false negative test (especially for antibody tests), they must stay home from practice and competition until they are symptom free.

**CONSIDERATIONS FOR PROTECTION**

*Protecting the athletes and spectators within the facility*

When it comes to protecting the environment around athletes, two considerations should be kept in mind; preventing the virus from getting into a facility and preventing the spread of the virus if the virus should find a way in. Common methods of quickly screening for the virus are temperature checks and questionnaires that ask about possible exposure and symptoms. These methods can be beneficial and rapid. However, they rely entirely on the trustworthiness of the attendee. There is also the disadvantage that there can be false positives (not specific) and false negatives (not sensitive). Reasons for poor specificity include warm weather, other infections, or symptoms such as allergic rhinitis and coughing. Reasons for poor sensitivity include asymptomatic coronavirus infection and symptom denial.

While the PCR tests are specific, disadvantages of these tests include intrusiveness towards the subjects, delayed results, and most importantly inaccurate negative test results (poor sensitivity). Accuracy of the results is between 50% and 90%, leaving potentially half of tested subjects with false negative results. A method that can be used for accurate, quick results in the future is “sniffer” dogs that have been trained to identify volatile organic compounds (VOCs) specific to coronavirus infection in human breath and body odours [30]. While impractical to use sniffer dogs at sporting venues, a similar method uses an electronic nose, originally developed by NASA for monitoring air quality inside space crafts, with technology that can detect VOCs from breath even in those who are asymptomatic. Early prototypes are cost effective and provide a promising method of rapid, on-the-spot screening [31].

If SARS-CoV-2 finds its way into sporting facilities or events, precautions should be taken to prevent further spread. This includes sanitizing equipment after use, decreasing equipment sharing among athletes, washing hands frequently, wearing masks, and social distancing. Athletes should try to change into their gear before attending practice or a game to limit exposure in a locker room. If the use of locker rooms is necessary, capacity should be limited and entrances and exits should be staggered as respiratory aerosols can carry the virus and remain in air for hours [32].

**Table 4**

Measures to reduce exposure to virus.

<p>Maximizing social distancing, including by limiting the number of spectators. Social distancing and use of masks must be also enforced in the baseball dugout, on the hockey bench and on the football sidelines.</p> <p>Decreasing closeness of contact with other players and duration of that contact. This could include smaller teams and individual skills practice in lieu of team training or staggered practice schedules, avoiding huddles, handshakes</p> <p>Diluting virus density in the environment. This makes outdoor sports generally less risky than indoor sports</p> <p>Avoiding using shared food and drink, equipment, and spaces (eg locker rooms). Each athlete should have their own masks, sanitizer, water bottle, and towels). Weight training only outside and in smaller groups. Cleaning equipment and masks after each practice.</p> <p>Temperature checks and questionnaires before games and practices.</p> <p>Limiting or avoiding travel competition. Travel time and air circulation in closed spaces may make bus travel riskier than airplane travel.</p> <p>Appropriate use of PPE which includes wearing effective masks correctly, and whenever possible.</p> <p>Athletes should stay home from practice or game if they're feeling sick or have any <b>symptoms</b> of COVID-19, and get a <b>test</b> if the doctor recommends.</p>
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An important way to improve safety is to ensure that ventilation techniques are being effectively used in indoor facilities. There are two main types of ventilation that have been tested for effectiveness in removing infectious aerosols: mixing ventilation and displacement ventilation. In buildings with mixing ventilation systems, clean air from outside is supplied at a high velocity, typically from ceiling level, to dilute the stagnant air with potential aerosol virus. The mixed air is then extracted from the room through a vent near the ceiling. This ventilation system with very frequent air exchanges is used on commercial aircrafts. Displacement ventilation systems introduce clean air at the floor level of the room at a low velocity and this is lifted and extracted through ducts at the top of the room by buoyancy forces. This positive pressure ventilation is the preferred system to decrease viral load as it limits recirculation of contaminated aerosol concentrations that could occur using the mixing ventilation method [33]. It is worth noting that only high flow systems should be used, as it is generally more difficult to reduce recirculation of infected air with weaker ventilation systems [34].

Ultraviolet-C [UVC] radiation can be used in sports settings. UVC is an effective disinfectant for air, water, and nonporous materials. Evidence suggests that this radiation can sterilize a surface layer of SARS-CoV-2. There are limited data about the dosage, duration, and wavelength that can best deactivate the virus. UVC is limited however, as it requires direct exposure to kill, meaning surfaces must be cleaned of any dust or dirt before use. UVC is ineffective for virus in crevices where direct exposure is difficult to achieve. There are also health concerns as exposure to UVC radiation can lead to degradation of some plastics and polymers, as well as skin burns and eye injuries [35]. The safest way to implement UVC radiation is to disinfect the air above occupants' heads by using wall mounted and ceiling suspended UVC air ducts [36].

