Impact of COVID on Sports Injury Patterns, Changes in Mental Well-Being, and Strategies to Prepare for Future Pandemics in Sport

Heather K. Vincent, PhD, FACSM; Shammi Patel, DO; and Jason L. Zaremski, MD, FACSM

Abstract

This review describes the available evidence of the acute respiratory syndrome coronavirus 2 (SARS-CoV-2, referred to COVID-19) pandemic on musculoskeletal injury patterns and prevalence in athletes. A brief overview of the epidemiology of COVID-19 and prevalence in active populations from youth through professional are provided. Responses to COVID-19 regarding sport participation at regional, national, and international organizations are summarized. Downstream effects of complete or partial training shutdown on injury risk and mental health are discussed. Strategies to maintain athletic potential and overall well-being include maintaining safe access to training facilities and resources, implementation of injury prevention programs, organization of athlete support networks, and incorporation of resilience and coping training.

Introduction

In 2019, a new coronavirus was identified as the cause of a disease outbreak that originated in China. The virus is now known as the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The disease it causes is called coronavirus disease 2019 (COVID-19).

COVID-19 spread as a global pandemic with impressive pace, challenging public health from many directions (1). As of March 30, 2022, there have been more than 480 million cases and 6.1 million deaths, reported worldwide, and infections have been reported across all ages and in almost every country (2). The virus's highly contagious nature is largely attributed to its transmission through viral shedding via respiratory droplets, and transfer from surfaces to mucous membranes through hand contact (3). While participation in exercise and sport is vital for health and overall well-being, it is important to understand the prevalence patterns and impact of responding to the virus on athletic populations as the virus rapidly mutates and spreads. This article will highlight the known downstream effects of complete or partial training pandemic-related lockdown on injury risk and mental health in athletes, and propose strategies to maintain athletic potential and overall well-being to prevent injury upon return to sport.

Infection Prevalence in Athletic Populations

Initially, there was concern that athletes would have an elevated risk of COVID-19 infection due to the general close contact nature of competitive sports, tight locker rooms, and training facilities, shared equipment among players, and frequent travel required for competitive events. Furthermore, athletes are usually not able to maintain practices of social distancing and donning of face coverings during training and competition, increasing transmission risk. Active lifestyles may be associated with better COVID-19 outcomes, including less severe morbidity and mortality (4). Therefore, COVID-19 infection in athletes is mostly mild with few complications; athletes younger than 26 years are more likely to have few-to-no symptoms with COVID-19 infection, especially females (5). This finding explains better outcomes in the athlete, but also increased transmission due to nondetection in the asymptomatic athlete.

Among youth and high school athletes, those in team sports (volleyball, football, field hockey, cheer/dance) had an elevated incident rate of infection compared with individual sport athletes (golf, tennis, cross-country running) (6). Even among team sports, incidence rate can vary; youth volleyball

Department of Physical Medicine and Rehabilitation, College of Medicine, University of Florida, Gainesville, FL

Address for correspondence: Heather K. Vincent, PhD, FACSM, Department of Physical Medicine and Rehabilitation, 3450 Hull Road, PO Box 112730 University of Florida, Gainesville, FL 32611; E-mail: hkvincent@ufl.edu.

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club sport athletes reported an incidence rate of 7.9 per 100,000 compared with 1.7 per 100,000 in soccer (7). Among quarantined collegiate athletes, 25% overall received positive tests, with the highest prevalence occurring in football (54.4% COVID-19 positive), swimming and diving (6.8% positive), and volleyball (5.5% positive) (8). The lowest infection rates occurred in softball, rowing, gymnastics, and golf (1.1% to 1.5%), and are lower in women than men (9).

Local-to-Global Sport Organization Responses to COVID-19

Since the first major sports league to cancel competition on March 11, 2020, there have been various approaches implemented to minimize exposure and transmission to COVID-19. Initially, the responses to sports competition were very conservative. The following summary of responses was compiled from publicly available news sources and web site updates for various sport leagues.

