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Impact Of COVID-19 Infection on Performance in Adolescent Athletes

Anika Shetty[1] and Ankit Mistry[#]

[1]Jamnabai Narsee International School, Mumbai, India
[#]Advisor

ABSTRACT

The COVID-19 pandemic has a significantly impacted athletes across various sports, genders, and age groups. Numerous studies have, in isolation, highlighted the effects of COVID-19 infection on cardiorespiratory endurance, mental health, sleep patterns, muscular strength, and recovery, emphasizing the need to address these issues and optimize recovery strategies. However, these studies are generic in nature and not specific to adolescent athletes. Our study aims to synthesize the existing literature on the physiological, psychological, and performance-related factors affecting adolescent athletes impacted by the COVID-19 infection, and bridge the existing knowledge gaps. This review is based on data and information gathered from relevant papers encompassing factors, including cardiorespiratory function, mental well-being, sleep quality, muscular strength, and recovery processes that are contextual to athletic performance. The main findings of this study underscore the multifaceted impact of the COVID-19 infection on adolescent athletes. The insights gained from this review can inform the development of targeted health protocols and recovery strategies for athletes affected by the COVID-19 infection. The unique challenges faced by the adolescent athlete population warrant the need for tailored interventions to be designed to support their safe return to training and competition. This comprehensive review provides a valuable resource for sports medicine professionals, coaches, and researchers seeking to understand the impact of COVID-19 on athletic performance, and develop evidence-based strategies to optimize recovery and support the well-being of athletes in the post-pandemic era.

Introduction

COVID-19 pandemic has had a profound impact on athletes across various disciplines, affecting not only their physical performance but also their overall well-being. Existing research has highlighted the detrimental effects of mild COVID-19 infection on sleep patterns, mental health, and cardiorespiratory fitness in endurance athletes, underscoring the need for strategies to address these issues and facilitate better recovery and performance post-infection (Śliż et al., 2023; Stojmenović & Marković, 2024; Vincent et al., 2022). Furthermore, higher risk of post-COVID-19 symptoms and fatigue in women athletes has also been identified (Śliż et al., 2023). While COVID-19-related interruptions in training have not reported any alterations in upper-limb strength, jump height, and flexibility, reduced lower-limb muscle strength in adolescent athletes has been reported (Obayashi et al., 2022).

Home-based training programs, though beneficial for improving lower-limb explosive strength, were less effective in enhancing agility and speed-endurance capacity, highlighting the limitations of attempts to replicate team training benefits with home training (Pucsok et al., 2021). Moreover, athletes who contracted COVID-19 experienced a significant decrease in their balance performance (Jaszczur-Nowicki et al., 2022). However, post-infection cardiac evaluations of athletes did not reveal negative impact on performance, suggestive of the sufficiency of standard cardiovascular post-infection assessments. However, abnormal cardiac findings in a small percentage of young competitive athletes post COVID-19 infection warrants caution and emphasizes the need for continued cardiac follow-ups (Colangelo et al., 2022).

Interestingly, the COVID-19 pandemic has not shown an adverse effect on the physical fitness of children aged 7-9 years, emphasizing the importance of long-term fitness programs and environmental factors in maintaining fitness levels. On the other hand, home confinements were shown to result in potentially detraining effects and increased the risk of injury in elite athletes (Asimakidis et al., 2022). Moreover, anaerobic and jump performances in young elite soccer players have remained unaffected by the SARS-CoV-2 infection and one month of COVID-19 confinement, respectively (Dauty et al., 2022).

While existing research has explored specific aspects of the impact of the COVID-19 pandemic on athletes, there is a dearth of a comprehensive approach that evaluates the multifaceted challenges faced by this population due to the pandemic. This review is based on a comprehensive analysis of over 20 research papers sourced from PubMed and google scholar. We systematically searched for and reviewed literature using the key terms "--19," "adolescent athletes," "SARS-CoV-2," and "athletic performance." The findings were then interpreted, and as highlighted in this review, COVID-19 was found to have significantly impacted young athletes, underscoring the urgent need for the development of appropriate diagnostic tests to asses athletic prowess. This review aims to provide an overarching perspective on the diverse effects of COVID-19 on athletes, encompassing physiological, psychological, and performance-related factors.

