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The COVID-19 pandemic: how to maintain a healthy immune system during the lockdown – a multidisciplinary approach with special focus on athletes

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ABSTRACT: On January 31, 2020, the World Health Organization (WHO) declared the outbreak of a novel coronavirus responsible for an infection termed COVID-19 as a global public health emergency. To slow the spread of the coronavirus, countries around the world have been implementing various measures, including school and institutional closures, lockdown and targeted quarantine for suspected infected individuals. More than a third of the world's population have been home confined less than 4 months after the start of the outbreak. The present article aims to advise healthy individuals and athletes who are in lockdown regarding their lifestyle in order to keep healthy, safe and fit. The advice contained in the present article could apply to anyone aiming at remaining in good physical and mental health while forced to undergo lockdown, quarantine, or limited movement (movement control order). Boosting the immune system is crucial during such periods for confined people and especially for confined athletes. Specific recommendations must be followed concerning boosting the immune system through physiological and psychological management. This article analyses the available scientific evidence in order to recommend a practical approach, focusing on nutrition, intermittent fasting or caloric restriction, vitamin D insufficiency, sleep pattern, exercise, and psychodynamic aspects as factors impacting the immune system and human health in general.

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INTRODUCTION

Coronavirus, an enveloped, single-stranded, positive-sense RNA virus, causes respiratory infections, which are generally mild but can sometimes be severe and even fatal [1]. Since late December 2019, an emerging coronavirus currently termed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and previously known as novel coronavirus 2019 (2019-nCoV) has caused a large-scale outbreak, which has quickly spread out from its first epicentre, Wuhan, Province of Hubei, People's Republic of China, affecting more than 210 countries and territories. On January 30, 2020, the World Health Organization (WHO) declared the outbreak a "public health emergency of international concern" (PHEIC) and on March 11, 2020, characterized it as a pandemic. The human-to-human transmissibility of COVID-19 during the peak travel season of the Chinese New Year celebrations and its highly contagious nature have led to the nationwide, and then global, spread of the infection. As of May 6, 2020, more than 3 million confirmed cases have been identified globally and more than 200,000 deaths have been reported (WHO) [2]. Thus, the present generations are facing an unprecedented outbreak situation for which currently there exist no effective vaccines or specific therapeutics that can effectively prevent or counteract/mitigate the burden of COVID-19. Behavioural, non-pharmacological interventions (NPIs), including use of masks, self-isolation, quarantine and even lockdown of entire territories and communities, are the strategies currently employed to prevent or, at least, to curb person-to-

person spread of the disease by physically separating people in order to interrupt transmission. Many are using the term "social distancing", although "physical distancing" would be a more appropriate expression [3, 4] because, thanks to the new information and communication technologies (ICTs), such as social networks and channels, many people are liaising with each other for working in on-line meetings and video conferences ("smart working"), or even staying in touch socially.

Quarantine, which implies a severe restriction in the movement of symptomatic subjects and of those suspected to have been potentially exposed to a contagious pathogen but not ill [5], had already been implemented successfully as an effective measure during the severe acute respiratory syndrome (SARS) epidemic that occurred in mainland China in 2002-2003 [6]. Quarantine is most successful in settings, such as South Korea and China, where detection of cases is prompt, and contacts can be listed and traced within a short time frame with immediate and effective issuance of restriction measures with a high voluntary compliance rate from the population. This suppression/eradication strategy is, however, unfeasible and unsustainable in western countries, where the acceptance of coercive and stringent measures is rather low, due to societal, economic-financial and ethical reasons. Therefore, these countries have preferred to opt for a mitigation strategy. Globally speaking, in order to minimize the risk of contamination, a community-wide quarantine is currently being implemented in several countries, enforced to an order of magnitude that mankind has never witnessed before. The evolutionary trend of epidemics depends on the timing and strength of interventions, especially on the scale of quarantined and suspected populations.

COVID-19 and its impact on sports events

As for many other activities (organization of international events, travel, etc) sports events have been cancelled and suspended in many countries. Even the Olympic Games 2020 (Tokyo, Japan) have been postponed by 1 year. In this environment, the athletes, and most specifically, elite and/or professional athletes, are highly in need of support. In order to support the recommendations of the WHO concerning the strict public health measures implemented, including quarantine, to stop the current viral outbreak, we here provide some suggestions to follow during such a period of confinement. These are intended for everybody, with a special focus on athletes. The present short article will focus on nutrition, fasting, intermittent fasting and caloric restriction, vitamin D insufficiency, sleep pattern, exercise and psychodynamic aspects as factors impacting the immune system.