Lockdown and Quarantine

All organizations initially proceeded with a complete lockdown from sport (quarantine) in March to May 2020. U.S. local and regional youth and collegiate sport engagement from March 2020 through the fall of 2020 varied. For example, as of September 28, 2020, fall competition was canceled in five states and the District of Columbia (DC). High school (HS) football was moved to early 2021 in 17 states. Quarantine durations were formed as a result of state or local or league/conference mandates. The National Collegiate Athletic Association (NCAA) canceled all winter and spring 2020 championships by March and athletic competition ceased. American and international professional sport leagues that canceled or delayed seasons included football, soccer, baseball, basketball, hockey, Artic Winter Games (incudes snow sports, biathalon, wrestling, judo, table tennis, volleyball, and more). Further, the 2020 Tokyo Olympics and Paralympics were delayed a full year until summer and fall 2021. Considerable inconsistency of time away from competition existed across sports with different player ages, different states, and level of competition. Consistent lockdown issues across athletic levels included restricted movement in the community, closure or restricted access to training facilities and gyms (10), and social isolation or physical distancing. Recreational events for the public, such as running race events, were canceled without alternative competition/participation methods (11). Even among athletes who did not require special training facilities (such as long-distance runners, soccer players), training habits changed such that volume and intensity decreased during lockdown (12,13).

Reopening

Variations in regional COVID-19 prevalence prevented all high schools and collegiate programs from reopening at the same time. During early phases of returning to sport, emphasis was on higher-level athletes (10). The west coast, mid-Atlantic, and northeast states reopened more cautiously whereas as other parts of the United States, such as the southeast, reopened more quickly. The method and procedures of reopening also differed across sport and level. For example, when the Big Ten Conference restarted play, protocols were implemented that required all active players to undergo daily antigen testing prior to each practice or game. At this unprecedented time, sport oversight organizations used best judgment to protect athletes, staff, and spectators used methods purported to prevent COVID-19 spread.

Semilockdown

Further challenges ensued with the emergence of the COVID-19 Delta Variant (also termed Delta B.1.617.2 and AY lineages). In July 2021, the 2020 Tokyo Olympics and the City of Tokyo banned all spectators and declared a state of emergency in the capital that persisted during the Games. In some states, after a return to full capacity crowds, the Delta variant forced a return to mask mandates. Local or regional decisions throughout the United States were made at youth and collegiate levels with respect to the reinforcement of restrictions to play or competitions in different sports. The wide variations in safety guidelines and mandates caused confusion, stress, and disruption to physical disruption in athletes and the support systems around them.

Reopening

As the development and availability of COVID-19 vaccinations, as well as a shift from the Delta to the Omicron variant phase of the pandemic, as of March 30, 2022, there have been changes in guidance of COVID-19 mitigation measures at numerous levels of society and sport. While the Centers for Disease Control (CDC) continue to recommend vaccination among people 5 years and older, there have been other changes as well. Masking guidelines changed. Masking outdoors was no longer required unless the individual was a caregiver for someone with COVID-19. Further, masking guidance is dependent upon COVID-19 community levels based on where one lives. However, numerous factors beyond evidence-based medicine have resulted in different recommendations from various state level agencies as well as different sports organizations. A challenge for sports medicine providers and team members is to remain current on their and sport organization guidance of the recommended measures to reduce COVID-19 positivity rate and spread as these rapidly change.

Combatting COVID-19

Sports organizations used a multipronged approach involving medical advisory groups, physical distancing and masking, screening, and testing.

Creation of Advisory Groups

The National Federation of State High School Associations Sports Medicine Advisory Committee provided guidance on reopening up high schools for sports and activities (14). The NCAA formed the COVID-19 Medical Advisory Group (15), whose roles were to provide guidance to the membership on training, practice, and competition. Testing protocols, infection spread, appropriate COVID-19 protocols applicable to training, practice, and competition, on-site management of student-athletes and essential personnel, nonessential personnel, and fans were regularly reviewed. Guidance related to physiological, medical, and mental health consequences of COVID-19, and other emerging information (such as vaccines and new medical treatments) also were updated (15). Most professional sports leagues used their own medical advisory committees to provide guidance on COVID-19 procedures but, youth or high school sports created their own COVID-19 advisory committees and guidelines (16–18).

