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REVIEW — META-ANALYSIS

# Considerations after lockdown and overcoming Covid-19: A systematic review for returning to safe physical exercise practice

## *Considérations après le confinement et les conditions d'infection au Covid-19 : comment revenir à une pratique sécurisée de l'exercice physique ?*

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**KEYWORDS**
Systematic review;
Return to physical activity;
Covid-19;
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Lockdown

**Summary**
*Objective*. — This systematic review aims to understand the problems associated with lockdown and the various conditions of Covid-19 infection and to help prepare athletes and exercise enthusiasts for the safe resumption of sport in a manner that promotes wellness, healthy competition, and a sports industry that survives the current situation. This systematic review was carried out, following the recommendations of the currently pre-established reporting elements for systematic reviews and meta-analyses. The following databases were consulted: ISI Web of Science (WOS), Scopus and Google Scholar. This review includes a total of 19 articles.
*News*. — The results are presented based on three predominant themes: (1) psychological impact produced by SARS-CoV-2; (2) post-Covid-19 cardiac abnormalities and (3) protocols for an adequate return to physical practice.
*Prospects and projects*. — Most of the protocols shown by the various papers are consistent in terms of duration and number of phases. Based on this, the safe return to practice protocol can be divided into four stages of seven days in each phase in order to progress according to the symptoms perceived. In each phase, the physiological demand and efforts necessary to cover the proposed activities are increased until optimal physical condition is recovered.


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**MOTS CLÉS**
Revue systématique ;
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Confinement

**Résumé**
*Objectif*. — Cette revue systématique vise à comprendre les problèmes associés au confinement et aux diverses conditions d'infection au Covid-19 et à aider à préparer les athlètes et les amateurs d'exercice à la reprise du sport en toute sécurité d'une manière qui favorise le bien-être, une compétition saine et une industrie du sport qui survit à la situation actuelle. Cette revue systématique a été réalisée en suivant les recommandations des éléments de notification actuellement préétablis pour les revues systématiques et les méta-analyses. Les bases de données suivantes ont été consultées : ISI Web of Science (WOS), Scopus et Google Scholar. Cette revue comprend un total de 19 articles.
*Actualités*. — Les résultats sont présentés selon trois thèmes prédominants : (1) impact psychologique produit par le SARS-CoV-2 ; (2) anomalies cardiaques post-Covid-19 et (3) protocoles pour un retour adéquat à la pratique physique.
*Perspectives et projets*. — La plupart des protocoles présentés par les différents papiers sont cohérents en termes de durée et de nombre de phases. Sur cette base, le protocole de retour à la pratique en toute sécurité peut être divisé en quatre étapes de sept jours chacune afin de progresser selon les symptômes perçus. Dans chaque phase, la demande physiologique et les efforts nécessaires pour couvrir les activités proposées sont augmentés jusqu'à ce que la condition physique optimale soit retrouvée.


## 1. Introduction

In late 2019, several pneumonias of unknown etiology started in Wuhan City, China. In January 2020, a new coronavirus named by the International Committee for Taxonomy of Viruses (CITV) as ''SARS-CoV-2'' (severe acute respiratory syndrome coronavirus) was identified. Finally, in February, the World Health Organization (WHO) named this disease, Covid-19, which spread at an accelerated pace both in Wuhan and other countries around the world, and the WHO declared it a pandemic [1]. Its origin is due to an RNA virus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). As a preventive measure, a lockdown was carried out whose restrictions affected work, social and international activities, resulting in inherent changes in lifestyles and significant limitations in activities, affecting the biological rhythm [2].

Covid-19 is considered after World War II as the greatest global state of emergency, not only for health, but also economically; like the last global crisis of 2007, it has had an impact on both non-sports and sports industries [3]. SARS-CoV-2 causes severe respiratory symptoms, affects the cardiovascular system and causes high levels of cardiac troponin and inflammatory biomarkers (i.e., interleukin-6 and serum ferritin): these were characteristic in cases with severe disease and patients did not survive it. This high inflammatory burden in Covid-19, described as a hyper-inflammatory response, is considered to be co-responsible for the development of ARDS, vascular inflammation [4], myocarditis, myocardial infarction, arrhythmias and heart failure by affecting cardiomyocytes, even when the disease was asymptomatic [5].

It is also important to note how lockdown increased anxiety, stress, uncertainty and mood disorders in percentages between 28 and 33%, as well as having negative effects on motivation. The feelings were similar to those of returning to sport after an injury due to thoughts related to the lowering of skill levels and capacity and for not meeting expectations, among others [6]. These psychological variables have their cause in the measures approved during lockdown, especially the prohibition of physical exercise outdoors and in sports facilities, including gyms and sports centres [7].

