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ORIGINAL ARTICLE

The spread of COVID-19 in athletes

Diffusion du COVID-19 parmi les athlètes

M. You*, H. Liu, Z. Wu



Physical Education College, China University of Geosciences, 430074 Wuhan, Hubei, China

Received 27 October 2020; accepted 4 March 2021

Available online 25 August 2021

KEYWORDS

COVID-19;
SARS-CoV-2;
Infected athletes;
Spread;
Demographics

Summary

Background/objectives. – According to the reported cases, more than 100 athletes were infected with severe acute respiratory syndrome coronavirus 2 in March 2020 alone, and this has created an increased interest in the effect of coronavirus disease (COVID-19) on athletes. This promoted us to study the spread of COVID-19 in athletes and formulate prevention strategies. **Methodology.** – We collected and analyzed the demographic information, such as nationality, sex, age, name, sport played, sport level, source and cause of infection, date of symptoms onset or confirmation of positive status, date of recovery, location of infection contraction, symptoms, and the people infected by the contracted athletes, of 521 infected athletes worldwide, as of the end of July, 2020.

Results. – The cohort comprised 95.49% male athletes; 57.2% were aged 19–35 years, with the average age 23 years. Most of these cases emerged in March 2020 (27.3%) and June 2020 (30.1%), 90.8% of cases were active athletes and 74.2% were professional players, 45.2% of infected athletes exhibited mild symptoms and 30.6% of them were asymptomatic; however, 23.1% of the cases died, including cases aged less than 40 years. Most infected athletes represented soccer (46.6%), football (15.9%), and basketball (10.9%). Most of the infected athletes were from the United States, Western Europe, and Eastern Asia. The athletes primarily contracted the infection in the United States, Western Europe, and Japan. The spread of COVID-19 in these athletes primarily occurred during training- and game-related activities. More than 60% of the infected athletes were unaware of their source of infection.

Conclusion. – It found that the halting of training and matches, isolation of athletes at home, and timely testing can effectively control the spread of COVID-19 among athletes, and it is recommended that athletes discontinue international travel, especially to countries with a high epidemic risk.

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* Corresponding author.

E-mail address: youmaolin@126.com (M. You).

MOTS CLÉS

COVID-19 ;
SARS-CoV-2 ;
Un sportif infecté ;
Diffusion ;
Démographique

Résumé

Contexte/objectifs. – Rien qu'en mars 2020, plus de 100 athlètes auraient été infectés par le coronavirus 2 du syndrome respiratoire aigu sévère, ce qui nous a amenés à étudier la propagation du COVID-19 et à élaborer des stratégies de prévention.

Méthodologie. – Nous avons recueilli et analysé des données démographiques sur la nationalité, le sexe, l'âge, le nom, le projet sportif, le niveau de mouvement, l'origine et les causes de l'infection, la date de l'apparition ou de la confirmation de l'état positif, la date du rétablissement, l'emplacement de la contraction, les symptômes et les personnes infectées de 521 athlètes infectés. Au niveau mondial, à la fin de juillet 2020.

Résultats. – Il y a 95,49 % d'hommes dans ce groupe ; 57,2 % sont âgés de 19 à 35 ans et l'âge moyen est de 23 ans. Au maximum, en mars 2020 (27,3 %) et en juin 2020 (30,1 %), 90,8 % étaient des athlètes actifs, 74,2 % des athlètes professionnels, 45,2 % des athlètes infectés présentaient des symptômes modérés et 30,6 % ne présentaient aucun symptôme. Au total, 23,1 % des cas sont mortels, dont les moins de 40 ans. Les athlètes infectés sont principalement le football (46,6 %), le football (15,9 %) et le basket-ball (10,9 %). Les athlètes infectés venaient principalement d'Europe occidentale et des États-Unis. Ces athlètes ont été infectés principalement aux États-Unis, en Europe occidentale et au Japon. La diffusion du COVID-19 parmi ces athlètes se fait principalement dans le cadre d'activités de formation et de compétition. Plus de 60 % des athlètes infectés ne savent pas d'où ils viennent infection.

