

Research article

The impact of COVID-19 on the incidence of myocarditis among athletes

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Abstract: In December 2019, the world of sports was marked by the outbreak of COVID-19, a disease caused by the SARS-CoV-2 virus. Initially considered an epidemic, it quickly turned into a global pandemic. COVID-19 presents a wide range of symptoms, from common ones (fever, cough, fatigue, loss of smell or taste) to less frequent symptoms (sore throat, headache, skin rashes) and some severe ones (breathing difficulties, loss of speech, chest pain). A significant phenomenon emerging from the infection is Long COVID, defined as persistent symptoms lasting at least 12 weeks after the initial infection, severely affecting individuals' physical and cognitive capacity. The pandemic had a major impact on sports, with the cancellation of key events such as the Tokyo Olympics and the European Football Championship, as well as the suspension of national leagues and championships, causing massive financial losses. Globally, the infection rate was estimated to be around 15%. Among the severe complications of COVID-19 is myocarditis, an inflammation of the heart muscle, which affects both sedentary individuals and athletes, both amateur and professional. The latter are often forced to suspend their sporting activities for 3-6 months or more. Myocarditis can lead to myocardial dysfunction and dilated cardiomyopathy, and proper evaluation of this condition is essential for preventing serious complications.

Keywords: COVID-19, myocarditis, athletes, incidence

1. Introduction

The world of sports changed in December 2019, with the identification of an outbreak of COVID-19. At that time, no one expected that a simple outbreak would expand into an epidemic, then a pandemic.

This coronavirus (COVID-19) was described by the World Health Organization (WHO) as being an infectious disease caused by the SARS-CoV-2 virus with a multitude of symptoms, from Most common symptoms such as: fever cough, tiredness, loss of taste or smell; to some that affect a smaller population and are called Less common symptoms: sore throat, headache aches and pains diarrhea a rash on skin, or discolouration of fingers or toes red or irritated eye; some that affect the smallest part of the population but are Serious symptoms: difficulty breathing or shortness of breath loss of speech or mobility, or confusion chest pain [1]. This definition is also supported by Thoms B. in 2024 and published in the JBI Evidence Synthesis Journal, saying that (COVID-19) is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and that it can impact individuals in different ways, from mild to severe problems, but at the same time they can also be asymptomatic [2]. But Thomas B. also mentions in the same article a condition

resulting from COVID-19, and which no one thought about at the beginning of this pandemic, the Long COVID, also known as post COVID-19 condition and says that it is defined by according to WHO it is as the development or persistence of symptoms 3 months after initial infection, with symptoms lasting for at least 2 months, but that The National Institute for Health and Care Excellence (NICE) defines long COVID as symptoms lasting over 12 weeks that develop during or after SARS-CoV-2 infection that cannot be explained by another diagnosis [2].

Common symptoms of long COVID frequently include fatigue, cognitive difficulties, shortness of breath, insomnia, muscle weakness, and joint stiffness. These symptoms can greatly affect one's physical and cognitive abilities, diminish quality of life, and hinder the capacity to carry out everyday tasks like work or household duties [2]. According to the WHO, the incidence of Covid-19 on August 11, 2024 is 775,917,102, also accumulating a number of 7,058,381 deaths worldwide [3, 4].

This pandemic put the world on pause, but they also put the sports world on hold. In the world of sports, the athlete, the clubs, the national and international events, the public, etc. matter. These things were highlighted by Yanguas X. in Journal Apunts-Medicina de l Esport in 2020, saying that the world of sports has faced major disruptions both nationally and internationally, with the cancellation of key events such as the Tokyo Olympics, the European Football Championship and the Copa America, all originally planned for the summer of 2020. In addition, the suspension of the National Leagues and Championships has led to billions of euros in losses for sports such as basketball and football [5]. The disease affects the global population to varying degrees, with an estimated infection rate of around 15% [5].