We would like to emphasize that, besides being timely due to the current situation of lockdown, these recommendations have a broader value given that: i) due to the highly contagious nature of COVID-19 and the economic-financial needs of western societies, which have preferred a mitigation strategy over a suppression/eradication approach, it will be necessary to implement and enforce more than a single set of non-pharmacological interventions, until a definitive cure or a vaccine is found and becomes commercially available; ii) scarce epidemiological and immunological information concerning COVID-19 is currently available and relapses/further waves could occur, with the disease potentially becoming seasonal and not fully eradicated. Therefore, the present article aims at advising untrained individuals and athletes on basic life hygiene measures that could be followed in cases of lockdown or limited movement periods. We hope that the COVID-19 pandemic will not last long, but at the same time hope that education measures will be implemented in order to have anybody prepared for such specific periods with limited movement.

Nutrition

The confinement period is a new situation, during which boredom and stress are threats that could lead the athletes to lose their usual daily pattern and adopt bad nutritional habits, such as sometimes overeating or snacking, especially foods rich in sugars and fats, and ultra-processed foods [7]. Therefore, nutritional principal education for athletes should be seriously considered by health practitioners. Nutrients are important for the immune response to pathogens so cells can divide, and produce and release cytokines and antibodies [8]. Many enzymes in immune cells require the presence of micronutrients, and critical roles have been defined for zinc, iron, copper, selenium, and vitamins A, B6, C, and E in the maintenance of optimum immune function [9]. Thus, to boost the immune system, a healthy diet providing all the nutrients needed is recommended during the quarantine, lockdown and movement control order. We appreciate that people forced to self-isolate could face some anxiety (see section on psychological management), but we encourage them to engage in cooking healthy meals as an investment for their health. Obviously, this might be very challenging due to the situation where not everybody has easy access to food as is the case in normal times. Athletes should try to maintain the quality of the food they are used to eating, assuming that they used to have healthy nutrition. In addition, they should consider changing the pattern of their meals by adopting some forms of fasting or caloric restriction.

Fasting and calorie restriction

Fasting or intermittent fasting (IF) has been shown to exert beneficial effects in patients with underlying co-morbidities, including various chronic diseases, and also to prevent diseases in healthy subjects, reducing oxidative stress and inflammation [10]. Indeed, C-reactive protein (CRP) and inflammatory bio-markers such as IL-6 have been shown to be significantly decreased by short and long IF [11, 12]. On the other hand, caloric restriction (CR) also reduces markers of oxidative stress and inflammation [13] and metabolic disease risk markers [14] among patients with moderate asthma and other respiratory diseases. Many authors recommend diet with CR, fasting (e.g., Ramadan fasting) or IF to boost the human immune system. Depending on their training capabilities in self-isolation (see below), athletes might spend less energy than for their regular training. In any case, they should consider changing the pattern of their meals

and tend to reduce their calorie intake or intermittently fast. IF does not mean consuming fewer calories, but consuming them differently, throughout the circadian rhythm. For instance, fasting for 16 hours a day (while drinking zero calorie fluids – water, sugar-free tea or coffee) allows for an 8-hour window of replenishment with food. This 8-hour window enables the consumption of 2 meals and possibly a snack, which is more than enough for humans and for most athletes (especially if caloric expenditure is limited in times of quarantine, lockdown or movement control order).

Vitamin D

Optimal nutritional status is an important factor to protect against viral infections [15]. Vitamin D is the essential nutrient that humans obtain through exposure to sunlight, and through diet and dietary supplements. Solar ultraviolet (UV) B (UVB) radiation converts 7-dehydrocholesterol in the skin to pre-vitamin D3 and subsequently to vitamin D3. The ability to form this pro-hormone is influenced by skin pigmentation, sun protection, latitude, age, amount of UV radiation exposure and coverage by clothing, any of which may significantly affect vitamin D levels [16]. In the diet, vitamin D is found mostly in oily fish, and in fortified grain and dairy products [17]. Numerous studies have revealed that vitamin D plays a vital and complex role in immune system function and regulation [16, 17]. Recent studies reported that vitamin D insufficiency has been linked with susceptibility to infection, particularly respiratory infections [18-21].

It was hypothesized that vitamin D could be very important in preventing the cytokine storm and subsequent acute respiratory distress syndrome that is commonly the cause of death in COVID-19 patients [22].