Effects on Endurance Performance

Cardiorespiratory Endurance

Recent studies have provided insights into the effects of COVID-19 on cardiorespiratory endurance in young athletes. SARS-CoV-2 infected elite adolescent soccer players demonstrated no alteration in their capacity of anaerobic performances, measured using squat jumps, countermovement jumps, and stiffness. Despite one-month of COVID-19 confinement jump performances in these growing soccer players were not altered (Dauty et al., 2022).

Contradictorily, lower VO2 levels have been reported one to three months following illness in COVID-19 patients compared to control groups (Weldon et al., 2023), suggesting a potential impact on aerobic capacity. A post-COVID-19 (cardiopulmonary exercise tests) CPET study reported no pathological cardiorespiratory changes in athletes, confirming that COVID-19 infection causes a decline in cardiorespiratory abilities at the cellular respiration level rather than at the internal respiration level, which would potentially impact the delivery and consumption of oxygen required for Adenosine Triphosphate (ATP) generation (Stojmenović & Marković, 2024).

Exercise Tolerance

COVID-19 can cause inflammation in the respiratory tract, leading to pulmonary edema and diffuse alveolar lesions. Consolidation of lung parenchyma caused by healing and fibrosis following infections can further impair lung function. These factors contribute to shortness of breath and fatigue post-COVID-19 infection causing exercise intolerance (Weldon et al., 2023).

The SARS-CoV-2 virus triggers a cytokine storm resulting in extended periods of high interleukin levels, which exacerbate systemic inflammation and cause chronic fatigue. Muscle atrophy and deconditioning resulting from prolonged recovery period have a detrimental effect on exercise tolerance (Weldon et al., 2023).

The high levels of inflammatory cytokines also facilitate muscle damage due to the SARS-CoV-2 virus targeting cells with TMPRSS2 receptors(Dauty et al., 2022). This aligns with the finding of reduced area of the rectus femoris cross-section and the anterior compartment of the quadriceps muscle in severe and critical COVID-19 patients (Andrade-Junior et al., 2021).

These findings collectively suggest that COVID-19 can have multifaceted effects on exercise tolerance in young athletes, impacting both respiratory function and muscular integrity.

Effects on Muscular Strength

Lower Body Strength

COVID-19 has been reported to negatively impact lower limb muscle strength in athletes, while jump height, upper limb strength, and flexibility remain largely unchanged. The lack of training for five weeks during the pandemic has been associated with muscle weakness in the lower limb and a significant decrease in athletes' ability to perform knee flexion and extension. (Obayashi et al., 2022). This finding aligns with reports demonstrating changes in muscle size and structure in lower limbs after unloading following extreme forms of detraining such as bed rest and unilateral lower limb suspension similar to detraining caused during the COVID-19 pandemic (Sarto et al., 2020). Significant decreases in aerobic and anaerobic fitness along with lower body explosive fitness have also been reported 8 months after the relaxation of pandemic restrictions (Ripley-Gonzalez et al., 2023)

Upper Body Strength

A controlled study that assessed the number of pull-ups performed in one minute as a measure of upper body strength found that upper body strength in female athletes significantly decreased just a year after the onset of the COVID-19 pandemic, with the decline ranging from −2.16 to −0.87 (repetitions) pull-ups per minute (Ripley-Gonzalez et al., 2023). Findings from a previous study that discussed the potential physiological changes in athletes due to home confinement during the COVID-19 pandemic noted decreased muscle mass and strength resulting from reduced physical activity and limited access to training facilities, thus suggesting that the decline in upper body strength among female athletes may be attributed to the disruptions in training caused by the pandemic (Sarto et al., 2020).

The authors of a review that examined the impact of the COVID-19 pandemic on athletes' performance and well-being also highlighted that the closure of training facilities and the limitations on group training sessions during the pandemic led to a significant reduction in training volume and intensity, potentially contributing to the decrease in upper body strength observed in female athletes(Jukic et al., 2020). In addition to studies that have considered the physical aspects, there are studies that have also investigated the psychological impact of the pandemic on athletes. Increased levels of stress, anxiety, and depression were reported in athletes during the pandemic, which could have negatively affected their motivation and adherence to training routines and may have indirectly contributed to the decline in upper body strength (di Fronso et al., 2022).

