



Discussion

COVID-19 countermeasures of Chinese national athletes: Prevention, treatment, and return to play

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ABSTRACT

Under the condition of normalized epidemic, how athletes train and compete well has been in the spotlight. This article reported the symptom, hospitalization and training situation of seven confirmed cases of coronavirus-disease-2019 (COVID-19) among Chinese national teams. Moreover, the paper summarized the experience of Chinese national teams in terms of epidemic prevention and control, treatment of infection, and safe return to play. Through a scientific combination of medication and non-medical treatment, seven athletes were all discharged from the hospital. These discharged athletes underwent strict isolation and scientific training before returning to sports teams. Before returning to play, continuous monitoring of physical and mental condition was required. All seven athletes returned to play safely and performed excellently. As for hosting large-scale sporting events, the entire enclosed-loop management from immigration to competition was proposed in this paper. This study could serve as a standard of epidemic prevention and control, treatment for infection and safe return to play during competition and training around the world.

Introduction

Coronavirus-disease-2019 (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2, was primarily reported in December 2019.¹ COVID-19 is defined as a pandemic in March 2020 by the World Health Organization, threatening the health and life of humans and transforming lifestyles. Despite the development of effective vaccines, COVID-19 has greatly impacted normal life. Since the virus is transmitted via respiratory droplets and direct contact, the risk of infection is high with physical exercise and competitions, so sports events have been canceled and stadiums have been closed. The Tokyo 2020 Olympics was also postponed to 2021 because of the COVID-19 pandemic. Under the situation of the normalized epidemic, how athletes should train and compete is in the spotlight with the confirmation of the Tokyo 2020 Olympics and the Beijing 2022 Winter Olympics. Controlling the epidemic and absorbing the experience, China resumed athlete training while holding national and international sports events. This article reviews and summarizes the situation in terms of prevention and control of COVID-19 among Chinese national athletes, the recommended medication and non-medication treatments for COVID-19, and the strategies for safe return to play after COVID-19 infection, which

could serve as the worldwide reference on prevention and control the epidemic while training for competitions and the treatment and safe return to play after the infection.

Prevention and control of COVID-19 among Chinese national athletes

To date, a total of 1488 people from the Chinese national teams returned from training abroad during the COVID-19 pandemic, with seven athletes having been diagnosed with COVID-19. The seven confirmed cases were from the fencing team (4 cases), the parallel giant slalom team (1 case) and the ice hockey team (2 cases), of which five were females, and two were males. Among the seven athletes, one case was of mild type, and six cases were of common type. All cases were imported rather than indigenous. In the name of General Administration of Sport of China, the information of the athletes was collected from doctors of sports teams. The doctors supervised and reported the health information of athletes every day since December 25th, 2019. The athletes were informed, and written informed consent was acquired. The institutional Review Board at the National Institute of Sports Medicine reviewed and approved this study protocol, and informed consent was obtained from each individual for each case study presented.

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Abbreviations

COVID-19	coronavirus-disease-2019
IL-6	interleukin 6
PaO ₂ /FiO ₂	pressure of Oxygen/Fraction of inspiration
VB1	vitamin B1
IFN-α	interferon-α
IgM	immunoglobulin M
IgG	immunoglobulin G
LV	left ventricular
FVC	forced vital capacity
FEV1	forced expiratory volume in the first second
FEF	forced expiratory flow

The seven, novel, coronavirus-infected patients from the Chinese national teams showed primary symptoms of fever, diarrhea, dysgeusia, anosmia, cough, and pharyngeal disorders. The symptoms and duration of them are shown in Table 1, and the length of hospital stay and nucleic acid test negative conversion time are shown in Table 2.

Risk of infection in athletes

COVID-19 is a highly contagious coronavirus that may be transmitted by asymptomatic carriers during a relatively long period of time. When exercise is suddenly increased, the immune system is temporarily suppressed. Athletes often require high-intensity trainings, which may put them at a higher risk of upper respiratory tract infections.² Therefore, rigorous surveillance of exercise training, nutrition, sleeping, and mental situation should be adapted in athletes.

The national team players are mainly trained within training camps, where close contact, common training equipment, and traveling together are inevitable; thus, infection within the team put the entire team personnel at a higher risk. COVID-19 may survive in aerosols for up to 3 h and may be detected on stainless steel and plastic for up to 3 days.³ Respiratory droplets may stay longer in environments rich in vapor, such as changing rooms, which also contribute to the risk of transmission. To reduce the risk of infection as much as possible, the Chinese national training teams adopted a series of epidemic prevention and control measures, including enclosed management of training bases, point-to-point specific vehicles for team or team member movement, strict protection on public transportation with details described below. Because of these prevention and control measures, apart from the seven imported cases on the early stage of the pandemic, no new cases have occurred to date in the Chinese national team up to the time of September 11th, 2021.

Impact of COVID-19 on athletes

The clinical manifestations of COVID-19 are predominantly in the respiratory system with the complications of other systems such as the

cardiovascular system. Clinical manifestations of COVID-19 are usually mild. Among the 72,314 cases reported in China, 81% were classified as mild (i.e., non-pneumonia and mild pneumonia), 14% were severe (i.e., hypoxia, dyspnea, lung infiltrates >50% within 24–48 h), and 5% were critical (i.e., shock, respiratory failure, multiple organ dysfunction or failure).⁴ Among all confirmed cases in this series, the mortality rate was 2.3%. Most cases of children, adolescents, and athletes were mild. Although athletes infected with COVID-19 have a lower risk of serious illness, complications such as pulmonary fibrosis and myocardial injuries should be given consideration. After hospitalization and relevant comprehensive assessments, personnel of the Chinese national team who was diagnosed with COVID-19 showed no organic cardiopulmonary injury. To date, all athletes returned to training and competitions and have reached their performance level before the illness without cardiopulmonary dysfunction.