Conclusions. – Constatant que l'arrêt de l'entraînement et des compétitions, l'isolement des athlètes chez eux et la détection rapide permettent de contrôler efficacement la propagation du COVID-19 chez les athlètes, et recommandant aux athlètes de cesser de voyager à l'étranger, en particulier pour les pays à haut risque épidémiologique.

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1. Introduction

Many people expect athletes to be strong and healthy enough to fend off being infected by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1]. Unfortunately, more than a hundred athletes were found to be infected with this virus in March 2020 ($n = 140$, 87.77% were men and 12.23% were women; they were from 30 countries, most of them were American (21), Italian (11), Chinese (11), German (8), British (7); they were infected in 24 countries, most of them infected in America (29), Spain (20), Italy (20), Britain (19), German (9); they aged from 14 to 95, 46.43% of them aged from 19 to 35; 57 cases reported their symptoms, 44 of them were mild and 3 were dead) and this has created an increased interest in the effect of coronavirus disease (COVID-19) on athletes.

Some studies have explained the effects of this virus in athletes [2], proposed suggestions for the prevention of COVID-19 in athletes [3], and further suggested that athletes should participate in low-to-moderate-altitude (2000–2500 m) training camps to preserve their health after the COVID-19 pandemic [4]. While there have been many discussions with respect to the effect of COVID-19 on athletes [5], we still do not understand how this virus is spreading in this group of individuals.

In the light of the spread of COVID-19 among athletes, it is important to develop strategies to protect the health of both athletes and the public and propose guidelines for professional sport leagues as they restart their games and for national sport teams as they commence preparation for Tokyo Olympic Games.

2. Methods**2.1. Sample collection**

In total, 521 COVID-19-positive athletes were identified as of July 2020. These cases do not represent all of the infected athletes, but athletes are the public persons, most of the infected athletes would be officially or individually reported. With the main search engines Baidu, Google, and Bing, it can be ensured that we collected most of the infected athletes worldwide before August 2020, and this study can generate valuable findings. The search terms used were “运动员”, “球员”, “athlete”, “player”, and “COVID-19.” The collected information regarding nationality, sex, age, name, sport played, sport level, the source and cause of infection, date of symptoms onset or confirmation of positive status, location of infection contraction, symptoms, and people infected by infected athletes (Table 1).

2.2. Data analysis

A distribution map of the infected athletes and the locations where they contracted the virus was generated using ArcGIS 10.2 (Esri, Redlands, CA, USA). Descriptive statistics such as frequency and percentages were determined to assess the demographics of the infected athletes using SPSS 19.0 (IBM Corp., Armonk, NY, USA). The graphs were drawn to visualize the statistical figures using Excel 2003 (Microsoft, Redmond, WA, USA).

Table 1 The basic information of infected athletes.

Demographic description	Items	<i>n</i>	Percentage
Sex	Male	492	95.53%
	Female	23	4.47%
Age	14 19	12	3.02%
	20 29	182	45.84%
	30 39	45	11.34%
	40 49	7	1.76%
	50 59	11	2.77%
	60 99	30	7.56%
Nationality	USA	144	37.02%
	Brazil	29	7.46%
	Japan	25	6.43%
	France	21	5.40%
	Britain	19	4.88%
	Italy	18	4.63%
	Russia	12	3.08%
	Spain	12	3.08%
	China	12	3.08%
	Serbia	11	2.83%
	Germany	8	2.06%
	Argentina	6	1.54%
	Iran	6	1.54%
	Dominica	5	1.29%
	Korean	4	1.03%
	Croatia	4	1.03%
	Turkey	4	1.03%
	Venezuela	4	1.03%
	Hungary	4	1.03%
	South Africa	3	0.77%
	Australia	2	0.51%
	Barbados	2	0.51%
	Cuba	2	0.51%
	Netherland	2	0.51%
	Sweden	2	0.51%
	Uruguay	2	0.51%
	Jamaica	2	0.51%
	Iraq	2	0.51%
	Indonesia	2	0.51%
	Ireland	1	0.26%
	Austria	1	0.26%
	Bahamas	1	0.26%
	Pakistan	1	0.26%
Paraguay	1	0.26%	
Bulgaria	1	0.26%	
Belgium	1	0.26%	
Bosnia and Herzegovina	1	0.26%	
Poland	1	0.26%	
Bolivia	1	0.26%	
Denmark	1	0.26%	
Ecuador	1	0.26%	
Gambia	1	0.26%	
Haiti	1	0.26%	
Malaysia	1	0.26%	
Peru	1	0.26%	
Mexico	1	0.26%	
Norway	1	0.26%	
Portugal	1	0.26%	
Switzerland	1	0.26%	