Effect on Respiratory Function

Lung Capacity and Function

The percent of maximal inspiratory and expiratory pressure was found to be statistically lower in athletes who tested positive for COVID-19 than that in athletes who tested negative for COVID-19, underscoring the role of the COVID-19 infection on inspiratory and expiratory muscle strength in athletes (Jaszczur-Nowicki et al., 2022). Poor sleep quality, potentially exacerbated by the pandemic, has been shown to be detrimental to oxygen uptake capacity, absolute oxygen uptake, pulmonary ventilation at the respiratory compensation po-19int and maximal oxygen absorption, absolute maximal oxygen uptake, maximal heart rate, and maximal pulmonary ventilation (Śliż et al., 2023). However, contrary to this majority of publications evaluating lung function indicate minimal changes in spirometry-based assessments of lung function, following COVID-19 infection (Williams & Hull, 2024).

Exercise-Induced Bronchoconstriction (EIB)

A post COVID-19 cardiopulmonary exercise testing (CPET)-based study have noted a high prevalence of breathing pattern disorders and hyperventilation (Williams & Hull, 2024), suggestive of the lasting impact of COVID-19 infection even after the acute phase of the illness. The findings of the study highlighted the potential of the persistent respiratory symptoms, such as breathlessness, to limit exercise performance following COVID-19. In addition, the study also reported spirometry-related defects in athletes, indicative of airflow obstruction following COVID-19 infection (Williams & Hull, 2024). Furthermore, COVID-19 has been associated with a higher incidence of new-onset asthma (Kim et al., 2024).Combined with the knowledge of asthma being a common cause of EIB in athletes (Parsons & Mastronarde, 2005), this finding is suggestive of the indirect contribution of COVID-19 to the development or worsening of EIB in some individuals.

Another study that investigated the impact of COVID-19 on pulmonary function in a cohort of young athletes found that some athletes experienced a decline in lung function parameters such as forced expiratory volume in one second (FEV1) and forced vital capacity (FVC), following COVID-19 infection (Anastasio et al., 2021). These findings suggest that COVID-19 may lead to airway obstruction, which could potentially exacerbate EIB in athletes. The SARS-CoV2 virus is known to cause inflammation and damage to the respiratory epithelium, leading to increased airway reactivity. The immune response to the infection further exacerbates airway inflammation resulting in the development of respiratory symptoms (Moein et al., 2020).

Performance-Related Effects

Coordination and Agility

Athletes who tested positive for COVID-19 reported decreased balance performance compared to uninfected athletes. The Romberg test reported the center of pressure (COP) parameters to be significantly worse following COVID-19 infection (Jaszczur-Nowicki et al., 2022). Disrupted training schedules during the pandemic caused athletes to restart sport participation with deficits in strength and flexibility (Vincent et al., 2022)(Vincent et al., 2022). Furthermore, large performance losses were noted in agility parameters following the infection (Fatih et al., 2021).

Cognitive Function and Focus

The pandemic lockdowns negatively impacted decision-making capacity and sport-specific contact skills in athletes, indicative of compromised mental well-being of athletes across age groups. Surveys administered during the pandemic have identified mood disturbances, behavioral changes, and varying levels of stress among athletes. The uncertainty of quarantine durations, boredom, frustration, lack of resources or access to training facilities, followed by re-opening and rapid return to semi-lockdown challenged the ability to maintain focus and performance in many athletes (Vincent et al., 2022).

Long-Term Effects and Recovery

Duration of Performance Impairments

COVID-19 infection has been found to negatively impact sleep quality and is associated with decreased oxygen uptake, pulmonary ventilation, and maximal heart rate in athletes, which are known to have a detrimental effect on athletic performance(Śliż et al., 2023). Quality sleep improves reaction time, vigor, mood, and prevents fatigue,

ensuring physical and mental regeneration. (Śliż et al., 2023)Therefore, it is essential for COVID-19 affected athletes to have access to professional medical and psychological support to manage sleep disturbances and optimize recovery.