Returning to the complications that Covid-19 had on health, one of the severe complications that humanity has faced and is facing after being infected with Covid-19, is that of myocarditis. This condition affects both sedentary people and active people or amateur and performance athletes. Amateur and performance athletes taking them out of sports for 3-6 months or more.

To be able to understand what it is about, Guerra M.A.R defined myocarditis as an inflammatory reaction of the heart muscle at the level of the myocardium triggered by multiple causes (infectious or non-infectious), and its entire inflammatory process led to myocardial dysfunction and dilated cardiomyopathy [6].

Material and method

For the preparation of this article, a complex documentary investigation was carried out, based on the consultation of the specialized literature of international circulation, with the aim of evaluating the incidence of myocarditis among athletes after infection with the SARS-CoV-2 virus and to analyze the impact that this condition had on their performance and general health. The bibliographic search process was carried out in a systematic manner, using the most prestigious and comprehensive scientific databases, namely Clarivate Analytics (Web of Science), Scopus and PubMed/MEDLINE, which are considered essential landmarks in the field of contemporary biomedical research.

The selection of articles was carried out by using carefully chosen and validated keywords by the consensus of the specialized literature, such as "myocarditis", "athletes", "incidence" and "COVID-19", as well as by various logical combinations of them, using Boolean operators to refine the searches and increase the accuracy of the results obtained. Following the application of these database query strategies, a considerable number of publications were identified,

covering a wide range of perspectives, methodologies and geographical contexts, which demonstrated the scope and complexity of the investigated issue.

From all the articles initially extracted, an additional filtering stage was carried out, through a critical evaluation of the abstracts and full texts, in order to distinguish studies with direct relevance to the objectives of the current research from those that deviated from the proposed topic. Articles that did not strictly refer to the relationship between the incidence of myocarditis and athletes in the post-COVID-19 context were excluded, as they did not meet the established eligibility criteria. This approach allowed maintaining a high level of specificity and coherence in the data analysis, avoiding diluting the conclusions by including collateral or irrelevant sources.

Finally, the bibliographic corpus used in the construction of the scientific argumentation of the article was constituted exclusively of those sources that presented a certain methodological validity, a recognized authority in the field and a direct applicability in relation to the formulated research question. This rigorous selection strategy gives the study not only academic solidity, but also a high degree of credibility and relevance in the current scientific landscape.

Discussions

A problem that emerged from the first months of COVID-19 was the data pointing to heart problems, which were related to the severity of the condition, but it was identified that heart problems can be from asymptomatic people to mild [7]. Moreover, cases of sudden cardiac death are reported in non-hospitalized COVID-19 positive people with only mild symptoms [8].

In 2022, most authors said that myocarditis is not so common after infection with Covid-19, but at the same time they said and declared that there are studies that highlight the condition of myocarditis after Covid-19.

One of them was Schellhorn P. writes in the European Heart Journal in 2020 that descriptions of mild myocarditis associated with COVID-19 are very rare or even non-existent, but nevertheless, in the assessment of eligibility for sports participation of athletes recovering from COVID-19, they could be very useful for further risk stratification and guiding reintegration into training and competition [8]

Even if Schellhorn P. says that there are few or no cases of myocarditis after an athlete's infection with Covid-19, he proposes a strategy that can be the adaptation of the general recommendations mentioned above for the return to sports in athletes with (suspected) myocarditis in Figure 1 [9].