Epidemic prevention and control of Chinese national teams

The Chinese National Training Teams adopted a series of epidemic prevention and control measures to reduce the risk of infection as much as possible. These measures mainly include enclosed management and strict routine disinfection of stationed training bases, and strict review and management of the personnel contacted by team members such as temporary access personnel, canteens, and express delivery personnel.

Stringent management of the enclosed areas

1. Continue adhering to enclosed management of the national team training bases, divided into red, yellow, and green areas. Reinforce pre-approval, and close loopholes.
2. Admission approval is required in advance. Personnel must carry relevant agreement documents while entering the bases, with on-site registration, valid test results verification, health code verification, and temperature measurements. When leaving the bases, personnel should carry valid certificates approved by the leader-in-charge.
3. The sports teams and staff who transfer from enclosed area (green area) to enclosed area (green area) via specific vehicles or “point-to-point” green transfer may enter the bases without undergoing quarantine.
4. Individuals who come from domestic low-risk regions by public transportation shall provide valid nucleic acid test results before entering the green areas in bases, strictly according to specific prevention and control measures and the observation time of local and corresponding bases.
5. Individuals who come from the domestic medium- or high-risk regions shall be quarantined for 14 days and verified by the nucleic acid and serum antibody tests before entering the green areas in the bases.
6. All national teams must stringently implement all measures of “guarding against imported cases.” Foreign coaches and other national team personnel returning from abroad shall be quarantined for “14 + 7” days for observation.

Table 1
Symptoms and duration.

Case	Gender	Age (years)	Sport	Severity	Duration of clinical symptoms (days)					
					Fever	Cough	Diarrhea	Hypogeusia	Hyposmia	Pharyngeal itching
1	Female	28	Fencing	Common type	8	33	10	20	77	×
2	Female	28	Fencing	Common type	1	30	×	14	23	×
3	Male	28	Fencing	Mild type	4	5	×	×	×	9
4	Male	22	Fencing	Common type	×	×	×	×	×	×
5	Female	26	Snowboarding	Common type	2	×	5	29	44	×
6	Female	23	Ice hockey	Common type	6	×	×	20	20	×
7	Female	24	Ice hockey	Common type	6	×	×	19	20	×
average					4.5	22.67	7.5	20.4	36.6	9

Table 2
Length of hospital stay and nucleic acid test negative conversion time.

Case	Gender	Age (years)	Sport	Severity	Date of positive conversion of the nucleic acid test symptoms	Date of negative conversion of the nucleic acid test symptoms	Duration of positive-to-negative conversion of the nucleic acid test (days)	Length of stay in hospital (days)
1	Female	28	Fencing	Common type	3.18	5.08	51	53
2	Female	28	Fencing	Common type	3.18	4.13	26	28
3	Male	28	Fencing	Mild type	3.18	6.24	98	100
4	Male	22	Fencing	Common type	×	×	×	15
5	Female	26	Snowboarding	Common type	3.18	3.28	10	20
6	Female	23	Ice hockey	Common type	3.27	4.1	5	19
7	Female	24	Ice hockey	Common type	3.27	4.9	13	19
average							33.83	36.29

Stringent management of epidemic prevention for service providers

1. Adhere to the combination of stringent management and scientific prevention and control.
2. All service providers shall strictly work within the enclosed area according to the requirements, with close-contact service providers undergoing dynamic follow-up inspections.
3. With combined methods of comprehensive testing, timely testing, and random testing, normalized nucleic acid testing should be guaranteed for service providers in the bases.
4. Personnel returning to duty or those who are newly hired should strictly satisfy the test requirements before being allowed to work in the bases.

Stringent management of entry-exit epidemic prevention for temporary personnel

1. Temporary activities in the bases must be proposed by a competent authority with a complete epidemic prevention plan instituted and submitted to the sports administration center for formal approval prior to preparation. The “inspection gate” for entering or exiting personnel should be guarded properly through strict temperature measurements, health code verification, and nucleic acid test results verification for all personnel on the training sites and bases.
2. The activity attendees and athletes should be “physically separated,” and the temporary personnel shall not come into contact with the athletes. Coordinate with the local disease control department in order to perform environmental and personnel health monitoring.

Stringent management of express items

1. The national training teams shall coordinate with their training bases to designate the addresses and specific places for receiving deliveries. Packages are not allowed to be directly delivered to team members.
2. Special personnel designated by the training bases should sterilize each received package and regularly disinfect the storage places.
3. Special personnel designated by the national training teams should go to the fixed reception point of the training bases to pick up their own teams' deliveries with registration and distribution documented.

Stringent management of canteen procurement safety

1. Food hygiene must be guaranteed, and purchase locations must be rigorously designated. Food and environmental monitoring of the athletes' canteen in the national team training bases should be reinforced.

2. All newly purchased cold-chain foods like those in refrigeration or freezing, including their package, must undergo nucleic acid testing and may be processed to eat if test negatively.
3. Canteen environmental samples of food processing and storage areas should be tested once a week.