As for the events held, the first preventive measures were, among others, the elimination of spectators in these practices and finally led to their cancellation, a good example being the Olympic games. Likewise, athletes were forced to an unprecedented halt in their training [8]. Then, for the purpose of doing sport, a protocol was based on the implementation of a series of rules of hygiene and social distancing between people that was applied both to daily life and sport. Moreover, the protocol includes symptom questionnaires and temperature measurements, including compliance with a 7-day quarantine. In addition, this protocol, with all its limitations, resulted in a quarantine for all gymnasts before the start of the season [9]. Among the effects suffered by athletes due to prolonged detraining, we find a deterioration of physical conditioning and performance, fatigue, increased risk of injury and injury recovery times [10,11], Specifically, in sports such as soccer, an increase of 500% of tendon ruptures in Achilles' tendons was found [12]. Likewise, a decrease in anatomical, physiological and performance adaptations was noted [13]. For the resumption of sport, it is therefore necessary to take into account the workload, the effort and any signs of injury [14]. In addition, initially, guidance should be directed at adjusting intensity and duration gradually, i.e., a preparation phase should be completed before resuming regular practice [15].

The new challenge following this situation led to studies aimed at minimising the impact of not training, a field of study that had previously been practically investigated by occupational physiology; however, these studies are limited and controversial, in addition to having shortcomings in some branches. It should also be added that they are often not compatible with the spaces and facilities, tools, equipment and resources of the home [12]. Healthcare professionals are confronted with an increasing number of athletes, both competitive (elite) and amateur, seek-

ing recommendations on how to return to their physical activity after being infected [4]. They were expected to advise on physical conditioning, to assess changes in body composition, performance, strength, cardiorespiratory fitness, as well as any aspects that have affected sport [12,16] and to study the relationship between SARS CoV-2 and cardiorespiratory diseases [5].

The aim of this literature review is to help prepare athletes and amateurs who exercise for the resumption of sport promoting wellness, healthy competition and a sports industry that survives the current situation [5]. Therefore, it is essential to know the optimal methods for this purpose.

## 2. Methods

A systematic review was conducted, following the recommendations of the current pre-established reporting elements for systematic reviews and meta-analyses (PRISMA) [17] during April, May and again in December 2021 to ensure that as complete a list of relevant articles as possible was compiled [18]. The systematic review aims to gather all available evidence according to pre-specified eligibility criteria to answer the research questions by using a systematic method that provides the most reliable results for drawing conclusions and consequently making decisions [19]. To compile the studies analysed in this research, the updated search protocol for developing a systematic review was closely followed [20].

### 2.1. Eligibility and selection criteria

Following the PRISMA guidelines, the report was conducted according to the PICO framework. This framework is commonly used to structure the reporting of eligibility criteria for intervention reviews [21]. It was established as follows: participants: human beings participating in any sport, exercise or physical activity; interventions: due to the novelty of the study topic, any experimental or theoretical intervention that directly addresses the return to exercise and its relationship to having suffered Covid-19 disease (thus excluding any opinion articles and experiments testing other concepts); comparisons: studies that include explanation and information on recommendations and guidelines to be followed, i.e., type of exercise, volume and intensity. Outcomes: any results derived from the implementation or proposal of a programme related to the return to physical activity after suffering from the disease (therefore, no limitations were imposed on the outcomes). Finally, the study design took into account articles from specialised scientific journals. Articles published on websites, blogs or non-specialised digital newspapers, books and book chapters, among others, were excluded and both qualitative and quantitative analyses were considered. Fig. 1 shows the flowchart of the search process and selection of the included studies.

### 2.2. Sources of information

The following databases were consulted: ISI Web of Science (WOS), Scopus and Google Scholar. Due to the novelty of the study topic, the publication dates were limited from 2020 to 2021 in order to obtain complete and recent search results.

### 2.3. Search strategy

The search focused on studies published between 2020 and 2021 in peer-reviewed journals. In general, articles were screened for inclusion following the PICO framework described above and adhering to the object of study. Exclusion criteria identified articles presented as reviews, reports; book chapters, topics other than the one sought, or that ultimately had no relationship to the proposed intervention. Advanced searches were conducted within the databases described above and were based on combinations of the following search terms related to return to play: (''return to play'' or ''play'' or ''comeback to play'' or ''return to sport'' or ''return to training''), (''physical exercise'' or ''physical activity'' or exercise) and SARS-CoV-2 disease (Covid or Covid-19 or Covid-19 or confinement or ''lock down'') An identical search was also conducted in Spanish. The search was conducted by title, abstract and keywords. Finally, so-called grey literature searches (analysing reference lists of relevant articles, also known as the snowball technique) were used to find more relevant articles not identified during the previous searches.