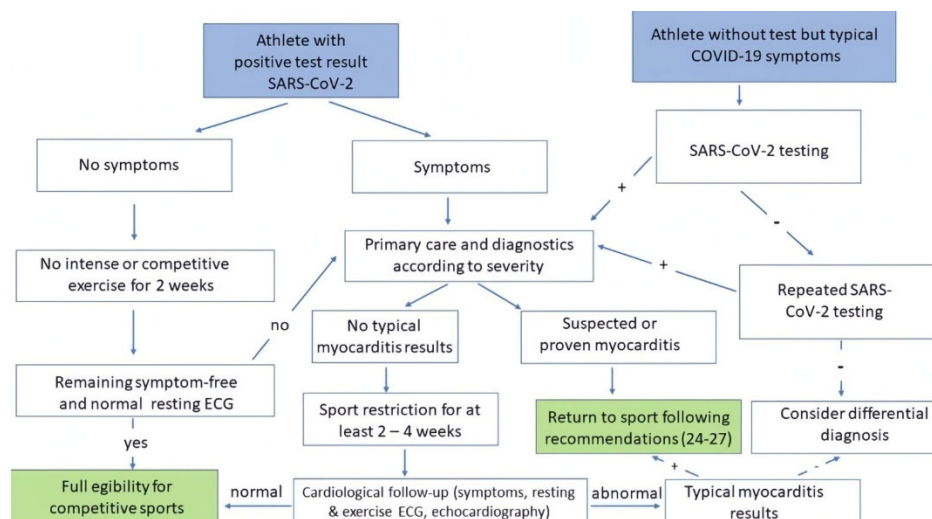


Figure 1. Schellhorn P.'s recommendation in the article Return to sports after COVID-19 infection. strategy that can be the adaptation of the general recommendations for the return to sports in athletes with (suspected) myocarditis [8].

Abreviation: SARS-CoV-2, Severe acute respiratory syndrome coronavirus, ECG – Electrocardiogram.

Guerra M.A.R confirms that COVID-induced myocarditis is uncommon, but initial evaluation of these patients is crucial because of the high mortality associated with myocarditis [6].

Even if Schellhorn P. said that myocarditis is not so common after the infection with Covid-19, he developed a protocol, but certainly even if he was not very sure about it, the studies from 2020 up to 2024 contradict him and how they contradict him.

Likewise, Sasbou L. says in 2020 that myocardial injury is one of the important pathogenic features of COVID-19 [9].

And in the study entitled Update on Covid-19 Myocarditis, written by Agdamag A.C.C, we find this observation according to which myocarditis is increasingly recognized as a complication of the Coronavirus-19 (COVID-19) and can result from direct viral injuries or from the host's exaggerated immune response and concludes with that myocarditis is one of the serious cardiac complications of the SARS-CoV-2 infection. [10].

In the article entitled "Sports, Myocarditis and COVID-19: Diagnostics, Prevention and Return-to-play Strategies", Schmidt T. states that infection with SARS-CoV-2 (COVID-19) may be associated with myocardial involvement [11].

Dass B.B, Kitsou V., gunes M. and Duh claim in their studies that myocarditis is one of the complications they see after Covid-19 infection [12, 13, 14, 15].

In the article entitled COVID 19 Myocarditis: Myth or Reality?, the authors discuss that the clinical presentation of SARS-CoV-2 myocarditis varies from one case to another, but the most urgent clinical sign is ventricular dysfunction and cardiogenic shock [9].

Davis T., contradicts Guerra M.A.R and Schellhorn P and writes in 2023 that covid-19 myocarditis can occur in up to 27% of Covid infections, regardless of whether pneumonia is present, and as myocarditis can present in a variety of forms, but rarely mimics acute coronary syndrome (ACS) [16].

Fairweather D. writes in 2023 in Circulation Research that cases of myocarditis and pericarditis associated with COVID-19 in the United States have increased approximately 15-fold from pre-pandemic levels [17]. In adults, these conditions occur more frequently in men under 50 years of age [17]. Sudden

cardiac death due to myocarditis is predominantly seen in young men under 30 years of age [17]. This demographic is also the most affected by myocarditis and pericarditis associated with both COVID-19 infection and vaccination against COVID-19, suggesting how viruses or viral antigens may trigger myocarditis. An explanatory model was proposed to clarify these observations in Figure 2 [17]:

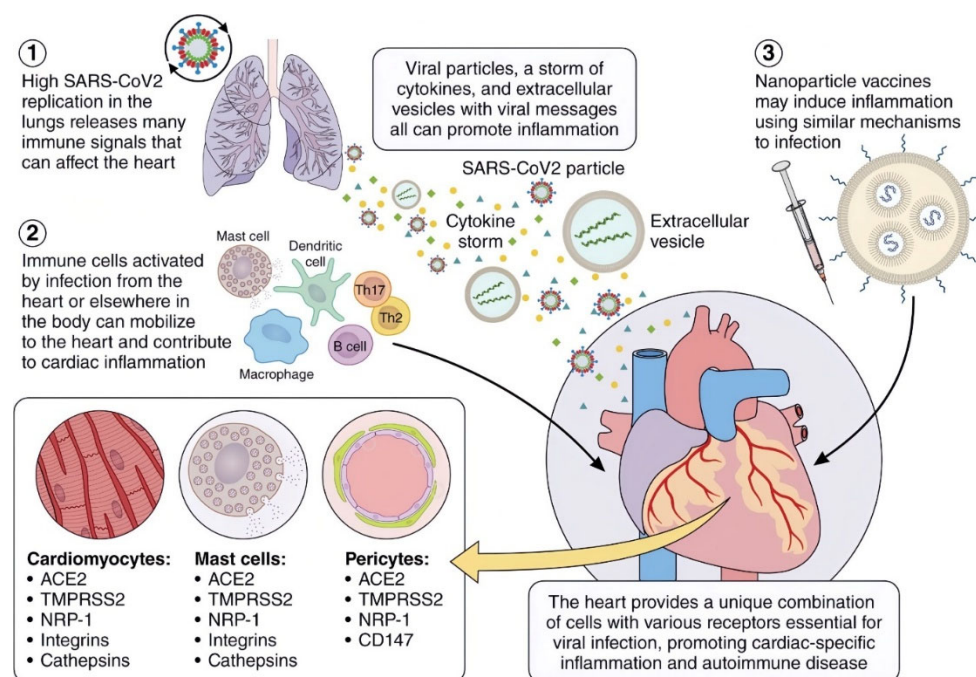


Figure 2. Mast cell signaling contributes to myocarditis and may contribute to SARS-CoV-2 or vaccine-associated myocarditis. ACE2 indicates angiotensin-converting enzyme 2; cKit, receptor tyrosine kinase; IL, interleukin; MHC, major histocompatibility complex; serpin A3n, serpin family A member 3n (α 1-antichymotrypsin); ST2, interleukin-1 receptor-like 1/IL-1RL1; TLR, Toll-like receptor; TMPRSS2, transmembrane protease serine-2; and TNF α , tumor necrosis factor- α . Illustration credit: Sceyence Studios [17]. Abreviation: SARS-CoV-2, Severe acute respiratory syndrome coronavirus, Th17 - T helper 17 cells, Th2 - T helper 2, B cell - B lymphocytes, ACE2 - angiotensin-converting enzyme 2, TMPRSS2 - ransmembrane protease serine 2, NRP-1 - neuropilin-1, CD147 - cluster of differentiation 147.

Now that it is understood that myocarditis is recognized as one of the complications after infection with Covid-19, the question we must ask ourselves is how does this influence sports complications and what is the incidence among athletes?

Related to the incident initially it was believed that cardiac involvement occurs 2 months after COVID-19 in upwards of two-thirds of patients, reporting subclinical myocarditis in 4 out of 26 (15%) college athletes [7].

In the same 2022 study, Schmidt notes that in the early stages of the pandemic, prevalence data were vague, raising fears of a high level of danger, with initial estimates indicating prevalences as high as 78 percent. Subsequently, several studies have become available suggesting that approximately 1-3% of athletes who test positive for COVID-19 have myocardial involvement [11].