Table 1 (Continued)

Demographic description	Items	<i>n</i>	Percentage
Sport practiced	800 meters running	1	0.20%
	Cricket	2	0.39%
	Baseball	45	8.88%
	Squash	1	0.20%
	Ice Hockey	14	2.76%
	Long-distance running	1	0.20%
	Sprint	2	0.39%
	Football	83	16.37%
	Golf	3	0.59%
	Figure-skating	1	0.20%
	Skiing	1	0.20%
	Fence	6	1.18%
	Weightlifting	1	0.20%
	Karate	3	0.59%
	Basketball	57	11.24%
	Hammer-throwing	1	0.20%
	Marathon	1	0.20%
	Volleyball	5	0.99%
	Box	5	0.99%
	Judos	1	0.20%
	Car racing	1	0.20%
	Gym	1	0.20%
	Discus	1	0.20%
	Netball	7	1.38%
	Modern pentathlon	1	0.20%
	Sumo	6	1.18%
	Bobsleigh	1	0.20%
	Swimming	7	1.38%
	Badminton	1	0.20%
	Bicycle	4	0.79%
Soccer	243	47.93%	
Sport level	Professional athlete	371	74.2%
	National team member	39	7.8%
	Youth athlete	2	0.4%
	College athlete	87	17.4%
	Amateur	1	0.2%
Month of appearance of symptoms or confirmation of positive status	January	1	0.20%
	February	6	1.19%
	March	140	27.67%
	April	67	13.24%
	May	47	9.29%
	June	154	30.43%
	July	91	17.98%
Location of the contraction of infection	USA	207	39.73%
	Spain	40	7.68%
	Italy	37	7.10%
	Britain	36	6.91%
	Brazil	35	6.72%
	France	27	5.18%
	Japan	26	4.99%
	Russia	22	4.22%
	Germany	15	2.88%
	Portugal	9	1.73%
	Turkey	9	1.73%

Table 1 (Continued)

Demographic description	Items	<i>n</i>	Percentage
	Serbia	8	1.54%
	Iran	8	1.54%
	Hungary	6	1.15%
	Thailand	5	0.96%
	Croatia	4	0.77%
	Netherland	3	0.58%
	Argentina	2	0.38%
	Dominica	2	0.38%
	Sweden	2	0.38%
	Indonesia	2	0.38%
	UAE	1	0.19%
	Ireland	1	0.19%
	Estonia	1	0.19%
	Australia	1	0.19%
	Barbados	1	0.19%
	Pakistan	1	0.19%
	Belarus	1	0.19%
	Bolivia	1	0.19%
	Canada	1	0.19%
	Malaysia	1	0.19%
	South Africa	1	0.19%
	Europe	1	0.19%
	Switzerland	1	0.19%
	Jamaica	1	0.19%
	Iraq	1	0.19%
	China	1	0.19%
Symptoms	Mild	84	45.16%
	Moderate	1	0.54%
	Severe	1	0.54%
	Death	43	23.12%
	Asymptomatic	57	30.65%

3. Results

3.1. Demographic description

The study sample comprised 95.53% men; the ages ranged from 14 to 99 years, the average age was 23 years, and 57.2% of the population was aged 19–35 years. In total, 90.8% of the sample comprised active athletes and 74.2% of them were professional players, followed by college athletes (17.4%), and national athletes (7.8%). There were few youth athletes (0.4%) and amateur athletes (0.2%). Furthermore, 45.2% of the infected athletes exhibited mild symptoms (the typical symptoms include fever, dry cough and shortness of breath) and 30.6% were asymptomatic; however, 23.1% of the infected athletes died. These athletes represented 31 different sports, with the three most common sports being soccer (46.6%), football (15.9%), and basketball (10.9%).

