THE EFFECT OF COVID-19 ON ROADRUNNERS IN CAPE TOWN

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Declaration

I, Usraa Gani, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise), and neither the whole work nor any part of it has been, is being, or is submitted for another degree at this or any other university.

Signed by candidate

Signature

FEBRUARY 2024

Date

Abstract

Background

During the worldwide pandemic declared at the beginning of 2020, many people and organisations were affected by the consequences of COVID-19 as well as the infection itself. Due to high transmission rates, strategies were in place to reduce the spread of the virus. While physical activity is well-known to prevent the adverse effects of COVID-19, it was difficult to maintain this behaviour during the COVID-19 lockdown. It takes four weeks of cessation of activity to note a decline in cardiovascular and neuromuscular adaptations.

Aim

The aim of the study was to explore the effects of COVID-19 infection and Post-Acute Sequelae of COVID-19 (PASC) on the athletic performance of long-distance roadrunners in the Cape Town Metropolitan area.

Method

A descriptive cross-sectional survey was conducted among roadrunners recruited from athletic clubs in the Cape Town Metropole. Instruments included a self-developed questionnaire exploring COVID-19 infection and PASC. The questionnaire included symptoms of COVID-19 and PASC, the history of the runners' pre-COVID running parameters, the runners' parameters two weeks post-COVID and four weeks post-COVID.

Results

Fifty-three out of seventy-six participants reported to have tested positive for COVID-19, and twenty-six of these participants experienced PASC (long COVID) symptoms. The most common symptoms of COVID-19 and PASC were fever and headaches for COVID-19 (53.8%) and fatigue for PASC (73.1%). There is a noted increase in heart rate ($p < 0.00001$) and race pace ($p < 0.05$) at two weeks and four weeks post-infection ($p < 0.00001$). It has taken more than three months to return to pre-COVID parameters in 22 participants, with fatigue being the most common symptom and shortness of breath being the second most common symptom affecting return to running.

Discussion

A significant decline in a proxy measure of performance parameters was noted in the 5 km time trial, RPE measures, race pace, and resting heart rate from the results. The symptoms

runners experienced were noted in research by other studies and are taken as the common symptoms affecting return to life and sport. This study has the potential to be taken forward on a bigger scale to provide a generalisation of the results to the public.

Conclusion

COVID-19 is clearly a multi-factorial systemic infection that has a wide range of symptoms. However, specific symptoms of the infection have lasting effects on the population. The effect on the sporting world is still to be explored with new data and factors to consider within the field.

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List of Acronyms

BMI	Body Mass Index
CDC	Centre for Disease Control
CFS	chronic fatigue syndrome
CRP	C-reactive protein
DLCO	diffusing capacity of the lung for carbon monoxide
ME	myalgia encephalomyelitis
MERS	Middle East respiratory syndrome
PASC	Post-Acute Sequelae of COVID-19
PTSD	Post-traumatic stress disorder
RPE	Rate of perceived exertion
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus-2
VO2 max	Maximal oxygen consumption
WHO	World Health Organization

Chapter 1 Introduction

1.1 Background to the Study

The most recent coronavirus was termed COVID-19 or Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2). This was named in 2020 and declared a global pandemic after an outbreak in Wuhan, China, in 2019 (Côrte et al., 2020). It was initially known as a respiratory virus that presented flu-like symptoms in its host that ranged between mild, moderate, and severe. A wide range of those infected were hospitalised with respiratory complications, and others were able to be managed at home. Common symptoms experienced included a fever, cough, fatigue, joint pain, muscle pain, headaches, brain fog, tachycardia, bradycardia, palpitations, chest pain and shortness of breath (Côrte et al., 2020; Davis et al., 2021; Gupta & McCarthy, 2021; Lima et al., 2021; Martin, Champ & Franklin, 2021; Sallis et al., 2021; Sarto et al., 2020; Yong, 2021).

Due to the high transmission rate of the virus, several strategies such as lockdowns, social distancing and isolation periods were put into place to contain the spread of the virus (Lim & Pranata, 2021). The restrictions on movements resulted in cancelled running competitions and closed training facilities (Lim & Pranata, 2021). This, along with the infection of COVID-19, left the sporting community vulnerable to the lack of competitive sports (Szczypińska, Samełko & Guszkowska, 2021). Physical activity is well-known to prevent the adverse effects of COVID-19; however, it was difficult to maintain this behaviour during the COVID-19 lockdown (Sallis et al., 2021).

1.2 Study Context

There was a considerable decrease in physical activity during the lockdown, as stated by many studies (Gupta & McCarthy, 2021; Sarto et al., 2020) Many athletes have gone from spending most of their days in training facilities and community–like environments to spending more than 20 hours per day at home and training alone (Gupta & McCarthy, 2021). According to a study done by Sarto et al. (2020), it takes as little as four weeks of training cessation to notice cardiorespiratory and neuromuscular adaptive declines (Sarto et al., 2020) This understanding would conclude that the fitness levels of athletes were altered during COVID-19 home confinement and adaptations to movement, as stated by Impellizeri et al. (2020). Athletes like roadrunners were disadvantaged as many relied on consistent outdoor training instead of using equipment like treadmills.