Implementation of Social Bubbles or Distancing

One approach to combating viral spread was to isolate teams in one location, termed "bubbles." Because of financial and resource constraints, bubbles were not possible at the youth, high school, or most collegiate levels and events. Professional athletes competed under a variety of bubble environments. For example, the National Basketball Association (NBA) isolated in Orlando, Florida and the Women's NBA isolated at the IMG Academy in Bradenton, Florida (19,20). The National Hockey League played games in two Canadian cities, Toronto and Edmonton. Teams reported to their respective sites, and each team was assigned to one floor at their designated hotel and were provided access to appropriate areas. Social distancing was achieved across the country for many levels of other sports, which included limiting event attendance to family members or restricting fan attendance to 20% to 25% stadium capacities. To prevent games from becoming "spreader events" the number of games was reduced by 63% in Major League Baseball, and this was accompanied by reduction in roster size and alterations to rules of play (allowing pitchers to use wet rags instead of spit for moisture, and banning of spitting items) (21). Further, masking was recommended to be worn by all coaches, sports staff, officials, parents, and spectators. If masking was not possible, then encouragement of physical distancing was recommended. Of note, the NCAA was able to provide a bubble for its 2021 NCAA men's as well as women's basketball tournaments. However, even a bubble is not 100% impenetrable as Virginia Commonwealth University had to forfeit its game against the University of Oregon after members of its team tested positive 5 d after entering the bubble.

Surveillance Testing and Screening

Secondary approaches to mitigating transmission included real-time polymerase chain reaction (PCR) testing and serological testing for SARS-CoV-2 IgG antibodies. Depending on the competition level, this testing and screening was performed at different intensities. Rapid and consistent use of PCR testing has been successfully used to restart German Bundesglia soccer to prevent spread of the virus among league members (22). In youth or HS sport due to financial resources, socioeconomic constraints, and medical provider availability, testing and screening had substantial variability. As a result, the Centers for Disease Control recommended the wearing of masks as much as possible to mitigate transmission. There were exceptions for playing high-intensity sports and for individuals with disabilities and underlying medical conditions. With suspected COVID-19 exposure or positive testing, athletes underwent a quarantine period.

As COVID-19 vaccination availability improved, vaccination uptake has increased, and the Omicron variant has become the dominant variant, there has been a shift in screening and surveillance testing. For example, the NFL stopped daily COVID-19 testing for unvaccinated players and the NCAA has defined quarantine to be 5 d after a positive test if there are no symptoms or symptoms are resolving. Further, states are changing their guidance on sports participation and COVID-19. For example, the state of Connecticut has indicated that fully vaccinated individuals no longer need to quarantine after an exposure to COVID-19 as long as they are asymptomatic and do not need to be included in regular screening programs for COVID-19 (23). Further, the American Academy of Pediatrics (AAP) has updated their guidance on return to sports and physical activity as of March 24, 2022 (24). The AAP recommends that pediatricians should inquire about past COVID-19 infections and vaccination/booster status as well as strongly recommends that all who are eligible should receive the COVID-19 vaccination and/or booster (24).

Lockdown Effect on Training Programs and Musculoskeletal Injury

Several consequences resulted from these lockdowns. First, lockdowns produced marked reductions in athletic training specificity, intensity, frequency, and duration (10,13). Athletes of all ages, from adolescent to professional and Olympian/Paralympian were less able to train at and maintain sport-specific conditioning. Epidemiological data from 12,526 athletes in six continents showed a clear emphasis on training goals of maintaining or developing general fitness/health and a deprioritization of developing skills/technique, flexibility, balance, muscle strength, and power (10). Many athletes trained at home and focused on bodyweight-based activity and cardiovascular conditioning. From the injury prevention standpoint, lockdowns were related to a loss of critical physical qualities including strength, aerobic capacity, power, high-speed running ability, acceleration, deceleration and change of direction, decision-making capacity, and game-specific contact skills (13,25). Also, quarantine-related physical effects are sport-dependent. For example, inactivity among handballers produces deficits in jumping, shooting velocity, maximal concentric strength of the upper limbs, and muscle power in the upper and lower limbs (13). Any or all of these can compromise readiness to participate in sport, reduce function, performance times (26), and increase injury risk after isolation-related reductions in training (27).