Stringent management of sterilization

1. Insist on daily sterilization, disinfection, and epidemic prevention and control of the environment and objects of the training areas, living areas, and public areas in the bases.
2. Indoor ventilation should be ensured.

Stringent management of routine protection

1. Each national training team should voluntarily monitor body temperature. The abnormal temperature must be reported immediately and followed by temporary quarantine with health monitoring.
2. While eating in the canteen, athletes should strictly abide by the prevention and control discipline, which includes no whispering to each other, maintaining social distance, and wearing masks except while eating.
3. All personnel in the enclosed area must strengthen their awareness of self-protection with frequent washing and disinfection of hands.
4. Masks must be worn except while training, and athletes must disinfect the used equipment before leaving.

Prevention and control experience of sports events in China

In November, the 2020 International Table Tennis Federation World Cup was successfully held in China. The epidemic prevention and control experience of the sports event is briefed as follows.

The entire closed-loop management was implemented from immigration to competition with the overseas personnel undergoing innovative “3+1+3+7” 14-day quarantine: arriving in Shanghai and quarantined for 3 days, the participants were transferred safely within one day and quarantined in Weihai for 3 days, followed by 7 days of simultaneous quarantine and training. The point-to-point specific transportation was arranged for sports teams. In terms of participants taking different flights with a higher risk of cross-infection, one-person-live-in-one-room enclosed management was implemented in the hotels. Multiple relatively independent areas were set up in training venues divided by training time and area. Disinfection was performed between two training sessions. The close-contact personnel, players, and key service providers underwent nucleic acid testing every day, every other day, and every three days, respectively. All personnel participating in competitions were

tested before and after the competition. The key personnel were vaccinated in advance.

The number of workers was decreased maximally to reduce unexpected risks. Under compartmentalization management, face recognition equipment was installed in the hotels and venues for competitions to ensure “one person corresponding to one card, one vehicle corresponding to one card, and one card corresponding to one zone.” The nucleic acid testing was performed on all cold-chain foods and external environment for designated hotels. Prepackaged foods for the event were properly purchased, supervised, and traced.

Summary

As a result of these epidemic prevention measures, the number of Chinese national team members infected with COVID-19 was relatively small, and all of them were imported cases on the early stage of the pandemic. The conditions of affected personnel were of mild or common types, who were cured after treatment in the hospital without cardiopulmonary dysfunction or organic disorders. All athletes returned to training and competition with recovery of their pre-illness sports level. Under the situation of normalized epidemic prevention and control, China has instituted prevention and control measures for routine training and hosting events. Because of the implementation of these measures, no new cases have occurred to date in the Chinese national team, and the international sports event was successfully held.

Recommended medication and non-medication treatments for COVID-19

The pathogen causing COVID-19 is a new strain of coronavirus that was unknown prior to the epidemic. This pathogenic coronavirus is characterized by strong infectivity, a reproduction number of 2–3 and an incubation period of 1–14 days.⁵

So far, no specific antiviral drugs for COVID-19 exist.⁶ The mainstay recommended treatments for COVID-19 are as follows: Maintain the autoimmunity of the patients; provide supportive therapies based on clinical symptoms, including oxygen inhalation, supplementation of fluid, nutrition enhancement, immunoregulatory treatment, fever management, and traditional Chinese medicine treatments. If the patients also have combined bacterial infections, concomitant use of antibiotic drugs is used with early symptomatic treatment usually achieving a better prognosis. At present, the majority of the COVID-19 patients, including severe and critical cases, are discharged after symptomatic treatment, oxygen therapy, and immunoregulatory treatment.^{7–9}

General treatment principles

The general treatment principles of COVID-19 depend on the clinical type, prewarning indicators for severe/critical disease, and whether the cases are confirmed or suspected.^{7,9}

General treatment is:

1. Stay in bed, enhance supportive care, and ensure sufficient energy intake; keep water and electrolyte balance, and maintain homeostasis; monitor vital signs and oxygen saturation.
2. The following tests may be performed according to the disease: routine blood test, routine urine test, C-reactive protein, biochemical indicators (hepatic enzymes, cardiac enzymes, and kidney function), coagulation function test, arterial blood gas analysis, and chest imaging. Cytokines measurement if possible.
3. Effective and timely oxygen therapy should be provided, including nasal cannula, mask oxygen inhalation, and high-flow nasal cannula oxygen therapy. Hydrogen-oxygen mixed gas inhalation (H₂/O₂:66.6/33.3) is administered if possible.

Enhance immunity and nutrition

No drugs have been proven for their ability to truly boost immunity. However, immunity may be enhanced and the inflammatory response induced by free radicals may be eliminated by appropriate nutritional supplementation. For example, routine doses of vitamin and mineral supplements, especially vitamin B1, vitamin C, Se, and Zn foods, contain rich ω -3 fatty acids, branched-chain amino acids, and high-protein enteral nutrition products.¹⁰ Qi-boosting Chinese patent medicines or herbs, such as *Astragalus membranaceus*, ginseng, or American ginseng are also recommended.

Antiviral treatment

To date, no specific drugs targeting the novel coronavirus exist. Therefore, antiviral drugs should be used with caution in addition to symptomatic treatments. It is now generally believed that drugs with antiviral potential should be used during the early stage of the disease.^{11–19} However, antiviral drugs should be used with caution due to their uncertain efficacy and their potential risk of severe adverse reactions.