The systematic review was conducted through three phases: identification, screening and eligibility and inclusion (Fig. 1). The lead author conducted the entire search and selection of articles. First, search strategies were applied in each database and the results were compiled in a single document for each reviewer in this section. Then, in the selection phase, titles and abstracts were read, reviewed according to the inclusion and exclusion criteria and publications that did not follow these criteria were excluded. The remaining articles after pooling were advanced to selection by full-text analysis. Therefore, only publications with information relevant to the study were included after a thorough review and in case of doubts, an expert contributing author advised and their recommendations were acted upon. Articles that met the inclusion criteria were coded in two separate data documents. This process is described as ideal by the PRISMA guidelines when including and analysing studies in a systematic review [20].

## 3. Results

In response to the study objective of what protocols or considerations to take into account for a safe return to physical activity, the search initially yielded a total of 253 results in the different databases. After removing duplicates, there were 136 studies, of which 72 were excluded after reading their titles and abstracts. Therefore, 45 full-text articles were reviewed and evaluated according to the eligibility criteria, and 26 articles were eliminated as they did not meet every one of the proposed criteria. In the end, this review included a total of 19 articles (Table 1). The results are presented based on three predominant themes:

- psychological impact of SARS-CoV-2;
- post-Covid-19 cardiac abnormalities;
- protocols for an appropriate return to physical activity.

Following Mulcahey et al. (2021), the current disruption in sporting activities caused by Covid-19 presents a

**Table 1** Articles selected after the literature search and compliance with the inclusion/exclusion criteria.

| Authors (year) | Methodology | Programme | Participants | Kind of PE | Population group | Instruments | Conclusions | Country |
|---|---|---|---|---|---|---|---|---|
| [22] | | — | — | | Healthy youth athletes | — | Through utilizing the personal assets framework (PAF), it offers researchers and practitioners a useful framework to illustrate the potential mechanisms and outcomes of youth sport during restrictive measures | UK |
| [23] | Quantitative — multiple cross-over trial | 2 weeks | Sixteen male volunteers | Aerobic training | Healthy adults | Demographic data were collected by a questionnaire<br>Electrically braked bicycle ergometer | In healthy subjects, short-term moderate-strenuous aerobic physical activity with a mask is feasible, safe, and associated with only minor changes in physiological parameters, particularly a mild increase in EtCO2 | Israel |
| [24] | Cross-sectional observational study | 27 days (range 22 to 33 days) | 54 student athletes | Sport | College-level athletes with Covid-1 | Two-dimensional and Doppler echocardiographic examinations were performed using GE Vivid E9<br>Speckle tracking echocardiography<br>Cardiac magnetic resonance imaging<br>CMR image analysis | More than 1 in 3 previously healthy college athletes recovering from Covid-19 infection showed imaging features of a resolving pericardial inflammation. Although subtle changes in myocardial structure and function were identified, no athlete showed specific imaging features to suggest an ongoing myocarditis | USA |
| [25] | A prospective longitudinal design with retrospective comparison to temporally matched data from a pre-pandemic school year | One full calendar year | 110 students | Elite-level circus training school in Montreal | Elite-level circus training athletes | Circus Daily Challenges Questionnaire (CDCQ)<br>Perceived coping state anxiety<br>A five-point scale habits and behaviors<br>The six item Kessler Psychological Distress Scale (K6)<br>Modified version of the validated consensus sleep diary<br>Creative activity checklist | Our comprehensive model could have implications for human development and performance optimisation in all performing arts, sport and athletics, military, rehabilitation, and health and well-being in the general population | USA |

Table 1 (*Continued*)

| Authors (year) | Methodology | Programme | Participants | Kind of PE | Population group | Instruments | Conclusions | Country |
|---|---|---|---|---|---|---|---|---|
| [9] | Quantitative | 9 weeks (May to July 2020) | 36 professional men's football teams | Elite football players | Football | PCR testing for SARS-CoV-2 RNA venous blood samples for antibody testing team physicians monitored players' symptoms using a questionnaire provided in a mobile app | Professional football training and matches can be carried out safely during the Covid-19 pandemic. This requires strict hygiene measures including regular PCR testing | Germany |
| [26] | Protocol | Protocol | — | — | Youth athletes sport | Covid-19 interim guidance: return to sports 2020 | Interim challenges regarding the physical and psychosocial importance of maintaining an active sporting programme for young athletes, reflect on safety measures for modifying sporting equipment and environmental protections to allow safest participation in training and competition | USA |
| [27] | Protocol | 4-stage return-to-play reconditioning progression | — | — | Aerobic and strength training | Sample return-to-play progression for athletes transitioning back into competitive sports after a Covid-19 infection | A return-to-play plan should be established to safely re-integrate high-level athletes into strength and conditioning, sport-specific drill work, and contact drill work | USA |
| [28] | Protocol | Return to play pathway | — | Elite sport | Sport | Return to play protocol | The potential for cardiorespiratory complications from Covid-19 requires a careful assessment based on the clinical and symptom course and severity of illness | UK |
| [29] | Protocol | Return to play algorithm | — | — | Sport | Algorithm for a return to sport for an athlete with positive test result of SARS-CoV-2 | The cardiovascular effects and long-term consequences of Covid-19 are currently unclear | Germany |