Second, reopening after a disrupted season resulted in a highly compressed timeframe to physically reprepare for reengagement into competitive events. While home exercise programs are available (such as video-conference systems, online forums, preprepared videos, and video libraries), these programs do not necessarily provide the highest level of maximal muscle tension or conditioning stimuli to replicate what is encountered in real competition. Both athletes and officials were at risk for restarting sport participation with deficits in strength and flexibility (28,29). This is particularly true for sport movements like sprinting or throwing. In addition, crowding of competition schedules after reopening to complete the season altered physical performance of athletes on the field. For example, professional Polish and Croatian soccer players handled match demands with greater distances covered in low-intensity running, fewer accelerations/decelerations than pre-COVID-19 (30,31). Athletes continued improving performance during the remainder of the season (32), but this window of time performing at lower intensities compared with usual competition increased vulnerability to injury. Moreover, tactical disorganization and less interaction of players occurred within team sport.

Third, there was a heightened incidence of musculoskeletal injury upon return to sport across competitive levels, particularly during the first couple of weeks after reengagement (27,33). Physical deconditioning with training reduction or

restriction is rapid (34,35). Myocardial mechanics and stroke volume, oxygen delivery and tissue uptake, and blood volume all decline; skeletal muscle protein turnover, strength, and mass quickly change commensurate with loss of tendon and ligament tensile strength and functionality — as quickly as 1 to 2 months after detraining (25,29). Strength and power performance declines with detraining in several upper and lower body lifts in as little as 2 wk, ranging from 5.1% to 6.6% (36). Metabolic processes decelerate and hormone production levels decline with less training stimulus (13). Musculoskeletal injury rates were affected across all levels of competition as described next.

Professionals

In running sports, such as soccer, hip adductor, and hamstring injuries increased by 16% in professional team members (37). The Premier League had more injuries and an accelerated time of onset to the first injury during the 2020 to 2021 season than the two preceding seasons (37). Elite senior men's cricket resulted in a significant increase in the proportion of in-season days lost to thigh injuries in 2020 compared with the previous five seasons (38). German Professional Bundesglia Soccer League players had a greater than three times higher rate of injury when controlling for games played compared with injury rates prelockdown (27). In professional baseball players, the overall injury incidence rate in the upper extremities and spine/core was nearly twice that in pitchers and fielders during their shortened 2020 season compared with the two prior seasons (39), and pitchers were 2.9 times more likely to undergo ulnar collateral ligament surgery after the lockdown compared with the previous three years (40,41). Retrospective evidence from the NFL showed that the injury rate of players during weeks 1 to 4 of the 2020 to 2021 regular seasons was higher than that of the three prior preseasons and regular seasons (40). Injury incidence increased in defensive players (from an average of 7.54 to 10.20 injuries per 1000 adverse events, with defensive backs most affected) (42).

Recreational Adult Athletes

An electronic survey administered during the peak isolation period to 1147 runners (novice through 20+ years of experience) revealed that the adjusted risk ratio for running related injuries was 1.40 compared with preisolation (11).

Collegiate

Interestingly, full time dance students in China showed a reduction of the injuries on the lower back, feet, and shoulders, but the knee, ankle, and groin/hip joint injuries remained the same (43). Fatigue degree of students decreased and their hours of sleep increased ($P < 0.01$) during the lockdown. Although injury prevalence dropped significantly during the first COVID-19 lockdown in Chinese dance students, the main dance injury characteristics remained the same. Decreased fatigue and longer hours of sleep could explain the aforementioned drop in injury prevalence during the lockdown. One might also consider the decrease in training as a reflection of less training exposure, which would inherently reduce opportunity for injury and theoretically lower injury rate. However, college-aged adults (defined as 19 to 22 years old in this article) comprised a larger proportion of sports-related emergency department visits in 2020 compared with 2018 (44). Authors hypothesized that this was due to available unofficial sports leagues and independent fitness training that was not available for high school aged and younger children.