Only four antiviral drugs are recommended by the Guidelines for the Diagnosis and Treatment of Novel Coronavirus Infection (Trial Version 8),^{17,18} which are interferon- α , ribavirin (used in combination with interferon or lopinavir/ritonavir), chloroquine phosphate, and arbidol. The concomitant use of three or more antiviral drugs is not recommended.

Immunotherapy

1. Convalescent plasma: Convalescent plasma is useful for fast-progressing, severe, and critical cases of COVID-19.
2. Intravenous injection of COVID-19 human immune globulin: This is useful for fast-progressing cases of both common and severe types.
3. Tocilizumab: Tocilizumab is suitable for patients with extensive lung lesions, severe cases, and those with an increased interleukin 6 (IL-6) level. Tocilizumab is contraindicated in patients with allergic reactions and active infections like tuberculosis.

Glucocorticoid therapy

For patients with progressive deterioration of oxygenation, rapid radiographic progression, and hyperactivation of the inflammatory response, short-term use (generally 3–5 days, and no longer than 10 days) of glucocorticoids can be considered (the recommended dose is equivalent to methylprednisolone 0.5–1 mg/kg/day). It should be kept in mind that large-dose glucocorticoids may have an immunosuppressive effect and delayed viral elimination.

Anti-cold medicine

The initial symptoms of COVID-19 are similar to those of the common cold and flu. Therefore, symptoms could be preliminarily mitigated by symptomatic treatment to make patients feel comfortable, boost immunity, and reduce the risk of progression to moderate and severe disease.¹⁹

In mild cases where the individuals are physically healthy before onset, rest is most important, maintaining a good mood, and a healthy diet are important. The immune system is generally strong at the initial stage of the disease. Most of these patients may soon recover after early symptomatic treatments.

Antibacterial medicine

Improper or blind use of antibacterial drugs should be avoided, especially combined with wide-spectrum antibacterial drugs. More importantly, the abuse of antibacterial drugs may lead to dysbacteriosis and adverse reactions associated with antibacterial drugs. The use of

antibacterial drugs is only considered when combined bacterial infection is confirmed.

Treatment of severe and critical cases^{11–18}

General treatment principles: Based on the above treatments, active measures should be taken to prevent complications, treat underlying diseases, avoid secondary infections, and provide functional support for the organs.

Respiratory support

Different respiratory support regimens should be implemented based on the pressure of oxygen/fraction of inspiration ($\text{PaO}_2/\text{FiO}_2$) threshold (200–300 mmHg, 150–200 mmHg, and <150 mmHg). The improvement of respiratory distress and (or) hypoxaemia may be evaluated if necessary. If symptoms are not improved, the respiratory support regimen should be changed. For patients receiving oxygen therapy, ventilation in the ventral position is recommended if it not otherwise contraindicated ventilation in the ventral position while awaking for greater than 12 h.

Circulatory support

If critical cases are combined with shock, vasoactive agents should be reasonably used on the basis of sufficient fluid resuscitation. Changes in blood pressure, heart rate, and urine volume should be closely monitored, along with lactic acid and base excess. Hemodynamic monitoring should be carried out, if necessary, to guide infusion, and the use of vasoactive agents should be used to improve tissue perfusion.

Anticoagulant therapy

Severe and critical cases of COVID-19 are more likely to be complicated by thromboembolism. For those patients who are not contraindicated for anticoagulant drugs and have a significant increase in D-dimer levels, the preventive use of anticoagulant drugs is recommended. Anticoagulation therapy should be administered according to the guidelines in the case of thromboembolic events.

Acute kidney injury and renal replacement therapy

Critical cases may be combined with acute kidney injury. The etiology, such as low perfusion and drug-related factors, should be identified. Water and electrolyte balance and acid-base balance should be maintained while correcting the etiology.

Blood purification treatment

Blood purification treatment consists of plasma exchange, adsorption, perfusion, and blood/plasma filtration. This treatment removes inflammatory factors from the blood and blocks the cytokine storms, alleviating the damage caused by the inflammatory reaction to the patients. It is suitable for early and mid-stage prevention and treatment of cytokine storm in severe and critical cases.

Other treatment measures

Regulators of intestinal microflora can be used to maintain the microecological balance of the gut and prevent secondary bacterial infection. Patients may become victims of anxiety and fear, which should be assuaged by psychological counseling or medication treatment if necessary.

Traditional Chinese medicine treatment

COVID-19 is a “plague” in the terminology of traditional Chinese medicine, which is caused by the evil Qi. Treatment based on syndrome may vary based on the disease situation, local climatic features, patients’ constitution, disease course, and clinical type. Addition and subtraction may be made based on traditional Chinese medicine treatment regimens. If the dosage is not recommended by the Pharmacopeia, traditional Chinese medicine treatment should be prescribed under the guidance of the physician.^{8,11–18}

Early rehabilitation and nursing

Early rehabilitation training and intervention should be highlighted based on the patient’s respiratory function, somatic function, and psychological disorders. Efforts should be made to maximally restore the physical capability, constitution, and immunity of the patient. The key points of nursing should be first identified based on the patient’s disease, and basic nursing should be strengthened. For awake patients, mental state should be timely evaluated, and mental nursing should be strengthened.^{11–18}

Treatment processes for Chinese athletes

Places of treatment

Among seven Chinese COVID-19-confirmed athletes, one case was diagnosed as mild, and the remaining six were of common type. Chinese athletes are usually engaged in collective training and life under closed-off management. These confirmed athletes were admitted to a designated hospital (Beijing Ditan Hospital) for treatment according to the local epidemic prevention and control requirements.