Vitamin D inhibits the production of inflammatory cytokines (IL-1, TNFα) by monocytes. It was suggested that vitamin D could play a significant role in reducing the risk of COVID-19 [23] but also potential severe outcomes of COVID-19 [24]. It is recommended that people at risk of influenza and/or COVID-19 consider taking 10,000 IU/day of vitamin D3 for a few weeks to rapidly raise 25(OH)D blood concentrations, and then lower the doses to 5000 IU/day. The goal should be to raise 25(OH)D blood concentrations above 40–60 ng/mL (100–150 nmol/L) [23].

Vitamin D insufficiency and severe COVID-19 share numerous associations including hypertension, obesity, male sex, advanced age, residency at high latitudes where sun exposure is insufficient, coagulopathy, and immune dysfunction [24]. It has also been suggested that vitamin D supplementation could possibly improve clinical outcomes of patients infected with SARS-Cov-2 [25].

Thus, people in quarantine or self-isolation should moderately expose themselves to the sun daily (if possible), and in any case, consider dietary sources of vitamin D mentioned above. Whenever possible, elite athletes should liaise with their physician to monitor their vitamin D levels.

Adequate sleep

Several studies have highlighted that sleep is vital for the immune system [26, 27]. The National Sleep Foundation (NSF) reported that too much sleep will not necessarily prevent sickness, but could instead adversely affect the immune system [28]. On the other hand, sleep loss and sleep deprivation impair immune function, since the release of cytokines, a protein that targets infection and inflammation, will decrease [26]. Moreover, the infection-fighting antibodies and cells are reduced during periods when humans do not get enough sleep [26]. Thus, sleep influences the immune system through the action of centrally produced cytokines which are regulated during sleep. Therefore, it is recommended to get enough sleep each night to fight off infectious diseases. The recommended duration of sleep depends on gender, age and physical activity, with the optimal recommended sleep duration being usually between 7 and 9 hours of sleep per night in adults [29]. Sleep deprivation has been linked with an increased risk of injury the day after [30]. In that regard, recent literature has shown the positive impact of napping for physical performance and oxidative stress in athletes [31]. Therefore, athletes are encouraged to put a high priority on their sleep pattern, and if necessary, complement night sleep with naps when necessary.

Physical exercise

The currently available body of scholarly evidence indicates that regular exercise is beneficial for the immune system and reduces the risk of contracting certain types of infection, such as upper respiratory tract infections (URTIs) [32]. In this context, several studies have revealed that during moderate or vigorous exercise, several positive changes occur in the immune system [33, 34]. Immunoglobulin (Ig)A is the predominant antibody contained in the secretions of the mucosal immune system, one of the body's first lines of defence against invading upper respiratory pathogens. Klentrou et al. [35] reported that IgA concentration and secretion rates at rest were significantly increased in subjects undergoing regular moderate exercise. Most studies have revealed enhanced functions of natural killer cells, which represent another important player of innate immunology activity, in athletes versus non-athletes [36].

On the other hand, some studies have shown that, partially due to their sporting performances, athletes, especially those practising acute bouts of endurance exercises, may be at higher risk of developing infections (the so-called "open-window theory") [37], even though some researchers have recently debunked currently available evidence in this regard [38]. Recently Simpson et al. [39] stated that it is imperative to maintain recommended exercise levels during this COVID-19 pandemic to mitigate the deleterious effects of inactivity and social isolation stress on our immune system.

A suggested daily routine for athletes in quarantine or self-isolation could be the following. For training regimes, coaches and fitness trainers could advise whether and which activities to perform. While it is challenging to exercise in self-isolation, there are some possibilities of performing endurance exercises (e.g. aerobics, calisthenics),

FIG. 1. Examples of home-based bodyweight training exercises can be found online at ASPETAR youtube account [40].

while for strength, in the absence of gym devices, there remain many exercises focusing on strengthening the core and the limbs with body weight. Examples of home-based bodyweight training exercises can be found online [40] (Figure 1). The intensity categories of home-based aerobic exercise training for various target groups have been proposed by Hammami et al. [41].

Daily routines of athletes will depend on their sports and their preferences, but we can suggest for instance that after waking up in the morning, they consume only water, tea and/or coffee (sugar free), relax (meditate) for stress/anxiety management, and possibly expose themselves to the sun, taking into account the hygiene of behaviour during virus outbreaks. For days with 2 training sessions, one can start an endurance training session (aerobics with ad libitum hydration) at around 11.30 am to 12.00 noon. After the session, the athlete can consume the first meal of the day at 1.00 p.m. After lunch there is time for a nap (if needed). A snack can be consumed at 4.00 p.m. followed by an intensive training session (high-intensity intermittent training and/or strength training) in the time zone 5.00-6.30 p.m. (this leaves 2 hours for dinner and desserts to be consumed at a low/easy pace (7 to 9 p.m.). After 9 p.m., no more food would be consumed, as IF will take place from 9 p.m. to 1 p.m. the day after (16 h of wet fasting). Others would like to keep the breakfast and therefore stop eating towards the end of the afternoon while still performing 16/8 h of IF.