Youth

A multicenter study of sports injury presentation in pediatric clinics showed that initial rates of injuries were reduced by 15% during the pandemic compared with the year prior; upon return to sport in May to June of 2020, sports injury rates more than doubled from lockdown (45). For skeletally immature younger athletes, rapid reentry into sport with inadequate time for adaptation increases susceptibility to overuse and acute injuries (46). For example, among gymnasts, week-to-week changes in training load following periods of various restrictions (additional lockdown, periods of isolation) were not always gradual. The relative risk for substantial injury was 5.3 when an ache/pain or injury to a different body part occurred the week prior (47). Another study using data from the National Interscholastic Cycling Association revealed that while overall cycling injuries decreased in the early pandemic compared with the two years prior among junior varsity and varsity boys and girls, the proportion of practice related injuries on trails increased 14.3% (48), likely as this was the only setting when cycling was performed.

Strategies for a safe return to sport

Safe reintegration back into sports should include a layered and multipronged approach to strength and conditioning, sport-specific drill work, and appropriate contact drills (49). Detrained athletes may be vulnerable to exertional heat illness, rhabdomyolysis, and cardiorespiratory failure and musculoskeletal injury (50,51). Further, there were concerns of how athletes could train safely but still maintain their skill set (30) in light of closure of training facilities and limited access to coaching and training staff. Gradual transition back into full training volumes can help avoid accelerated overload and loading on musculoskeletal tissues (52,53). Moreover, coaches and athletes should be encouraged to monitor and log perceived loads using perceived exertion scales commensurate with actual training loads, in the return to training process. In cases of elevating effort relative to stage of training, loading, and/or volume can be scaled back. Nonsevere but persistent injuries also should be tracked and addressed to reduce the risk of a more substantial, time-loss injury (47). Resistance training to failure with lighter loads, high-speed running, nutritional adherence, and plyometric training are some strategies (25). One common theme among all sports is to ensure athletes participate in a progressive, consistent progression in all aspects related to their sport (25,54).

Mental Health Impact of COVID on Athletes

Collective evidence from Europe (13,55–63), Asia (64,65), Canada (66), South America (67), and the Middle East (68–70) is demonstrating that the pandemic-related restrictions had clear negative impact on mental well-being among athletes across all ages. Surveys administered one to three times during the pandemic have identified mood disturbances, behavioral changes, and varying levels of stress among competitors ranging in age from youth, collegiate through professional. Several instruments were used including general impact of the pandemic that assess anxiety, depression, mood, and impact of

events. Other studies provided special surveys or personal interviews to identify specific stressors among athletes and compensatory behaviors (71).

Stress manifests as anxiety, depression, posttraumatic stress, and a heightened perception of impact of events and difficulty sleeping (72). Uncertainty of quarantine duration, boredom, lack of resources or access to training facilities frustration, coupled with reopening, and rapid return to semilockdown challenged the coping ability of many athlete subgroups. More than 52% of athletes experienced negative emotions during lockdown (73), and athletes in developing nations with limited resources experienced a worse psychological impact than athletes who were better resourced (62). It is important to note that the pandemic affected athletes across age brackets and sport events differently. For example, in Italy, distress was reported by 50% of youth, 32% of adolescent, and 30% of adult athletes, suggesting there was less resilience to cope with stress in younger people (56). Among Olympic competitors from Romania, the negative impact of the pandemic was greatest in kayakers/canoeists, and track and field athletes and lowest among tennis players and footballers (57). These findings could suggest that coping with stressors during lockdown was more challenging for individual performing athletes than team athletes (56). Interestingly, compared with healthy nonathletes, athletes had lower anxiety, depression, and posttraumatic stress scores (68,69). Epidemiological data show that mental well-being is positively and directly related to weekly activity levels during the COVID-19 pandemic (74). Thus, involvement in physical activity or preservation of activity patterns during forced restrictive periods may relieve psychological stress. Compared with nonathletes, student-athletes remained part of a built-in supportive community. Thus, even with virtual and/or isolation measures, student-athletes potentially had an advantage of some socialization compared with nonstudent-athletes.