General treatment

All athletes were advised to rest in bed with sufficient energy intake and maintenance of water and electrolyte balance. Daily vital signs and oxygen saturation were closely monitored. During the first few days of hospitalization, blood samples were drawn once every 3–7 days for the routine blood test, routine urine test, C-reactive protein test, biochemistry tests (hepatic enzymes, cardiac enzymes, and kidney function), coagulation function test, and chest computed tomography. After the patients’ conditions were stabilized, the above monitoring was performed once every two weeks. During hospitalization, all patients were administered oral vitamin B1 (VB1) to enhance immunity.

Antiviral treatment

All seven athletes were concomitantly given two antiviral drugs: interferon- α (IFN- α) (5 million units, aerosol inhalation, twice daily); lopinavir/ritonavir (200 mg/50 mg/tablet, two tablets, twice daily), for ten days. All athletes completed the antiviral treatment as planned except for one, who discontinued lopinavir/ritonavir due to severe nausea with mildly abnormal liver function.

Traditional Chinese medicine treatment

All patients received traditional Chinese medicine prescriptions therapy throughout their stay in the hospital for the purposes of opening the lungs and waking the spleen, nourishing the spleen, and removing damp toxin. The principles of homology between food and drug, small-prescription, and small-dose were followed. The main herbs prescribed included *Agastache rugosa*, almonds, raw *Semen coicis*, and *Platycodon grandiflorus*. Treatment determination based on syndromes was carried out according to the clinical course and clinical type. Addition and subtraction of certain herbs were made if it was deemed appropriate. The treatment regimens of the seven athletes can be found in [Appendix A](#).

Summary

COVID-19 has become an unprecedented challenge for the entire world. Early detection, prompt reporting, swift isolation and early treatment are highly important for preventing and controlling the COVID-19 epidemic. Symptomatic treatments using evidence-based drugs are favored at the early stage of the disease. Potent antiviral drugs are generally recommended to be used with caution if necessary. Based on the above treatments, active measures should be taken to prevent complications and progression to severe and critical conditions, treat underlying diseases, avoid secondary infections, and provide functional support for the organs. Treatment based on syndromes in traditional Chinese medicine could be concomitantly given along with the measures to enhance nutrition, immunity, and the functional

recovery of organs. Traditional Chinese medicine can be of great help to COVID-19 patients to survive the dangerous period and enter the recovery period early.

Strategies for safe return to play after COVID-19 infection

In the Chinese national sports team, a total of seven Chinese athletes were confirmed to have COVID-19. All of them recovered and returned to training and competition in 2020. Like other youth populations, athletes have better physical fitness and cardiopulmonary functions compared to elder populations. Therefore, they have a lower risk of complications damaging the respiratory system.^{10, 11} Although all seven athletes described in this paper were of mild and common type, some management strategy plans should have still been taken after recovery. First, the occult COVID-19 virus should be prevented from transmitting among the sports team; second, the short- and long-term adverse impact of viral infection on the cardiopulmonary function of athletes should be reduced to ensure a safe return to play after sufficient treatments.

Quarantine measures

In most Chinese national teams, the athletes would gather in a relatively closed base for training life. Rapid viral transmission is more likely to occur in a densely populated environment, leading to a mass outbreak. Long-term medical observation and sufficient isolation are crucial to prevent the further spread of COVID-19. The measure of “14 + 14” quarantine was recommended to athletes after being discharged from the hospital. This phrase refers to compulsory quarantine for 14 days and home quarantine for 14 days. After quarantining in an initial, centralized, designated hotel for 2 weeks, all athletes moved to the hotel for relative isolation in the China Bicycle and Fencing training base for another 2 weeks. Recovery training and psychological education guidance was recommended to athletes online. The process of quarantine was as follows.

Once confirmed to have COVID-19, athletes were sent to a designated special hospital for treatment. In the meantime, other athletes, coaches, and team staff continued quarantine for another 14 days. All athletes received nucleic acid and serum antibody testing before returning to the training base.

The athletes were initially sent to a designated hotel for two weeks of quarantine after being discharged from the designated hospital. If the nucleic acid of oropharyngeal was tested negative on the 15th day of quarantine, athletes were further sent to the hotel in the China Bicycle and Fencing training base as “home quarantine” for another two weeks of relative isolation. During this period, appropriate home exercises and psychological consultation were recommended by experts to athletes online.

When “home quarantine” in the training base hotel ended, athletes could return home or to local sports teams and wait for an invitation to rejoin the national sports team.

Even after returning to the national sports team, the athletes needed to understand epidemic prevention, which was as follows:^{20,21}

1. Strictly obey the epidemic prevention regulations of the training bases.
2. Keep awareness of self-protection, wear masks, avoid unnecessary touch, and report temperature daily.
3. Wash hands frequently, wear masks when fetching foods, and use separate eating utensils.
4. Avoid touching frozen foods and packages without protection.
5. Take baths and change and clean clothes immediately after training.
6. Keep distance in public life and avoid mass gathering.