3.2. There is a close relationship between the number of infected athletes and local 3.2 epidemic of COVID-19

It found that most of the infected athletes were from the regions with more serious epidemic (Fig. 1), and contracted

in these regions (Fig. 2). First, the earliest reported case was a Chinese on January 26, 2020, then China was the epidemic center. Second, 79.95% of the infected athletes reported were from the USA (37.02%), Brazil (7.46%), Japan (6.43%), France (5.4%), England (4.88%), Italia (4.63%), Russia (3.08%), Spain (3.08%), China (3.08%), Serbia (2.83%) and German (2.06%). Third, 81.15% of them contracted the disease in the USA (39.73%), Spain (7.68%), Italia (7.1%), England (6.91%), Brazil (6.72%), France (5.18%), Japan (4.99%), and Russia (4.22%). The findings indicate that the distribution of infected athletes with respect to the different countries and regions was consistent with the spread of the disease locally.

3.3. There is a close relationship between the spread of COVID-19 in athletes and training- and game-related activities

A major cause of the spread of the virus in athletes can be the hosting of sports events (e.g., the NBA and Olympic-qualifying events), which created favorable conditions for the infection. For example, when an infected South Korean fencer participated in an Olympic-qualifying fencing event held in Hungary in May 2020, she shared a drink with her two

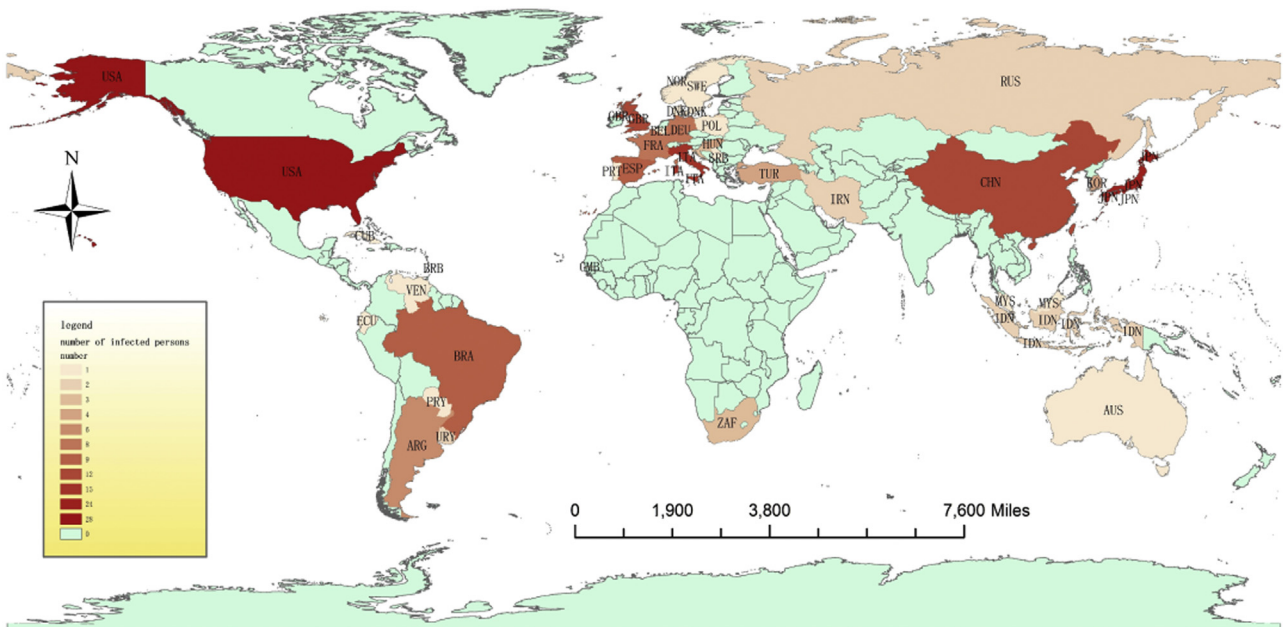


Figure 1 Infected athletes' nationalities.