Abrupt reductions in training volume, cessation of competition, and isolation from teammates/coaches are triggers for psychological stress. Stress occurred irrespective of competition level, but elite or professional athletes experienced more severe mental stress than nonelite athletes (75). This heightened stress was attributed to loss of exposure to fans and their teammates, to loss of income from professional play, and to the insecurity about their careers as an athlete (58,75,76). Spring sport athletes who were collegiate juniors at the time of the lockdown missed their junior and senior seasons of sport. Athletes around the globe missed opportunities to complete their sport career at different levels or missed opportunities for recruitment to the next level of their sport. Women and girls reported 9% to 22% higher prevalence of anxiety compared with men, and 32% more women ranked their outlook "a little or much worse" after lockdown and were twice as likely to worry about their future than men (63,69,71). For some athletes there was a positive outcome from delayed participation, where athletes at the collegiate levels were provided an extra year of eligibility due to the disruption from COVID-19. In addition, the challenges of collegiate athletes moving back home mid-season was more difficult for women than men. The hardest-hit subgroup was women — with lower socioeconomic status, higher academic load, and/or worse training conditions under lockdown (77). Some of these sex differences especially in elite athletes may be driven by less maintenance of physical activity in lockdown, large sponsorship gaps, less support for women's and girls' programs, and less media coverage than in men or boys (71,73,77).

Mood changes paralleled reduction in training volume and loss of competition. Negative moods that increased with lockdown and semilockdown included anger, fear, confusion, restlessness, irritability, fatigue, concern, and tension (60,70,73,78), whereas positive vigor moods and emotions like vigor and happiness decreased at these timepoints (53). Negative mood state is a key suppressor of motivation and focus and maintenance of physical activity. Several studies show that psychological traits related to lower mental stress and better handling of restricted training are resilience and emotional intelligence (13,79). Athletes with strong athletic identities (degree to which an individual identifies with the athlete role and looks to others for acknowledgment of that role (80) are more likely to have anxiety severity greater than nonathletes (79). In addition, cancellation of public events, such as running races, contributed to lack of motivation to run, worry about changes in training on different surfaces, and loneliness without supportive runners to participate with (11). Even young athletes experienced these mood changes, reduction in well-being, and loss of motivation, as observed in long-distance runners (81).

Preparatory Strategies to Maintain Athlete Activity and Well-Being

While evidence of injury and mental well-being among athletes during pandemic situations is useful, it is important to put into context how this evidence can be used to navigate complex interplay between the athletes and public, policymakers, and community organizations to implement prevention efforts and exposure mitigation. Here, we propose reparatory considerations for athlete physical activity and well-being. Several strategies can be applied to help athletes across the board preserve fitness status and well-being in times of lockdown or similar public health situations, the details of which are provided in Tables 1 and 2, respectively. These strategies can be implemented on a larger scale and among people who have limited resources and can be applied in different sectors as needed.

1. *Preparation of Training Facilities to Maintain Access.* For viruses that are transmitted via airborne or surface contact mechanisms, several approaches can be used: repetitive disinfection of equipment, frequent hand hygiene, focus on fewer multijoint exercises rather than many isolated exercises for specific muscles to minimize contamination (88). Use a "get in, train, and get out" method of training in public facilities, with plans in place to provide extra space for vulnerable athletes (paraathletes, comorbid conditions) (54). Further, masks should be worn when deemed appropriate and/or per guidelines as a preventative measure. However, masking guidelines are "continuously being developed and updated" (84).
2. *Early Implementation of Injury Prevention Practices.* Table 1 provides specific details on implementation of these practices. At the initial onset of a lockdown, standardized neuromuscular training programs such as the Fédération Internationale de Football Association (FIFA

Table 1.
Potential physical training strategies during pandemic lockdown and return to sport.