Table 1 (*Continued*)

| Authors (year) | Methodology | Programme | Participants | Kind of PE | Population group | Instruments | Conclusions | Country |
|---|---|---|---|---|---|---|---|---|
| [30] | Quantitative | Three months of follow-up | Two hundred thirty-nine patients | Physical activity | Recreational | The survey contained questions regarding demographics Self-reported walking time — daily steps completing two questionnaires | Patients who experience persistent symptoms after Covid-19 may still demonstrate a significantly decreased walking time six months after the onset of symptoms | The Netherlands |
| [31] | Protocol | Return to different kind of sports | — | Professional athletes | Different sports | The AIS frame-work for rebooting sport in a Covid-19 environment | The AIS framework provides a timely tool for sport organizations to guide the cautious and methodical resumption of sport activity | Australia |
| [2] | Quantitative | Data were collected from 11 to 15 May 2020 | 1613 adults | Strength, resistance and power training, aerobic training and stretching | Physical activity | The questionnaire used in this online survey included demographic information, questions about self-perceptions of the impact of the Covid-19 in the life routines and the 14-item Hospital Anxiety Depression Scale | Participants who felt a higher impact of quarantine on their physical activities tend to have higher prevalence of anxiety and depression symptoms. Individuals who practiced physical activities reported that social distance had a high influence on their practices | Brazil |
| [32] | Protocol | — | > 16 years of age after Covid-19 infection | — | Sports | Flowchart for stratification of athletes after Covid-19 for pre-participation screening | In this point-of-view article, we offer the (sports) cardiologist or sports physician in the Netherlands a practical guide to pre-participation screening, and diagnostic and management strategies in all athletes > 16 years of age after Covid-19 infection | The Netherlands |

Table 1 (*Continued*)

| Authors (year) | Methodology | Programme | Participants | Kind of PE | Population group | Instruments | Conclusions | Country |
|---|---|---|---|---|---|---|---|---|
| [15] | | Two competitions held 4 weeks before lockdown (pre) and two competitions 10 weeks after training had recommenced (post) | Fifty-four female national level eventing horse-riders | Horse-riding | Horse-riding competi-tions | Performance was assessed by the penalty points attained, anxiety by the Competitive State Anxiety Inventory-2, strain by the rating of perceived exertion (RPE) method | In conclusion, emotional stress in dressage and workload in cross-country should be carefully managed by equestrian eventing stakeholders when planning training and competitions after a period of lockdown | Italy |
| [10] | Protocol | — | Elite football players | Fitness and perfor-mance | Football | Protocol guidelines | During this extraordinary preseason, we recommend a progressive build-up of aerobic high-intensity, speed endurance and power training. Players' fitness level and health situation should be monitored closely, and high emphasis should be given on optimal recovery protocols including a high focus on nutrition and injury prevention strategies | Denmark |
| [33] | Protocol | Return-to-play recommendations after Covid-19 infection | — | — | Sports | Covid-19 screening questionnaire | Medical assessment including history and physical examination with consideration of resting electrocardiography and troponin can be considered in the athlete manifesting new active cardiac symptoms or a marked reduction in fitness | Canada |

Table 1 (*Continued*)

| Authors (year) | Methodology | Programme | Participants | Kind of PE | Population group | Instruments | Conclusions | Country |
|---|---|---|---|---|---|---|---|---|
| [12] | Quantitative | 24-day off-season period after 63 days of quarantine | 23 male professional soccer players | Physical fitness | Football | Body composition<br>Jump performance. Subjects performed the squat jump (SJ) and countermovement jump (CMJ)<br>Nordic hamstring exercise (NHE)<br>Sprint performance. Three photocells<br>Intermittent cardiorespiratory fitness. YO-YO test for soccer | 63 days of quarantine impaired several physical performance measures compared with regular off-season in soccer players | Brazil |
| [5] | Quantitative | Retrospective cohort study | 26 elite athletes | Different sport categories, including strength, mixed and skill disciplines | Polish national Olympic team and top league professional volleyball and football clubs | Myomaps software (Siemens), dark-blood T2-weighted images with fat suppression, and late gadolinium enhancement (LGE) with phase-sensitive inversion recovery sequence were used | We have demonstrated that in elite athletes with mainly asymptomatic to mild Covid-19, lack of electrocardiographic changes and normal troponin concentration after a 1—2 months from the diagnosis. There were no signs of acute myocarditis, but 19% of athletes had some abnormalities mostly non-limiting them from return to play as assessed by cardiac magnetic resonance | Poland |
| [6] | Quantitative | April and May 2020 | 759 competitive athletes | — | Different sports | Psychometric self-report measures of anxiety (TFAI-return) and motivation (SMS-return) to return to sport | The results of this study suggest that elite athletes may have suffered from external pressures to return to sport during the lockdown. Additionally, participants with a training program during the lockdown seemed to be less anxious and more self-determined to return to sport after the lockdown | USA |