Return to play safely

For these seven athletes, the average time for the nucleic acid test to turn negative was 34.44 days (5–98 days), and the average length of hospitalization was 37.89 days (15–100 days). Among the seven cases, one case with a maximum hospital stay of 100 days was extremely special and needed further investigation. The symptoms of this athlete completely disappeared after 23 days of hospitalization while the nucleic acid test remained positive for a longer period of time. Only when the nucleic acid tests in sputum samples and nasopharyngeal swabs and the COVID-19 immunoglobulin M (IgM) antibodies and immunoglobulin G (IgG) antibodies were consistently negative, would the athlete be discharged.

All seven cases had their diagnosis confirmed in March 2020. No matches and competitions were allowed for a long time afterwards. Therefore, these athletes relatively had sufficient time for recovery. The average time of return to play from infection confirmation to recovery of training was 70.9 ± 29.3 days. All seven athletes successfully returned to play in 6 months. All the fencing athletes participated in the national championship, which was the formal match held by Chinese Fencing Association 254 days after infection confirmation. Three athletes won golden medals, and one won second place in this competition. The results of cardiopulmonary function test did not show abnormalities 7 months after infection. No clustering infection in their sports team after they rejoined the team was detected (Table 3).

From the literature review, it remains controversial as to whether athletes with acute symptoms of COVID-19 infection can return to play. In 2003, Metz reported the guideline for returning to play in athletes with upper respiratory infections.²² The decision to allow an athlete to play or not can be guided by the “neck check” rules and can also take into account nonmedical factors. If symptoms were confined to positions above

Table 3
Information on returning to play after COVID-19.

Case	Gender	Age (years)	Sport	Severity	Length of hospitalization (days)	Return to play after infection (days)	Return to competition after infection (days)	Ranking in the national competition
1	Female	28	Fencing	Common type	53	84	231	1
2	Female	28	Fencing	Common type	28	63	254	1
3	Male	28	Fencing	Mild type	100	132	231	2
4	Male	22	Fencing	Common type	15	47	254	1
5	Female	26	Snowboarding	Common type	20	60	–	–
6	Female	23	Ice hockey	Common type	19	55	–	–
7	Female	24	Ice hockey	Common type	19	84	–	–

Table 4
Cardiac function test before returning to play.

Case	Gender	Age (years)	Sport	Severity	Ejection fraction	LV fractional shortening	LV end-diastolic inner diameter (mm)	LV end-systolic inner diameter (mm)
1	Female	28	Fencing	Common type	66%	35%	450	290
2	Female	28	Fencing	Common type	60%	30%	430	280
3	Male	28	Fencing	Mild type	65%	30%	530	380
4	Male	22	Fencing	Common type	65%	36%	540	340

LV, left ventricular: One of four heart's chambers located in the bottom left portion of the heart.

the neck (e.g., nasal discharge, nasal obstruction, sore throat, or sneezing), athletes were allowed to undergo training of a lower intensity than usual; if the symptoms affected positions below the neck (e.g., systemic fever or discomfort, severe cough, gastrointestinal symptoms, or myalgia), athletes should not undergo training. Therefore, athletes who have a fever and are confirmed to have COVID-19 should not continue training.

Athletes infected with COVID-19 may only suffer from mild symptoms, such as headache, sore throat, nasal discharge, fatigue, and myalgia, which may be relieved in 5–7 days.²³ However, another study showed that the second stage in which clinical deterioration appeared might develop in 7–9 days. For this reason, the period of returning to play after COVID-19 infection should be longer than that of other common upper respiratory infections. Athletes who recently suffered from ageusia or anosmia should also receive necessary tests for COVID-19. We recommend nucleic acid testing in both the oropharynx and nasopharynx and isolation for at least two weeks before gathering in national teams.²⁴

All athletes received hospitalized treatment (15–100 days) and enough quarantine (two weeks of quarantine in a government-designated hotel plus two weeks of “home quarantine”). Neither the mild cases nor the common type cases showed signs of organic damage in the lungs or heart. All of the athletes safely returned to play gradually, and fatigue was closely monitored. Once athletes return to play, abnormal post-training fatigue deserves extra attention, and relevant examinations and evaluations should be conducted. Athletes should receive regular evaluations, including viral screening, hematological examinations, electrocardiogram, transthoracic echocardiography, exercise test (maximal exercise test), 24 h Holter, lung function test, and chest x-ray/computed tomography. Moreover, athletes should receive timely psychological intervention and adjustment at the end of the quarantine to avoid anxiety and other psychological problems. For all fencing athletes, sports performance, cardiac and lung function were normal 8 months after infection, which was due to necessary medical monitoring, appropriate training control, and psychological treatment (Tables 3–5). Details of athletes' return to play is found in Appendix A.

Table 5
Lung function test prior to competition.

Case	Gender	Age (years)	Forced vital capacity (FVC)	Forced expiratory volume in 1 s (FEV1/FVC%)	Forced expiratory flow at 50% of FVC exhaled (FEF50)	Forced expiratory flow at 75% of FVC exhaled (FEF75)	Lung function
1	Female	28	5.48	90.2	120	182	Normal
2	Female	28	5.33	76.9	89	72	Obstructive pulmonary dysfunction
3	Male	28	7.29	75.3	77	100	Obstructive pulmonary dysfunction
4	Male	22	7.58	57.2	45	42	Obstructive pulmonary dysfunction

FVC, forced vital capacity: Amount of air that can be forcibly exhaled from the lungs after taking the deepest breath.

FEV1, forced expiratory volume in the first second: Volume of air exhaled in the first second during forced exhalation after maximal inspiration.