During Lockdown	Goal: Prevent Detraining and Maintain Musculoskeletal Tissue Strength and Integrity
Power, strength, explosive activity (79)	• FIFA 11 + program, OSTRC Shoulder Injury Prevention Program, and/or Nordic hamstring exercise • Multijoint exercise to address high-force, low velocity aspect of neuromotor performance (squats, deadlifts, >80% to 90% 1 repetition maximum, 3 to 4 sets, 4 to 8 repetitions) at least once a week • Incorporate strength and proprioceptive exercise at beginning and end of training sessions to expose athletes to neuromotor challenges during fatigued and nonfatigued conditions before return to sport
Cardiovascular conditioning (79,82,83)	• Maintain 2 to 3 sessions a week separated by no more than 48–72 h to minimally maintain fitness • High-intensity interval training bouts provide brief, high force muscle actions and potent cardiovascular stimulation; this can be performed at a minimum of 1 to 2 X per week to preserve $\dot{V}O_2$ peak
Sport-specific skills	• Focus on the technical aspects of a sport motion when access to facilities is limited (*e.g.*, ball handling drills in basketball or soccer, wall ball in tennis or lacrosse, putting skill in golf) • Maintain strong sport motion through multidirectional training drills involving agility or unanticipated demands (forward, backward, lateral and varying patterns)
Return to Sport	Goal: prevent musculoskeletal injury with reengagement into sport
Slow and gradual progression of volume, intensity, and complexity	• Depending on the sport, consider a gradual return to preexercise lockdown volume and intensity over a period of weeks to months. • Allow adequate time for the musculoskeletal system to remodel and adapt with return to sport and competition with controlled ramp-up of exercise exposure and rest/relative rest days. • Reintroduce multiplayer engagement drills first, followed by full-scale competitive volumes, and interaction and collision (if applicable)
Monitor effort levels, changes in musculoskeletal aches or pain	• Use a monitoring system (paper, phone, or electronic) to track training volume daily and weekly to avoid accelerated rate of return to sport • Use a numerical pain rating system with athletes and instruct documentation of new aches or pains and severity of pain. Reduce training volume/ intensity with new pains or worsening pain symptoms to prevent onset of chronic injury and time loss.

$\dot{V}O_2$, rate of oxygen consumption.

11+), Nordic Hamstring exercise, or Oslo Sports Trauma Research Center (OSTRC) Shoulder Injury Prevention Program should be rapidly implemented to help protect against injury with re-engagement into sport (85,93,94). Continuation of high-intensity training maneuvers will help maintain explosive performance and protect against vulnerable tissues. These maneuvers include resistance training to failure with lighter loads, plyometric training, and exposure to high-speed running to ensure appropriate hamstring conditioning (25). Maintenance of cardiovascular conditioning and strength/durability of musculoskeletal tissues can be achieved through a minimal maintenance schedule of aerobic training volume (94). Muscle mass and strength also can be maintained through the regular performance of high resistance loading using multijoint exercise (94). Finally, optimization of overall nutrition, regardless of time away from sport, to prevent injury is paramount as data has suggested isolation alters nutrition behaviors, such as unhealthy eating patterns (82).

3. *Organize a Multifaceted Player Support Network:* This network should include experts (coaches, psychologists, sleep hygiene experts, nutritionists, physicians and care team, peers, and family) and include integration of technology (visual or audio capacity with direct athlete contact via phone calls, video calls, or written messaging) to support athlete mental health (13). The network should include the development of a personalized home training program that leverages available space and equipment resources and works to meet the sport-specific demands. Experts in the network should guide athletes on best practices for recovery (relaxation techniques, sleep techniques, nutritional) (86,89,90) to optimize overall well-being (Table 2). Organizational guidelines should be set to help with recognition of stress escalation signs and action plans enacted to support athletes with the best available resources and evidence supported practices.
4. *Embed Resilience Training and Promote Mental Health in the Lockdown*: These techniques would likely have the greatest impact among athletes with low resilience, who are female with low resources, or at the professional level. Even brief programs that emphasize resilience can enhance goal motivation, tolerance to negative affect, and persistence (95,96). Video or audio training exercises or face-to-face options can be deployed depending on the resources or situation. Some interventions can incorporate families,

Table 2.
Components of programs designed on maintaining optimal mental health during lockdown.