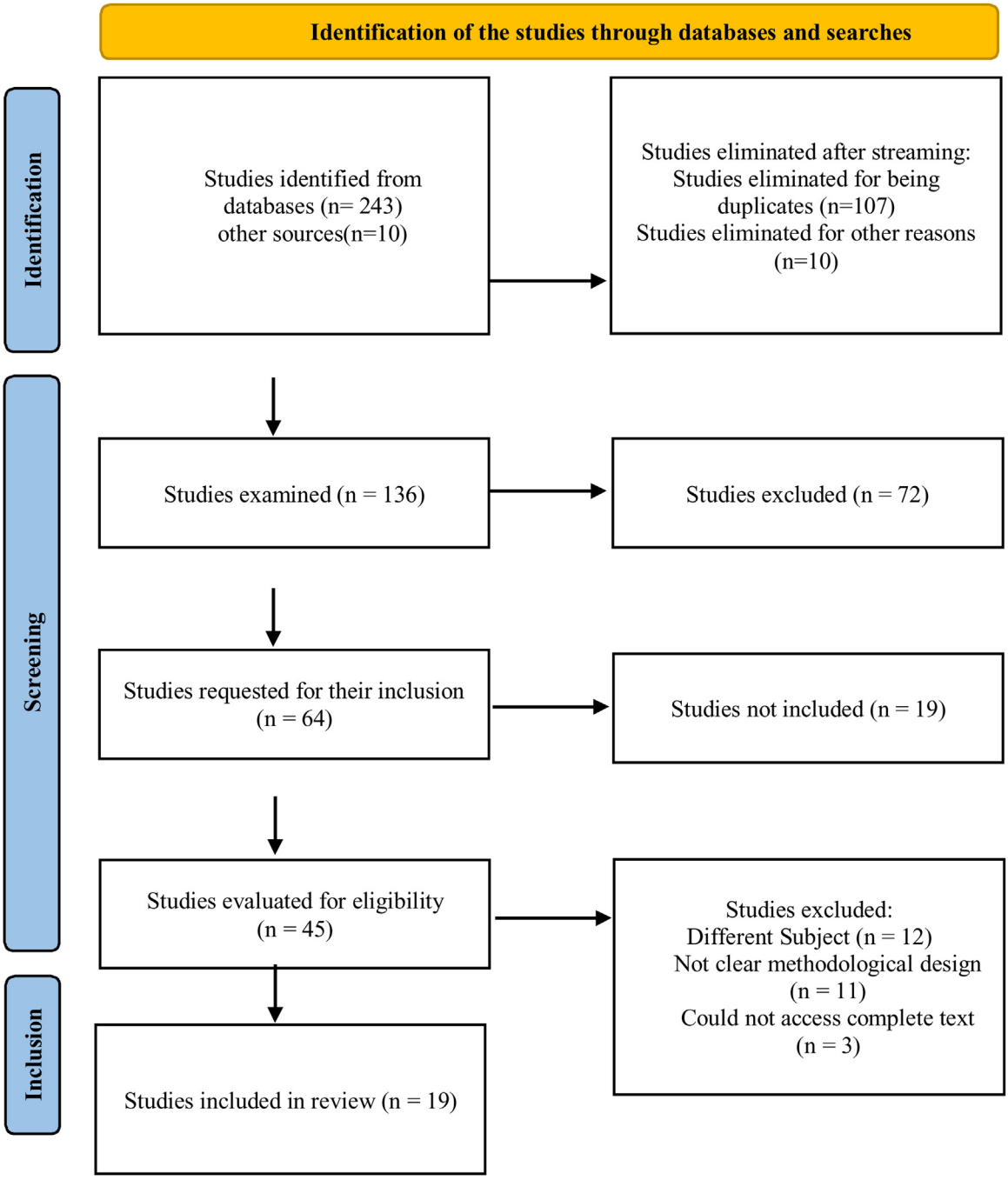


**Figure 1** The flow process of selection, screening and inclusion of articles.

challenge to clinicians, coaches and trainers in discerning best practice for a safe return to sport. There is a clear need to develop and adopt consistent measures for the resumption of sporting activities in a manner that supports the health and well-being of athletes, coaches, allied personnel and spectators.

### 3.1. Psychological impact of SARS-CoV-2

In relation to psychological impact, Leguizamo et al. (2021) y Stuckey, Richard, Decker, Aubertin y Kriellaars (2021), specify the connections between perfectionism and trait anxiety with mental health indicators (mood, depression, anxiety and stress) in high-performance athletes during lockdown, as well as strategies that athletes have applied and their usefulness in managing negative emotional states.

