Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Editorial

Cardiovascular screening of athletes during the COVID-19 pandemic: The (ir)relevance of elevated cardiac troponins

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A journey of a thousand miles begins with a single step

- *Lao Tzu*

Since the Coronavirus disease 2019 (COVID-19) pandemic started raging across the globe earlier this year, many sports medicine physicians have been questioning the best return-to-play strategy after recovery from a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. Potential COVID-19-related myocardial damage is a hot topic [1], especially after a recent publication of Puntmann and colleagues, which reported signs of cardiac involvement and ongoing inflammation on cardiovascular magnetic resonance (CMR) in the majority of recovered COVID-19 patients [2]. This might be particularly important for athletes, in whom myocarditis is an established risk factor for sudden cardiac death [3]. Recently, a targeted symptom-based approach for athletes affected by COVID-19 has been proposed by an expert panel [4]. However, data from large studies are currently lacking to underpin their recommendations. In this respect, studies focussing on aspects of screening protocols in athletes during the COVID-19 pandemic are of great interest.

In the current issue of the *International Journal of Cardiology,* Mascia et al. [5] describe a screening protocol recommended by the Italian Soccer Federation FIGC early March 2020, and its outcomes in 2 Italian Serie A teams, comprising 58 professional soccer players. The protocol consisted of a weekly PCR screening for SARS-CoV-2, as well as a baseline assessment of high-sensitivity cardiac troponin I (hs-cTnI) and an ECG. In COVID-19 positive athletes comprehensive blood analysis, echocardiography, cardiopulmonary exercise test, and 24-h Holter monitoring were performed. After a positive PCR test, training was interrupted until 2 negative PCR tests had been obtained, followed by an additional 2 weeks of rest. Repeated measurements of hs-cTnI and a CMR with T2-weighted imaging and late gadolinium enhancement (LGE) were performed in athletes with significantly increased hs-cTnI levels, irrespective of COVID-19 status. In total, 13 subjects tested positive for SARS-CoV-2 by PCR, and only 2/13 had mild respiratory symptoms. These 2 mildly symptomatic COVID-19 positive athletes, as well as 2 COVID-19 negative athletes showed elevated hs-cTnI, without elevated biomarkers of inflammation, signs of myocarditis or other pathological findings on CMR. In conclusion, asymptomatic or mild COVID-19 infection in 13 Italian professional soccer players did not result in important cardiac consequences, despite the finding of elevated hs-cTnI in 2 subjects.

The approach used by the FIGC is a more liberal application of the recent return-to-play consensus, in that also asymptomatic athletes were screened. The authors need to be complimented for their meticulous approach in this context, specifically the serial measurement of hs-cTnI. Indeed, a recent overview of the value of cTn measurement in COVID-19 stressed the value of serial measurements of this marker [6]. Conceptually, an isolated slight increase does not give the same information as a peak-trough evolution (acute myocardial damage) or persisting, but more moderate elevations (ongoing myocardial damage). Of note, in the present study the measurement of hs-cTnI in the healthy group was performed while engaged in a home based aerobic exercise program. This gives rise to uncertainty regarding the interpretation of the results. In a series of 10 individuals, hs-cTnI elevation post-exercise depended largely on exercise intensity and varied among subjects [7]. The levels returned to baseline within 48 h post-exercise. Ideally, the measurements of hs-cTnI would have been performed outside this window. This is not of only academic relevance; in the hypothetical event that the detected hs-cTnI in the non-SARS-CoV-2 affected population was strictly related to exercise and was normal outside the exercise program, resulting in 0 elevation of hs-cTnI in this group, the effect of the SARS-CoV-2 infection would have been statistically significant (Fisher Exact $p = 0.0472$), radically altering the interpretation of the study results. The actual message in this is that (as often) higher numbers of events are needed to draw firm conclusions.

The true value of the applied test battery in the detection of myocarditis is unknown, theoretically leaving open the possibility that the currently proposed algorithms underdiagnose a significant number of patients. The absence of CMR in the majority of patients in the study by Mascia et al. can be seen as an important limitation. Moreover, parametric mapping was not performed, potentially limiting sensitivity to detect myocardial inflammation on CMR. However, while performing CMR in every COVID-19 positive competitive athlete might seem interesting from a research point of view and might improve confidence to resume sport activities in case of a normal exam, it is questionable whether this approach truly improves patient management in this specific subgroup. Firstly, routine referral for CMR after COVID-19 infection

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before sports resumption seems an unrealistic approach for many countries due to limited availability and insufficient reimbursement. Secondly, overinterpretation of CMR findings might cause unnecessary concern impeding or delaying sports resumption with potential detrimental physical, emotional and economic consequences [4]. While the findings by Puntmann et al. [2] showed a high proportion of LGE and findings consistent with myocarditis, there was a large overlap between recovered COVID-19 patients and risk-factor matched controls (presence of LGE in 32 vs 17%; native T1 values range 1099–1157 vs 1098-1124 ms). Moreover, most of these patients were symptomatic and had elevated troponins during the disease course, so their findings might not apply to asymptomatic young patients without elevated biomarkers of cardiac damage. More recently, a CMR study by Rajpal et al. in 26 asymptomatic or mildly symptomatic athletes recovering from COVID-19, showed myocardial LGE in 12 subjects (46%) [8]. While their patient group is more similar to the study cohort of the present paper, their findings should be interpreted with caution since there was no control group. Moreover, none of these patients had chest pain, elevated troponins or ST/T wave changes on ECG, and concomitant signs of oedema by T2 mapping were only seen in 4/12 patients with LGE, making a sound clinical diagnosis of acute (inflammatory) myocardial injury/myocarditis in most patients rather unlikely. To date, large multi-centre registries with blinded analysis of CMR and follow-up data in recovered COVID-19 patients are lacking, and the benefit of extensive risk-stratification by advanced imaging in asymptomatic or mildly symptomatic athletes remains to be proven. Therefore, a more conservative approach with further evaluation in case of persistent symptoms or significant abnormalities on physical exam, blood analysis (significantly elevated hs-cTnI), ECG or echocardiography might be sufficient.

In conclusion, the current paper does beautifully fit in the quest for much needed sound scientific data on the subject of COVID-19 and return-to-play in athletes, and points out an interesting path for future research: what is the value of measuring hs-cTn levels in athletes that suffered from COVID-19?

Declaration of competing interest

The authors report no relationships that could be construed as a conflict of interest.

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