Factors Influencing Recovery

The presence of lower respiratory (LR) symptoms during the acute phase of COVID-19 has been associated with a higher likelihood of delayed sports recovery and prolonged loss of training time (Williams & Hull, 2024). Additionally, the failure of over 25% of the athletes at the 2020 Tokyo Olympic and Paralympic Games to return to full sport participation one-month post-COVID-19-infection highlighted the pronounced impact of COVID19 infection on full athletic recovery. Yet another data set obtained from an elite cohort of athletes reported the presence of LR patterns, including dyspnea, chest pain, and cough, was most indicative of a prolonged return to full training and was associated with extended loss of training time (Hull et al., 2022).

Conclusion

This review provides a comprehensive overview of the impact of COVID-19 on various aspects of physical performance in adolescent athletes. Furthermore, by collating findings from multiple studies the review addresses several knowledge gaps and presents a holistic view of the effect of COVID-19 on young athletes. While most studies have reported multi-systemic negative effects of COVID-19 infection, there are some contradictory findings of negligible effects on athletic performance, such as studies stating that the COVID-19 infection did not affect upper-limb strength. Such contradictions warrant the need for a balanced perspective, which this review has aimed to provide by interpreting findings from several relevant studies.

The findings of this review underscore the need for comprehensive diagnostic tests and evaluations of athletes encompassing all aspects of athletic performance. Evaluation criteria must be designed to ensure that athletes who have suffered from the COVID-19 infection are not unfairly disqualified or at a disadvantage against athletes who were not infected. This review highlights the importance of considering the multifaceted impact of COVID-19 when assessing and supporting young athletes in their return to sports participation.

This study is a valuable resource for sports medicine professionals and researchers beyond the immediate aftermath of the pandemic as the long-term effects of COVID-19 infection continue to unfold. Knowledge of the impact of the infection on various aspects of athletic performance remains crucial, and can be instrumental in informing the development of strategies to support the ongoing recovery and development of young athletes in the years to come.

Strengths and Limitations

Strengths

The studies reviewed in this context so far have focused on specific aspects of athletic performance, such as agility or muscular strength, rather than providing a comprehensive assessment. This review addresses this limitation by consolidating findings across multiple studies, covering a wide range of performance factors, and emphasize that any argument suggesting COVID-19 does not affect athletes would be inaccurate.

Although the reviewed studies do not explicitly mention adolescents, the samples included in the studies are within the adolescent age group. Adolescence is a critical period characterized by significant physiological changes that impact athletic performance. This review elucidates the effect of the COVID-19 infection on these developmental changes providing valuable insights for personalized sports medicine.

Limitations

This review focuses specifically on the adolescent population of athletes, which may limit the generalizability of the findings. Athletes can be categorized based on various criteria, such as the sport played, their origin, diet, sex-based differences, and demographics. These criteria have a significant impact on an athlete's performance, which have not been accounted for in this study. The findings of this study, however, could support future studies investigating the impact of COVID-19 infection on athletic performance across different subgroups to generate more comprehensive and targeted information.

Furthermore, due to the limited scope and available data, this review does not compare athletes whose physical performance was not affected after COVID-19 infection and those who were severely impacted. Such comparative studies in the future that aim to identify the characteristics and strategies employed by athletes who successfully recovered from COVID-19 without significant performance impairments would provide valuable insights into the factors that contribute to recovery and resilience among athletes. The development of comprehensive evaluation criteria for assessing the impact of COVID-19 infection on athletic performance warrants collaborative studies involving researchers, sports organizations, and healthcare professionals. Such efforts would be pivotal in establishing standardized evaluation protocols and gathering the necessary data to facilitate informed decision-making processes.

Despite these limitations, this review provides a valuable foundation for understanding the impact of the COVID-19 infection on adolescent athletes' physical performance. It highlights the need for ongoing research and collaboration to address knowledge gaps, develop targeted interventions, and support the recovery and development of young athletes in the post-pandemic era.

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