The study by Ruffault, Bernier, Fournier, and Hauw (2020) correlates sports performance with anxiety produced by quarantine and restrictions triggered by Covid-19. In their study, they stress the importance of continuing to train, keeping in contact with staff or other athletes, having goals and activities on a daily basis. According to Delbressine et al. (2021), these types of behaviours are ideal conditions for

having confidence in returning to sporting practice and trying to reduce the loss of performance.

In this context, resilience is the ability to adjust positively to stress, crisis and adversity while maintaining health. Mindfulness training involves accepting the momentary with intentional and non-judgmental attention. In this context, Yuan (2021) proposes to explore the situation during the Covid-19 pandemic and highlights as fundamental, opening up the way for resilience among adolescents to adapt to the negative experiences they may encounter. Mindfulness will be an advantage in boosting athletes' resilience and emotional intelligence due to the control of the epidemic situation in specific areas [22]. If this resilience training is not successful, it will result in anxiety outcomes and low motivation to return to sport in women, young athletes, elite athletes or athletes who lacked a training programme in lockdown and athletes who suffered an injury in the first period of lockdown, variables that directly correlate with their sporting performance [6].

It is important to highlight that coaches and teachers who have or have had other instructors throughout their training, play a fundamental role in training these athletes with sufficient management and coping strategies for effective control in the management of complex situations or crises such as the one experienced during the current Covid-19 pandemic [34].

The effects of Covid-19 are not only reflected in psychological symptoms, but can also cause significant electrocardiographic changes in elite athletes or very active individuals who have stopped their exercise rhythm [5,29,32].

### 3.2. Post-Covid-19 cardiac abnormalities

Tuka, Sovová, Godula, Jiravský y Kubuš (2020) state that moderate and regular physical exercise supports the immune system and reduces the likelihood of more serious infections. It is for this reason that physical exercise, especially of medium intensity, should not be limited and, on the contrary, should be encouraged in asymptomatic individuals. It is intense physical activity that will lead to mild immunosuppression and increase the likelihood of infectious diseases. The reason for this is that it increases virus replication in cells, as well as the risk of complications related to myocarditis and sudden death. In the same vein, Małek et al. (2021) identify other abnormalities that may be caused, such as arrhythmias, heart attacks and immunological reactions. Likewise, Brito et al. (2021) estimate that incidences of myocardial injury can end fatally in 28% of cases, consequently, a prior cardiological study is deemed necessary before athletes affected by the virus return to training.

According to McKinney et al. (2020) and Verwoert et al. (2020), athletes can be divided into three groups according to low, medium or high risk for an appropriate return to training; these are further subdivided into:

- asymptomatic: they have an almost negligible risk of cardiac complications, the recommendation is that they do not exercise for 14 days and then gradually return to physical activity;
- non-hospitalised symptomatic: they should consult their sports cardiologist to differentiate between changes in the electrocardiogram due to adaptation to exercise and abnormalities;
- hospitalised patients without myocardial injury: among other recommendations, it is emphasised that they complete a comprehensive, multidisciplinary rehabilitation programme before resuming sporting activity. Afterwards, a stress test should be performed;
- hospitalised with myocardial injury: comprehensive rehabilitation is paramount to avoid late onset cardiac complications. Without a complete cardiovascular evaluation, it is not possible to return to sport.

Therefore, a public health policy will be required to guide this decision making upon return to sport, especially for competitive athletes with more high-intensity physical training [5,33]. To go further, neurological assessment may be necessary in individuals with severe pneumonia, pulmonary infiltrates and hypoxaemia [35]. Following the study by McKinney et al. (2020), a pragmatic approach to return to sport is necessary, ensuring individual well-being and health, and that takes into account heart failure and sudden cardiac arrest that may be caused by Covid-19 conditions. Along the same lines, Małek et al. (2021) show in their study that elite athletes with asymptomatic or mild corona viruses do not usually present acute myocarditis, only 19% of them suffered from it.

According to the above classification, each patient will have different needs for the return to practice, aiming at all times for a comprehensive recovery [29,32], promoting health, economic, social and cultural benefits. For a safe return to practice for the athlete, it is necessary to establish protocols according to the level of affection caused by the disease [31].

### 3.3. Protocols for an appropriate return to physical activity

All decisions on return to practice should be made on the basis of general directions that will provide guidance on when sporting activities should be resumed [22,31]. Martinez et al. (2020) conclude from surveys and tests the changes in sporting practices after the epidemic that 90.6% of the participants stated that the Covid-19 lockdown measures had a major impact on their lives. Previously, the most common practices were strength training and aerobic training, however, after coronavirus and lockdown, these practices were reduced by more than 90%.