FEF, forced expiratory flow: Velocity of air coming out of the lungs during the middle portion of a forced expiration.

The epidemic prevention and control measures taken by the Chinese national teams have both commonalities and differences compared with those of other regions and countries. In other regions and countries, if an athlete develops an illness with symptoms of COVID-19, they should be isolated within rooms, undertake appropriate quarantine, testing, and tracing. The monitoring items are similar to ours, including resting heart rate, rated perceived exertion, sleep, stress, fatigue and muscle soreness, respiratory function assessment, cardiac monitoring, blood testing and psychology. Meanwhile, athletes should maintain a balanced diet and good hydration. In enclosed spaces with sporting activities, face-covering should also be used.^{25–27}

The World Health Organization (WHO) recommend that sports event organizers should assess the risk of sporting events before organizing. The organizers should assess whether social distancing is possible (contact sports or not). The scale of mass gatherings should also be learned. It is important to assess whether the event includes international participants (athletes and spectators) from countries that have documented active local transmission of COVID-19 or not.^{25,26}

According to the current measures, experience and data, the article also proposed the following suggestions regarding the prevention and control of the COVID-19 for Chinese athletes.

As for athletes in enclosed management, athletes should pay particular attention to:

1. Monitor the daily temperature before training.
2. Pay more attention to the cardiorespiratory function.
3. Sanitize training equipment with diluted bleach before and after the usage.
4. Treat minor abrasions with water and soap plus antibacterial solution and bandages.

As for cured athletes who have been discharged:

1. Follow up on all confirmed cases of COVID-19 to evaluate the long-term impact of the COVID-19 on athletes.

2. Monitor the following indicators: resting heart rate (RHR), ratings of perceived exertion (RPE), sleep status, stress and muscle soreness, psychological preparation for return to play.
3. Adjust the training intensity properly.
4. Implement psychological intervention and adjustment to prevent psychological issues such as anxiety.

For persons in close contact with athletes:

1. Implement stringent epidemic preventative management: temperature and health code verification shall be checked every day, and nucleic acid test results shall be verified every week.
2. In principle, temporary personnel are not allowed to contact athletes. If inevitably, the health code verification, nucleic acid test results, and the approval of superiors are required.

Conclusions

This article summarized the experience of prevention and control of COVID-19 among Chinese national athletes, as well as treatment and return to play after infection. We believe that athletes may safely train and compete under scientific epidemic prevention and control. Athletes infected with COVID-19 usually suffer from mild symptoms and may quickly recover through comprehensive treatment and return to play at their pre-injury level after scientific evaluations.

Submission statement

The articles and studies cited in this interview are represented honestly and without fabrication or data manipulation. This manuscript has not been published and is not in review elsewhere.

Ethical approval statement

The institutional Review Board at the National institute of Sports Medicine reviewed and approved this study protocol, and informed consent was obtained from each individual for each case study presented.

Authors' contributions

All authors listed have made a substantial, direct, intellectual contribution to the work, and have approved it for publication.

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Conflict of interest

The authors have no conflicts of interest to disclose.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.smhs.2021.12.001>.