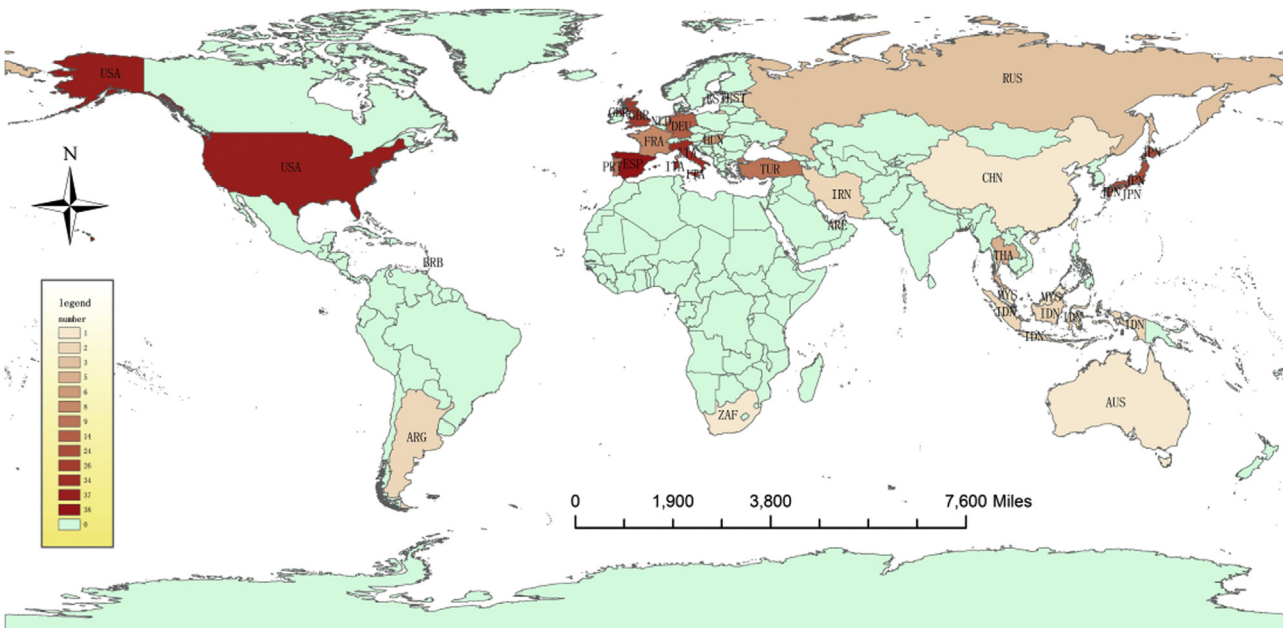


Figure 2 Athletes infected in different regions.

teammates and infecting them and subsequently, the three infected fencers infected their three opponents [6]. During training and matches, it is easy for athletes to interact closely with various persons (e.g., teammates, coaches, and fans), and only 36.66% of them ($n=191$) were able to identify a specific infection source, while 81.68% of them were infected by teammates and opponents. There was another phenomenon that is the fluctuation of infected athletes in moths, most of them emerged in March 2020 (27.3%) and June 2020 (30.1%) with sports events (Fig. 1 and Fig. 3).