Van name J. says that myocarditis is a rare inflammatory process of cardiomyocytes, usually caused by viruses, with potentially devastating cardiac sequelae in both competitive athletes and the general population, in the article entitled Myocarditis - A silent killer in athletes: Comparative analysis on the evidence before and after the COVID-19 pandemic.[18]

As a calculation before the pandemic, the incidence of myocarditis was 6.1 per 100,000 in men and 4.4 per 100,000 in women, ages between 35 and 39, but with

similarities also for ages between 20 and 44, but the incidence of myocarditis after the diagnosis of SARS-CoV-2 was 150 per 100,000 individuals. [18]

Also Van Name J., says in 2024 that in addition, according to the data available from the Vaccine Adverse Events Reporting System (VAERS), COVID19-induced myocarditis risk estimates may be even more concerning, with some studies suggesting a 40-fold increase in incidence in COVID positive patients compared to non-COVID patients in the pandemic era, compared to the previously mentioned figures. [18]

A very important thing that Van Name J. mentions is that studies recently indicated that athletes have a risk of myocarditis after recent COVID-19 infection compared to the general population.[18]

This happens because due to the unique nature of the competitive athlete and their participation in high-intensity exercise, athletes have different factors and are more susceptible to developing myocarditis and severe complications (eg, sudden cardiac death, fulminant heart failure, etc.). [18]

Table 1. List of the key risk factors affecting myocarditis susceptibility in athletes by Van Name J in 2024. [18]

Risk Factors	Impaired	Immunologic competence	Age	Endurance sports
Causes	• sleep deprivation • climate shifts	• exgaustive exertion	• incresed risk of cardiomyopathy comorbidity	• exhaustive exertion • incresed cortisol levels • immunosuppression

Van Name J. Offers in the figure below the the phasic pathophysiology of myocarditis caused by the selected viral pathogens is summarized in Figure 3. [18]