References

1. Wang W, Tang J, Wei F. Updated understanding of the outbreak of 2019 novel coronavirus (2019-nCoV) in Wuhan, China. *J Med Virol*. Apr 2020;92(4):441–447. <https://doi.org/10.1002/jmv.25689>.
2. Hull JH, Loosemore M, Schwellnus M. Respiratory health in athletes: facing the COVID-19 challenge. *Lancet Respir Med*. 2020;8(6):557–558. [https://doi.org/10.1016/S2213-2600\(20\)30175-2](https://doi.org/10.1016/S2213-2600(20)30175-2).
3. van Doremalen M, Bushmaker T, Morris DH, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med*. 2020;382(16):1564–1567. <https://doi.org/10.1056/NEJMc2004973>.
4. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. *JAMA*. 2020;323(13):1239–1242. <https://doi.org/10.1001/jama.2020.2648>.
5. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. Feb 15 2020;395(10223):497–506. [https://doi.org/10.1016/S0140-6736\(20\)30183-5](https://doi.org/10.1016/S0140-6736(20)30183-5).
6. Hutchinson NT, Steelman A, Woods JA. Behavioral strategies to prevent and mitigate COVID-19 infection. *Sports Med Health Sci*. 2020;2(3):115–125. <https://doi.org/10.1016/j.smhs.2020.09.001>.
7. Becker RC. Covid-19 treatment update: follow the scientific evidence. *J Thromb Thrombolysis*. 2020;50(1):43–53. <https://doi.org/10.1007/s11239-020-02120-9>.
8. Ren JL, Zhang AH, Wang XJ. Traditional Chinese medicine for COVID-19 treatment. *Pharmacol Res*. 2020;155, 104743. <https://doi.org/10.1016/j.phrs.2020.104743>.
9. Xu X, Ong YK, Wang Y. Role of adjunctive treatment strategies in COVID-19 and a review of international and national clinical guidelines. *Mil Med Res*. 2020;7(1):22. <https://doi.org/10.1186/s40779-020-00251-x>.
10. Shi HP, Yu Z, Yu KY. Expert suggestions on nutrition therapy for severe COVID-19 patients [in Chinese]. *SCIENTIA SINICA Vitae*. 2020;50(8):874–886. <https://doi.org/10.1360/SSV-2020-0055>.
11. General Office of National Health Commission. *Guidelines for the Diagnosis and Treatment of Novel Coronavirus (2019-nCoV) Infection (Trial Version 1)*. The State Council The People's Republic of China; February 2nd 2020; February 2nd 2020. http://www.gov.cn/xinwen/2020-02/02/content_5473933.htm. Accessed July 12, 2021.
12. General Office of National Health Commission. *Guidelines for the Diagnosis and Treatment of Novel Coronavirus (2019-nCoV) Infection (Trial Version 2)*. National Health Commission of the People's Republic of China; April 13th 2020. <http://www.nhc.gov.cn/xcs/zhengcwj/202104/f82ac450858243e598747f99c719d917.shtml>. Accessed August 20, 2021.
13. General Office of National Health Commission. *Guidelines for the Diagnosis and Treatment of Novel Coronavirus (2019-nCoV) Infection (Trial Version 3)*. The State Council The People's Republic of China; January 22nd 2020. <http://www.gov.cn/zhengce/zhengceku/2020-01/23/5471u832/files/106d59e45ac948ceb3cb12d400b8053c.pdf>. Accessed August 20, 2020.
14. General Office of National Health Commission. *Guidelines for the Diagnosis and Treatment of Novel Coronavirus (2019-nCoV) Infection (Trial Version 4)*. National Health Commission of the People's Republic of China; February 6th 2020. <http://www.gov.cn/zhengce/zhengceku/2020-02/07/5475813/files/9a774a4d4efee44daa05894138bd0509a.pdf>. Accessed February 20, 2020.
15. General Office of National Health Commission. *Guidelines for the Diagnosis and Treatment of Novel Coronavirus (2019-nCoV) Infection (Trial Version 5)*. National Health Commission of the People's Republic of China; February 4th 2020. <http://www.gov.cn/zhengce/zhengceku/2020-02/05/5474791/files/de44557832ad4be1929091dcbfca891.pdf>. Accessed August 20, 2020.
16. General Office of National Health Commission. *Guidelines for the Diagnosis and Treatment of Novel Coronavirus (2019-nCoV) Infection (Trial Version 6)*. National Health Commission of the People's Republic of China; February 18th, 2020. http://www.gov.cn/zhengce/zhengceku/2020-02/19/content_5480948.htm. Accessed August 20, 2021.
17. General Office of National Health Commission. *Guidelines for the Diagnosis and Treatment of Novel Coronavirus (2019-nCoV) Infection (Trial Version 7)*. National Health Commission of the People's Republic of China; March 4th 2020. <http://www.nhc.gov.cn/yzygj/s7653p/202003/46c9294a7dfe4cef80dc7f5912eb1989/file/s/ce3e6945832a438eaae415350a8ce964.pdf>. Accessed August 20, 2021.
18. General Office of National Health Commission. *Guidelines for the Diagnosis and Treatment of Novel Coronavirus (2019-nCoV) Infection (Trial Version 8)*. National Health Commission of the People's Republic of China; August 19th 2020. <http://www.gov.cn/zhengce/zhengceku/2020-08/19/5535757/files/da89edf7cc9244fbb34ecf6c61df40bf.pdf>. Accessed August 20, 2021.
19. Pang WY, Wang QY, Zhao ZG. Development and progress of clinical trials of Coronavirus Disease 2019 antiviral drugs. *Expert Rev Clin Pharmacol*. 2020;13(9):945–956. <https://doi.org/10.1080/17512433.2020.1803740>.

20. Toresdahl BG, Asif IM. Coronavirus disease 2019 (COVID-19): considerations for the competitive athlete. *Sport Health*. 2020;12(3):221–224. <https://doi.org/10.1177/1941738120918876>.
21. Santos-Ferreira D, Tomas R, Dores H. TEAM to defeat COVID-19: a management strategy plan to address return to play in sports medicine. *Orthop J Sports Med*. 2020; 8(9). <https://doi.org/10.1177/2325967120951453>, 2325967120951453.
22. Metz JP. Upper respiratory tract infections: who plays, who sits? *Curr Sports Med Rep*. 2003;2(2):84–90. <https://doi.org/10.1249/00149619-200304000-00007>.
23. Hull JH, Loosemore M, Schweltnus M. Respiratory health in athletes: facing the COVID-19 challenge. *Lancet Respir Med*. 2020;8(6):557–558. [https://doi.org/10.1016/S2213-2600\(20\)30175-2](https://doi.org/10.1016/S2213-2600(20)30175-2).
24. Chen D, Xu W, Lei Z, et al. Recurrence of positive SARS-CoV-2 RNA in COVID-19: a case report. *Int J Infect Dis*. 2020;93:297–299. <https://doi.org/10.1016/j.ijid.2020.03.003>.
25. Carmody S, Murray A, Borodina M, et al. When can professional sport recommence safely during the COVID-19 pandemic? Risk assessment and factors to consider. *Br J Sports Med*. 2020;54(16):946–948. <https://doi.org/10.1136/bjsports-2020-102539>.
26. Elliott N, Martin R, Heron N, et al. Graduated return to play guidance following COVID-19 infection. *Br J Sports Med*. 2020;54(19):1174–1175. <https://doi.org/10.1136/bjsports-2020-102637>.
27. Shurlock J, Muniz-Pardos B, Tucker R, et al. Recommendations for face coverings while exercising during the COVID-19 pandemic. *Sports Medicine Open*. 2021;7(19): 1–8. <https://doi.org/10.1186/s40798-021-00309-7>.