3.4. The spread routine of COVID-19 in athletes

Generally, the athletes did a complex travel, then contacted with various people. For example, the Taiwan Centers for Disease Control reported the travel of an infected badminton player who visited Spain from February 16 to 24, Germany from February 25 to March 7, England from March 8 to 15, and France from March 16 to 17, before returning to Taiwan. He was in close contact with his teammates, coaches, team staff, fans, opponents, fellow travelers, and

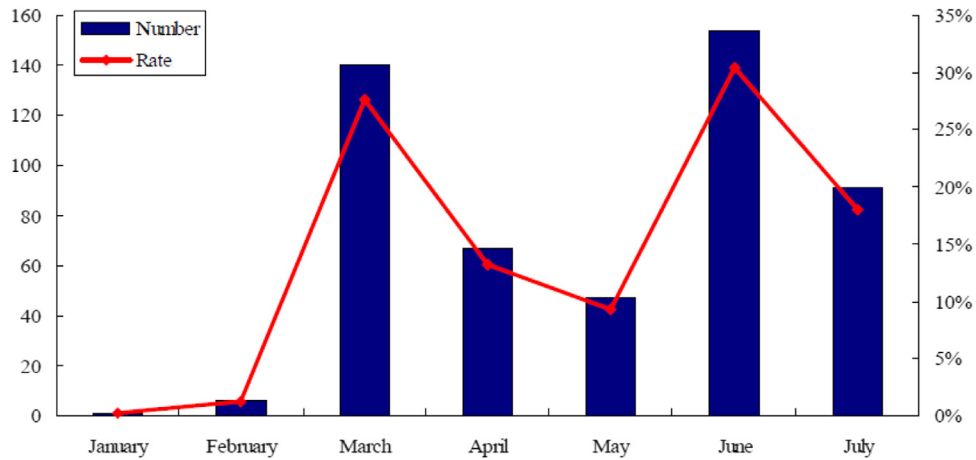


Figure 3 Athletes were confirmed to be COVID-19-positive or became ill in months.

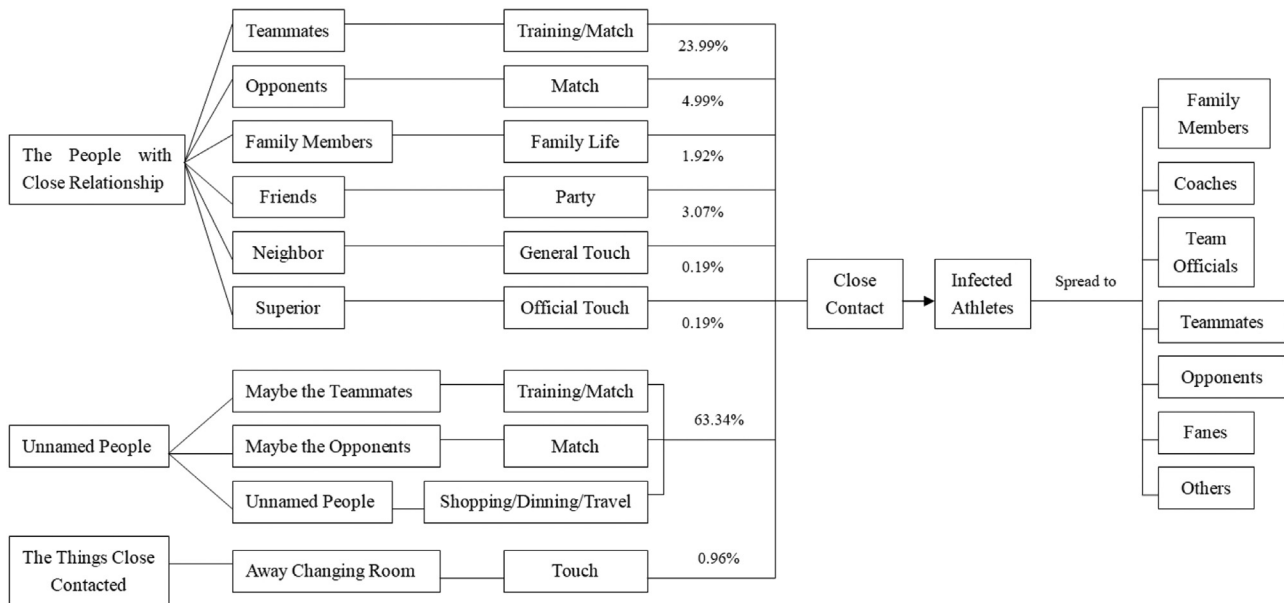


Figure 4 The spread routine of COVID-19 in athletes.

strangers during training, matches, shopping, dining, and traveling. So, 63.34% of the infected athletes ($n = 330$) did not know who infected them, and there were almost 30% of the cases infected during training and match, but the infection source is unclear. This is an unfortunate consequence of the spread of COVID-19 in athletes because it means that we do not know who infected the athletes or whom these athletes will infect. Once an athlete is infected, their family members, coaches, teammates, opponents, team staff, fans, reporters, and other potential contacts are all at risk of infection (Fig. 4).