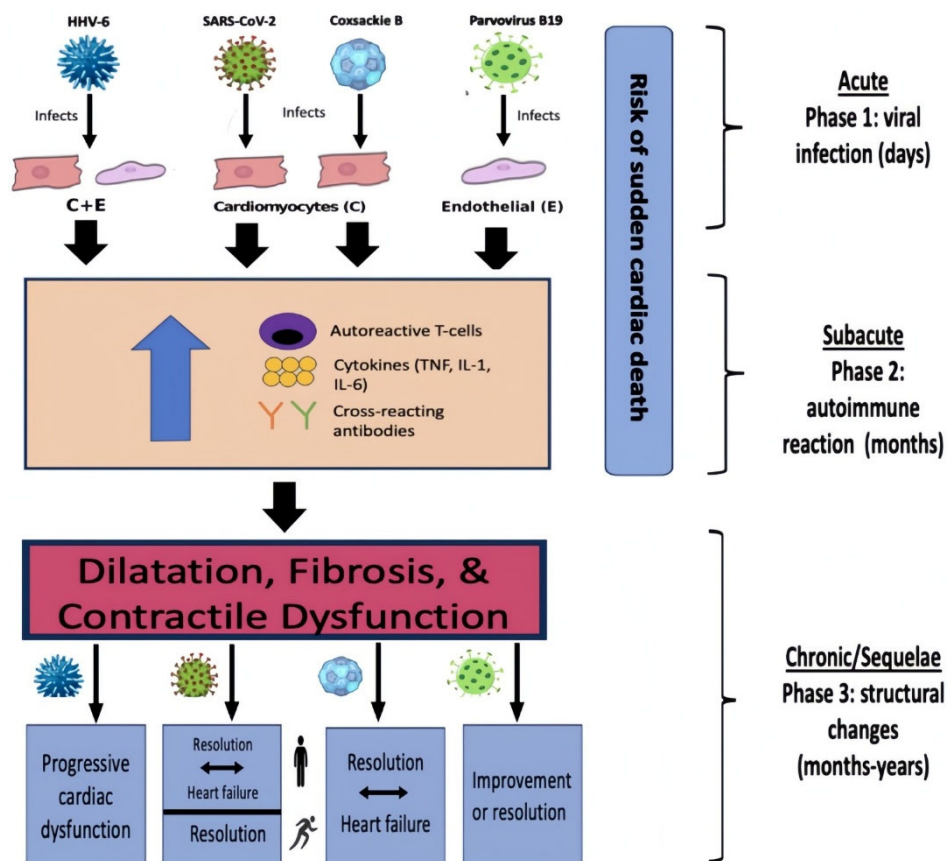


Figure 3. Schematic summary of viral myocarditis phasic pathophysiology and clinical outcomes in selected viral pathogens offered by Vane Name J in the article Myocarditis - A silent killer in athletes: Comparative analysis on the evidence before and after COVID-19 pandemic[18].

Abbreviation: HHV-6 - human herpes virus-6; SARS-CoV-2 - Severe acute respiratory syndrome coronavirus 2; *TNF* - tumor necrosis factor; IL-1 - *interleukin 1*; IL-6 - *interleukin 6*.

The issue of returning to sporting and competitive activity is quite complicated due to the occurrence of myocarditis after the Covid-19 infection.

Perillo M. reinforces in the article Sports in Covid-19 Times: Heart Alert Esporte em Tempos de Covid-19: Alerta ao Coração Jorstad's words, arguing that the resumption of sports practices not preceded by an adequate pre-participation cardiac assessment in athletes affected by COVID- 19 may be a thoughtless decision that puts him at risk of sudden cardiac death [19].

According to current recommendations, a release for intensive sports activities and competitions can be issued 3-6 months after the acute illness phase, only if it meets the specific criteria, otherwise, it is extended until the criteria are met [11].

Another study that included data on over 100 football players from the Big Five European Football Leagues, analyzed 28 indicators of Match technical performance (MTB) in football players after they had Covid-19, the mild form or average, and they discovered that to reach the performances before the infection with Covid-19, the players needed 3.09 matches.

This means that they needed at least 3-4 weeks (1 match per week) to be able to reach normal capacity, without them being affected by the complications of post-Covid-19 myocarditis [20].

Peball M. observed in the study published in 2024 that patients with COVID-19 but who were severely affected had increased body mass index and body fat and performed worse on physical outcome measures 1 year after COVID-19 [21].

It can also be seen that even after 1 year of reintegration into sports and competition, not all athletes return to 100%. Athletes from Outcomes Registry for Cardiac Conditions in Athletes (ORCCA) investigated intermediate duration cardiovascular outcomes of young athletes with confirmed SARS-CoV-2 infection. ORCCA, which included 4,675 athletes with confirmed recent SARS-CoV-2 infection, showed that 0.6% of the studied athletes experienced continued myocardial or myopericardial abnormalities one year after COVID-19 diagnosis.[18]

Another thing that has not been taken into account is wearing a mask during aerobic exercises and how this impacts health and sports performance. Here Pifarre F. published in the magazine *Apunts-Medicina de l Esports* in 2020 an article about Covid-19 and the mask in sports, concluding with wearing masks while at rest typically reduces oxygen availability by an average of 14% and increases inhaled CO₂ levels by up to 30 times. During brief exercise at an intensity of 6–8 METS, mask use leads to a 3.7% reduction in oxygen and a 20% increase in CO₂ concentration, and in certain mask models, CO₂ levels can reach 20,000 ppm (2%) during exercise, which may cause discomfort and symptoms in some individuals [22].

Conclusions

In conclusion, the association between COVID-19 and myocarditis is of paramount importance for athletes. The potential for severe cardiac complications necessitates a cautious approach, which includes thorough evaluation and a mandatory waiting period before the resumption of competitive sports. The long-term impact of COVID-19 on athletic performance and overall health remains an area of active investigation, underscoring the importance of continuous monitoring and further research in this domain.

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