Most of the protocols shown by various papers agree in terms of duration and phases [27,28,36]. On this basis, the return to practice could be divided into four phases, which we will group into two further sub-phases: phase 1—2 in which the activity should be of a light intensity for two weeks, with training in this phase starting in small groups and progressively reaching the full team. Activities may include housework or stability exercises and yoga. In phase 3—4, the activities will progress in terms of physical demands and will be more challenging according to pre-disease capacity. Phase 4 involves more complex movement where coordination, strength and balance are challenged,

for example, running with changes of direction. Seven days are proposed for each phase to avoid sudden additions to the training load. However, individuals will remain in the phase they feel most comfortable in for as long as necessary. It is also important to incorporate a healthy diet and a physically active lifestyle, as sedentary lifestyles negatively affect the neuromuscular system, muscle protein metabolism, impaired glucose homeostasis, cardiorespiratory system and energy balance.

Clinical researcher Salman et al. (2021) present a practical approach to make the return to physical activity after SARS-CoV-2 more effective. It brings together those who have become unfit or have spent a prolonged period of inactivity with no lasting post-acute Covid-19. They recommend considering the person's pre-illness baseline physical condition and tailoring the guidance accordingly to five phases with a minimum period of seven days in each phase. It may start at a more or less advanced stage depending on the individual's symptoms. These results, although described with one less phase in their protocols, would be in agreement with those previously described in various studies [28,36].

Regarding the use of facemasks during sports, taking into account the study by Epstein et al. (2020), in healthy subjects, short-term moderate to strenuous aerobic physical activity with a facemask is feasible, safe and associated with only minor changes in physiological parameters, particularly a slight increase in the amount of end-expiratory carbon dioxide. Subjects with lung disease should undergo careful assessment before attempting physical activity with any type of mask. Finally, Meyer et al. (2021) debate at length about the return to professional sport during the Covid-19 pandemic. Of course, players and clubs have an interest in continuing their professional activities. However, appropriate safety precautions must be taken to ensure the health of players and officials and the integrity of the competition.

## 4. Discussion

The aim of this literature review is to help prepare elite and amateur athletes for the resumption of sport; promoting wellness, healthy competition and a sports industry that survives the current situation.

During lockdown, whether major or minor, as long as athletes are in good health, Mulcahey, Gianakos, Mercurio, Rodeo y Sutton (2021) recommend that coaches and trainers implement an individualised training programme where athletes should continue to use the space available in their homes for sport practice. These same authors show how it is important to develop a return-to-play protocol for athletes. Previous studies recommend 3 to 4 cardio sessions per week, not exceeding 60 minutes per day, with intensities limited to 80% of maximum heart rate [37,38]. In addition, fortnightly strength training sessions should be incorporated but not exceeding 60 minutes. Similarly, exercises with maximal loads with complete muscular exhaustion should be avoided [39,40].

According to Santos-Ferreira et al. (2020), although athletes have a lower risk of serious illnesses, preventive measures are still very important to minimise time away from training, avoiding possible complications. Athletes should be assessed before returning to play and monitored accordingly through appropriate clinical assessments and testing. In addition, several authors [2,37,40] show how regular moderate exercise is beneficial for improving the immune system and preventing viral infections. Thus, the immune system may be temporarily suppressed during acute bouts of prolonged endurance exercise. Top athletes train at higher intensive workloads to improve their fitness, potentially placing them at greater risk of upper respiratory tract infections. Therefore, it is important to assess their level of fitness and cardiac fitness before returning to physical activity [35,41].

People who have had Covid-19 disease, whether high-performance athletes or not, suffer changes in glycolytic enzymes in muscles, both in quantity and activity, leading to a decrease in muscle oxidative capacity. Similarly, there is a reduction in the capacity of skeletal muscles to generate volitional force. The time it takes for an athlete to recover his or her muscular and cardiorespiratory fitness is a consequence of the time of inactivity and the level of the disease condition [5,41]. Thus, in order to adapt the training stimuli, individual effects and sporting demands, a battery of specific tests is necessary to assess the condition of each athlete and so achieve good planning (Girardi et al., 2020).

One of the most serious conditions found in various studies is the presence of myocarditis as a consequence of Covid-19 [28,32,42]. If SARS-CoV-2 myocarditis is diagnosed, a comprehensive clinical evaluation, including an electrocardiogram, should be performed. In patients with myocarditis, intensive follow-up after discharge and sports restriction for at least 3—6 months is recommended, according to general recommendations for myocarditis [43]. Return to sports should be evaluated by a multidisciplinary team of experts and include sports cardiology and sports medicine reports.