4. Discussion

Since athletes may have better resistance to SARS-CoV-2 [7], and infection is not always apparent. And the athletes' social contact histories were complex, containing wide ranges of people who include many strangers, and more than 60% of

the athletes were infected by unidentified people. Therefore, it is important to be aware of the spread of COVID-19 in athletes. Athletes are easy in close contact with several people, if infected athletes are unaware of their COVID-19 status, then they may spread COVID-19 unknowingly, causing a serious threat to public health.

According to the outbreak time period of COVID-19 in athletes, competition should be the mayor reason. Athletes are the basis of development of sports industry, and the sports events halted with the impact of COVID-19 around the world, although many sports events restarted in June, no spectators and held in one place. Obviously, the epidemic of COVID-19 caused serious damage to global sports industry.

Our findings indicate that the spread of the epidemic locally created an external environment that facilitated the spread of the virus from the public to athletes, while training and match conditions created an internal environment that facilitated the spread of the virus among athletes.

The halting of training and matches, isolation of athletes at home, and timely testing have limited the spread of the virus. These preventive measures have kept athletes from close contact with each other and have played a part in thwarting the spread of COVID-19. These successful methods suggest that we should cut off the spread of COVID-19 from the public to the athletes, and then make sure the athletes are healthy.

So, it is recommended that close contact among athletes themselves and between athletes and strangers be prevented. It is also recommended that athletes be lodged separately, they play in a closed area to avoid contact with the public, and they also discontinue international travel, especially to countries with a high epidemic risk.

Funding

This work was supported by the Fundamental Research Funds for the Central Universities.

Contribution

You Maolin had the idea for the article, organized the study and wrote the manuscript. Liu Heng collected the reported information of the infected athletes. Wu Zijing helped with the analysis.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgments

We acknowledge the work and contribution of all authors from China University of Geosciences (Wuhan). We would

like to thank Editage (www.editage.cn) for English language editing.

References

- [1] Yang ZG. Are athletes more resistant to COVID-19? China daily. Available from: <http://www.global.chinadaily.com.cn/a/202003/26/WS5e7bdb69a31012821728204a.html>. Accessed April 16, 2020.
- [2] Howley EK. What athletes need to know about COVID-19. U. S. News & World Report. Available from: <http://www.health.usnews.com/conditions/articles/what-athletes-need-to-know-about-covid-19>. Accessed April 12, 2020.
- [3] Toresdahl BG, Asif IM. Coronavirus disease 2019 (COVID-19): considerations for the competitive athlete. *Sports Health A Multidiscip Approach* 2020;12:221–4.
- [4] Manferdelli G, Bishop DJ, Franchi MV, et al. Recommendations for altitude training programming to preserve athletes' health after COVID-19 pandemic. *Br J Sports Med*. Available from: <https://bjsm.bmj.com/content/early/2020/06/12/bjsports-2020-102561>. Accessed June 8, 2020.
- [5] Beijing Sport University. Are athletes easier to be infected with SARS-CoV-2? Answers Experts Beijing Sport University. Available from: <http://www.bsu.edu.cn/kjxgfyyqzt/fwxx/9cdc07aa7e574b3f8acab650aebddd9a.htm>. Accessed March 20, 2020.
- [6] Lu WA. Chinese fencers infected with coronavirus in Hungary. *Global Times*. Available from: <http://www.globaltimes.cn/content/1183249.shtml>. Accessed April 28, 2020.
- [7] Koop J, Rutberg J. What athletes should do about coronavirus COVID-19. *CTS*. Available from: <http://www.trainright.com/athletes-and-coronavirus/>. Accessed April 16, 2020.