This is of course only one example of how an athlete in isolation could organize their daily schedule to cope with the situation of promoting their health and training while avoiding getting infected by the virus. As the pandemic period did also include Ramadan 2020, we direct the readers to a review paper written to advise Muslim athletes on their training during Ramadan [42]. Nevertheless, to the best of the authors' knowledge there is no literature on exercise during Ramadan during a pandemic.

Psychodynamic management

Studies on quarantined individuals reported negative psychological effects of confinement including confusion, anger, and post-traumatic stress symptoms [43]. Because of involving strict home confinement, the COVID-19 crisis can have harmful psychological consequences in athletes, for at least two reasons. First, confinement imposes physical distancing with loved ones, which can generate severe affective frustrations, thereby precipitating psychological ill-being or disorders [44, 45]. Every individual seeks to satisfy one's innate psychological needs [46], such as the needs for authentic ties, physical proximity and love, that isolated or confined environments can severely thwart. The frustration of such needs might be higher in athletes living on their own. Second, the COVID-19 disease has turned out to be more harmful than it was expected to be. While many politicians, scientists and physicians around the world initially agreed to consider this disease as if it were a commonplace flu, they quickly realized their mistake after helplessly observing the lethal tragedy in their own medical centres and countries. This story shocked the world and led some to call into question certain myths of global order, such as the myth of the superiority of the West and modern/Western medicine. Indeed, mass media and social networks extensively presented the struggle of the West's medical centres, the cries of nursing staff, and the deaths of experienced physicians after developing COVID-19. Inevitably, these dramatic events undermined the myth of the West's dominance that apparently had the psychological function to make most people feel protected against any environmental threats. Psychoanalysis suggests that people would be most willing to recognize and submit to the power and authority of a natural/societal (e.g., manager, scientist, political chief, government) or supranatural force (e.g., divinity, God) – which is, according to the psychoanalytic approach, deeply rooted in the internalized paternal figure – in exchange for the convincing promise to be protected against any (real or imaginary) external threats [47]. Thus, following that perspective, the epidemic outbreak would expose people to chronic anxiety via, at least partially, the perceived decline of the dominance of the West.

How to deal with that? Theoretically, the response seems obvious: by satisfying the needs for safety and for authentic, physical and affective relationships. Practically, the confinement and the anxiety-provoking climate constitute strong obstacles to the attainment of this goal. However, we can encourage people – including athletes and coaches – to use all of the technological tools not only to stay in touch with their loved ones, but also to reaffirm as much as possible their love, attachment or warm feelings. Love expressions – possibly reanimating the maternal love, according to psychoanalysis – would be experienced as a highly effective shield against not only feelings of insecurity, but also the development of mental disorders [48], especially when the protective function of the governmental authority – referring to the protective nature of the paternal figure, according to psychoanalysis again – has been impinged. Additionally, athletes and coaches should reinforce their supportive and cooperative actions during the confinement period by activating and performing programmes of biomechanical (technical), cognitive (tactical) and psychological (motivational and affective) training. For instance, with the intervention of sport scientists (including specialists of biomechanics,

physiology and psychology), they might: (a) analyse and comment on their biomechanical, cognitive and psychological performances via kinematic analysers accompanied by experiential and emotional comments; and (b) explore physical and mental strategies intended to reinforce the quality of complex patterns of performance associated with high-level standards (while taking into account the complex and dynamic biopsychosocial dimensions of sport performance). Also, and interestingly, interacting with scientists in the time of COVID-19 might develop a sense of psychological comfort because they are often perceived as figures of scientific authority. Their knowledge and scientific spirit may generate feelings of confidence, especially when exposed to uncertainty. Finally, all of these recommendations should help athletes and coaches buffer the anxiety-provoking effects of the COVID-19 disease, reinforce their scientific and technical cooperation, and especially boost their immune system.

CONCLUSIONS

During the COVID-19 pandemic, people around the world are facing a unique situation. Boosting the immune system is crucial during such a period of limited movement. Following the above recommendations might help people in self-isolation to cope with the special situation of quarantine and/or "physical distancing" even when the situation returns to normality. Indeed, maintaining healthy habits is not only good for people in healthy conditions but will certainly benefit their performances and quality of life if they are elite athletes.

Conflict of interest

All authors declare having no conflict of interest.

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