#### Protecting the athlete

Depending on the sport, the most effective preventative measure is wearing a face mask. Although use is encouraged by the CDC, some sports organizations, recreational, collegiate, and professional alike have abandoned masks. This is likely due to discomfort to the face as well as respiratory discomfort. In a comparison study between a surgical mask and an N95 respirator, physiological factors such as blood pressure, heart rate, oxygen saturation, and time to exhaustion differed minimally from the maskless control group. The only significant deviation was end-tidal carbon dioxide (ETCO<sub>2</sub>) levels rose significantly with the N95 respirator as workload increased [37]. While insignificant for milder workout loads, strenuous and heavy workouts resulted in higher ETCO<sub>2</sub> for both surgical masks and N95 respirators and may lead to mild hypercapnia [38]. However, increased levels of carbon dioxide may improve respiratory adaptation, thus over time reducing the rate of fatigue for respiratory muscles [39]. N95 respirators and other form fitting masks are the safest option for protecting ath-

letes from the spread of Covid-19. However, it is impractical for all athletes to have access to N95 respirators due to the cost. Face masks can be used by recreational and school athletes where other preventative measures are unavailable.

Gaiters are a face covering option that is frequently used by coaches in professional sports. One study suggested that gaiters are the least effective form of face coverings when it comes to preventing the release of respiratory particles from the nose and mouth. This study even showed that the gaiter releases more particles than the maskless control group, possibly due to the fabric "splicing" large aerosols into higher quantities of smaller aerosols [40].

For sports requiring helmets, face shields are an effective approach for protection of athletes with their durability, ease of cleaning, and prevention of autoinoculation from touching of one's face. Simulation studies suggest that face shields reduce viral exposure by 96% when within 18 inches [45 cm] of a cough [41]. American football offensive and defensive linemen play most of the game within inches of each other's faces with heavy breathing involved, and face shields attached to the helmets could be the solution to limiting this exposure. Since many players already wear visors that cover their eyes, it is reasonable to assume that a full-face shield wouldn't be much of an inconvenience.

Another option for athletes is antimicrobial masks that have positively charged ions that inhibit virus attachment. Popular materials for these masks include copper and silver, which can kill virus within hours of contact. However, there isn't enough evidence to suggest that these work when metal strands are embedded in a cloth mask [42]. There is also the risk of false confidence for those wearing antimicrobial masks and users may be less inclined to wash the masks frequently enough, decreasing effectiveness. Additionally, the CDC advises that *any* mask with an exhalation valve be avoided because of the vents in the valve allow virus particles to escape [43].

The ideal mask for an athlete is lightweight, effective, and affordable. It is important to consider various materials that can be used as well as multiple layers to increase effectiveness. Wet layers of fabric introduce the risk of respiratory droplets traveling through the mask to the wearer's face. Since sweating occurs during most sports, at least one water repellent layer could be made from non-woven polypropylene or polyester and polyamide. It is also important that the mask form a tight seal on the face to prevent aerosols escaping from the mask. A line of nylon with the mask is a useful way to create a better seal between the mask and face, preventing viral particles from escaping [44].

In aerobic activities such as running and biking, studies suggest that the need for masks is more important, due to aerosol droplets spreading up to 5 meters at a walking pace and 10 meters at a jogging pace [45]. The Tour de France bike race required masks for all contestants, proving that it is possible to hold top-tier sports events with athlete masks [46]. For sports in which masks can be a breathing hazard, such as competitive swimming or diving, athletes should be advised to socially distance themselves and wear a

mask until the time when they enter the water. There is no evidence to suggest that SARS-CoV-2 can be spread through the water in swimming pools [47]. Full face snorkel masks have also been considered as these reduce the expelling of viral particles into the air or water from the swimmers, and while these snorkel masks may be acceptable for practice sessions; they cannot be used in competition [48].

While professional sports have experienced the benefits of an isolated “bubble” setting, it is impractical to implement the same strategies with amateur athletes. As an alternative, it is essential to take the preventative measures as discussed before. In instances where mask-wearing is not feasible, the American College of Sports Medicine emphasizes continuous testing as frequently as resources allow and contact tracing. Secure facemasks worn over both the nose and mouth should be required for staff members, team coaches, and sidelined players [49]. In situations where athletes participate in two sports or two different teams in the same sport, they should choose just one to limit exposure, a strategy implemented by the Finnish Ice Hockey Association [50]. A further consideration includes the risks to sports officials such as referees, especially if they are older and more vulnerable. This has been highlighted in a recent article in the Washington Post citing COVID-19 fatalities linked to youth outbreaks in sporting teams, prompting calls for more frequent [weekly or biweekly] screening of athletes [<https://www.washingtonpost.com/health/2021/04/06/youth-sports-outbreaks-covid-testing/>].

Many sports leagues, amateur and professional alike, require some form of long-distance travel. Appropriate precautions must be taken such as disinfecting between trips, mask-wearing, and social distancing on the bus; athletes should not share seats. Weather-permitting, windows should remain open to ensure airflow. For airplane travel, current screening requires a negative COVID-19 test within 48 h of boarding or a validated vaccination passport. Mitigation measures should be ensured such as maximising use of masks with exceptions for eating, minimizing movement about the cabin, disinfection of contact surfaces, promoting staggered entrances and exits from the plane, and frequent hand sanitizing [51]. These mitigations combined with the mixing ventilation system used on commercial airlines, should make air travel a safer means of transportation for athletes.

## CONCLUSION

Covid-19 completely disrupted athletic sporting training and competition. Even as communities emerge from the restrictive consequences of the pandemic, the ability to return to athletic competition will take years and the rules and etiquette of competition will likely be forever altered.

## DIRECTIONS FOR FUTURE RESEARCH

- Understanding the long-term effects of COVID-19, especially cardiorespiratory, in young athletes.
- Developing sports gear that is comfortable to wear, reasonably priced, but effective in preventing respiratory virus infection and transmission.

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