Method	Details and Actionable Examples
Resilience and coping (84,85)	Improve resilience to negative situations and ability to redirect attention from internal to external tasks; relaxation and stress reduction; cognitive behavioral training; regulate thoughts; manage thoughts and problem solve; control the controllable; appreciate teammates *e.g.*, Breathing exercises, self-directed body scans; "Changing Minds, Changing Lives" program for athletes; "Help Out a Mate" program; "Your Path to Success" in sport program
Reframing training (56,79)	Provide athletes the view that this is a "window of opportunity" to recover and rebuild for the next season or competition. Reframing contributes to positive mood state and a sense of coherence during uncertainty, provides meaning to training during lockdown or opportunity to master techniques. Ex: Consider developing aspects of the sport not commonly focused on during a regular season or training program which are "weak links" (*e.g.*, clearing and running field distance in lacrosse, or fast short distance transition speed across a tennis court, improving endurance and aerobic intensity)
Setting new goals or new focus (33,86,87)	Clarify objectives with simple training tools and resources; set the context of the training goal in the overall view of the sport. Setting multiple achievement goals may be beneficial in the context of pandemic confinement. *e.g.,* Develop mobility in power lifters or weightlifters during times of limited access to equipment for their normal lifting routines; this new goal and focus can directly translate to gains in performance upon reengagement in the sport after lockdown ends.
Team and customized contact	Coaches, instructors, trainers, and medical staff maintain open lines of communication through unstructured or structured communication in team and individual formats (face-to-face or online). Track mental well-being through simple surveys and review training practices and nutrition. Provide individualized feedback on programming and support accomplishment of new goals. *e.g.,* Review weekly wellness survey scores with each athlete and listen to concerns or issues. Suggest podcasts on topics that may help athletes navigate the lockdown challenges through the Association of Sport Psychology (https://appliedsportpsych.org/media/featured-podcast-library/)
Sleep health (88–92)	Phase delays occur in athlete circadian rhythm with lockdown, thus downregulating arousal and fostering mindset for high sleep efficiency will mitigate impact of COVID on sleep and stress, and will reduce risk of overeating during waking hours; address insomnia and frequent daytime napping observed in athletes during lockdown, especially among older athletes. *e.g.*, attention meditation techniques to promote relaxation; consider light meal rich in tryptophan 1 h before bedtime. Maintain normal bedtime; Use smartphone apps to implement deep breathing techniques before sleep.
Nutritional balance (81,88)	Ensure adequate nutritional intake to combat infection; Encourage personal tracking of dietary intake of macro and micronutrients especially vitamins A, B6, B12, C, D, E, and folate) and other elements (*i.e.*, zinc, iron, selenium, magnesium, and copper), which can modulate viral infection course; focus on healthy food patterns and maintenance of normal meals and time of consumption. *e.g.,* Minimize deviations from healthy eating patterns (avoid consumption of foods with high saturated fat, high sugar content) and obtain high intake of fiber, whole grains, unsaturated fats, and antioxidants using phone tracking apps or food logs; avoid eating large meals late at night.

teammates, and other athlete partners (97). Training can be complemented by positive interactions with medical staff; for example, positive and prosocial behaviors of athletic trainers help to cultivate resilience, and suppress psychological stress and foster healthy nutritional habits among athletes (98). Time away from sport may be considered a window of opportunity for an athlete to reflect on mental well-being outside of their athletic identity.

Conclusions

Disruptions to normal training and access to training facilities and resources during pandemic-related lockdowns can increase mental stress and increase the risk for musculoskeletal injuries in athletes upon return to sport. These maladaptations can occur in youth through professional levels. As the field of sports medicine continues to evolve and learn during this unprecedented time, strategies can be implemented to help athletes of all ages and backgrounds navigate back to normalcy. These include maintaining safe access to training facilities and resources, implementation of injury prevention programs, organization of athlete support networks, and incorporation of methods to improve resilience and coping ability.

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