On the other hand, several safe return-to-play protocols are presented, of which we can summarise a protocol based on four phases containing various training parameters [27,28,41]. It is important to emphasise that sports medicine personnel establish a return-to-play plan for athletes recovering from Covid-19 infection to avoid orthopaedic, respiratory and cardiac complications [27]. A return-to-play protocol should include a monitored increase in sport-specific loading that incorporates aerobic/anaerobic capacity components, general strengthening and sport-specific training [29]. Low-intensity aerobic training, such as running at low to moderate speed, has been correlated with a reduced risk of soft tissue injury in elite athletes [10]. Anaerobic training, such as high-speed sprint intervals, has been shown to have a positive impact on performance and reduce the risk of injury when exposed to high-speed scenarios during play [44]. Endurance training should be closely monitored, with gradual increases in intensity and volume and work/rest ratios of 1:4 or more to begin with [45]. Sport-specific training is the most difficult aspect of a return-to-play protocol to replicate, but its application is crucial for injury prevention as athletes transition to normal sport participation [46,47]. In addition to cardiac testing protocols prior to entering a return-to-play protocol, athletes should be monitored during their return-to-play progression to prevent cardiac complications [33].

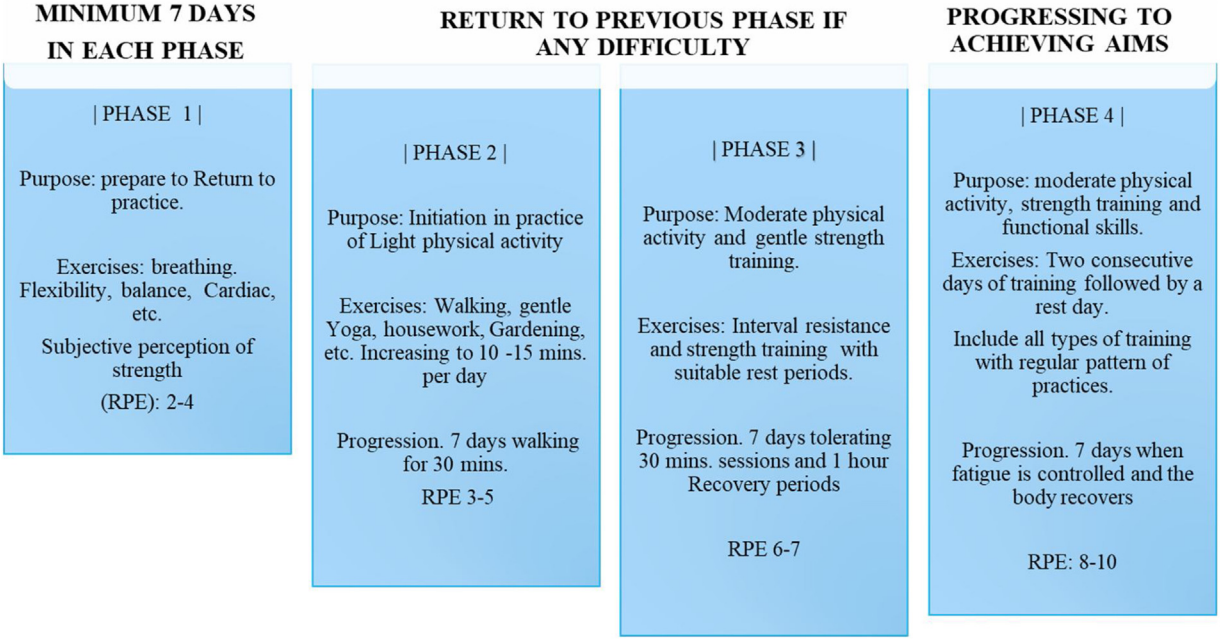


**Figure 2** Four-stage safe return to practice protocol according to Covid-19 disease condition.

## 5. Practical applications

Most of the protocols shown by the various papers are consistent in terms of duration and number of phases. Based on this, the safe return to practice protocol can be divided into four stages (Fig. 2).

At each stage, activities will be based on physical needs and will be more challenging based on pre-illness abilities. Only do physical exercise if you feel recovered from the day before, you have not felt any symptoms related to the disease again. Use the first 5—10 minutes to warm up properly before starting the session and cool down appropriately. However, people will remain in the phase where they feel most comfortable for as long as necessary.

Another important aspect is the need for cardiac and neurological assessment of people with severe pneumonia, pulmonary infiltrates and hypoxaemia. It is important to devise a pragmatic approach to return to sport while ensuring the well-being and health of individuals. Heart failure and cardiac arrest, which can be caused by Covid-19 disease, must be taken into account. Each patient has different needs and it is necessary to plan follow-up visits with local health centres to achieve a full recovery.

It is important to stress that the trainers and teachers that each person has or has had throughout the training process, as well as other educators, play an important role in training with appropriate coping strategies to effectively manage complex or crisis situations, such as those experienced by Covid-19 during the current pandemic.

One of the limitations of the study is the lack of case studies in which each of the protocols presented theoretically in the studies analysed in this systematic review have been put into practice. Despite the lack of research, there does seem to be a clear consensus on the proposals for a safe return to practice in both high-level and amateur sportsmen and women, taking into account the degree of involvement of the athlete in the sport and the previous level of fitness of each subject.

## Disclosure of interest

The authors declare that they have no competing interest.

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