While running is a sport that can be done individually, many rely on clubs and groups to improve their running performance and overall mental health by being a part of a supportive community-like environment. Various levels of restrictions on movement were instilled over the course of the pandemic, which created an inconsistent opportunity to return to running. Performance is described as the ability to carry out a skill well to obtain an achievement; in some sports, it is quantifiable (Orr, 2022). In the case of this study, the definition of performance applies to the ability of a runner to complete their race distance within their known race pace or better.

It is understood that the restrictions on movement were not the only factor affecting the athlete's performance. The adaptive training of the active individual was further affected when they contracted the virus and needed to cease training together due to the active infection. There were reported chronic complications of the virus for some that presented as long-standing symptoms of the virus. This was known as the Post-Acute Sequelae of COVID-19 (PASC), more commonly known as 'long-COVID' (Dixit et al., 2021). The two terms are acceptable and used interchangeably throughout the study.

PASC/Long COVID is the presence of any COVID-19 symptoms from 5 weeks to, and not limited to, 12 weeks after the initial infection (Fernández-De-Las-Peñas et al., 2022). The Centre for Disease Control (CDC) has most recently referred to long COVID in 2023 as a "wide range of new, returning, or ongoing health problems people can experience four or more weeks after being infected with SARS-CoV-2, the virus that causes COVID-19" (CDC, 2023: Long COVID or Post-COVID Conditions | CDC). For this study, the abbreviation of PASC was used. The length of PASC is still widely researched, and some studies have shown symptoms lasting up to 6–7 months (Yong, 2021). In a recent study, a participant reported fatigue symptoms almost 12 months after contracting COVID-19 without hospitalisation (Fanous, Zero & Rice, 2022). The most common and debilitating symptom reported has been fatigue, followed by dyspnea and myalgia (Davis et al., 2021; Yong, 2021). As stated above, these post-COVID symptoms are not limited to patients who have been hospitalised (Logue et al., 2021). Furthermore, over 10% of asymptomatic or mildly symptomatic patients experienced persistent symptoms up to 8 months post-COVID infection (Logue et al., 2021).

Therefore, for the healthy and active individual, the severity of the disease was low, but the post-COVID complications were a reality, and this reality led to difficulties in returning to activity (Côrte et al., 2020). As known with any active infection, the athlete's performance following the cessation of activity had to be gradual, and some felt the frustration of seeing a decline in their physical ability and inability to reach their pre-COVID state (Akbarialiabad et al., 2021); Lim & Pranata, 2021; Małek et al., 2021).

Several studies have been done since the outbreak of the virus in relation to the effect on roadrunners (de Vries, Kotze & Morton Mckay, 2022; Toresdahl et al., 2022). In the study by Toresdahl, it was found that more injuries were found in the participants who were diagnosed with COVID-19 compared to those who did not have COVID-19. De Vries, Kotze and Morton McKay found a significant negative impact on participation in park runs following COVID-19. (de Vries, Kotze & Morton Mckay, 2022). Most of the research focuses on team-based sports, Olympic sports (Szczypińska, Samełko & Guszkowska, 2021) and a mixture of different types of athletes (Lim & Pranata, 2021) as opposed to a sole focus on road runners. Many studies have been done internationally where most of the population has access to home training equipment to maintain fitness and telehealth programs (Lim & Pranata, 2021). A study conducted in South Africa among runners and cyclists showed a decline in training data post-COVID-19 (Emeran A, 2022).

1.3 Study Purpose

The purpose of this study is to fill the gap in research by exploring the effects of COVID-19 and PASC on roadrunner's performance. Recommendations were taken from previous studies in which it was advised that time trials and resting heart rates were determined within this study (Emeran A, 2022). It also brings relatable results as the study was conducted locally in South Africa.

1.4 Study Aim

The aim of this study is to explore the effects of COVID-19 infection and PASC on the athletic performance of long-distance roadrunners in the Cape Town Metropolitan area.

1.5 Study Objectives

The objectives are:

1. To determine the prevalence of runners in South Africa that had COVID-19 from the period March 2020 – December 2022.
2. To determine the duration of COVID-19 symptoms experienced by the runners who tested positive within this period, in South Africa.
3. To determine the distance raced most often prior to COVID-19 by the runners in South Africa.
4. To determine the race pace at pre-infection, two weeks post-infection and four weeks post-infection.
5. To determine the heart rate at pre-infection, two weeks post-infection and four weeks post-infection.
6. To determine the most common symptom affecting return to running after COVID-19.
7. To describe mean time taken to return to pre-COVID running performance.
8. To determine the most common symptom of PASC experienced by the runners who experienced PASC.

Chapter 2 Literature Review

2.1 Introduction

This narrative literature review focuses on the impact of COVID-19 and PASC on the performance of road runners. Articles published in English from 2019-2023 were included. Earlier articles used were for comparison. Only articles freely available in full text from EBSCOhost, PUBMED, and Google Scholar were included. The search terms used included COVID-19, Endurance, Running, Athletes, and Post-Acute Sequelae of Covid-19, Long COVID.

2.2 COVID-19 and the spread of the infection

COVID-19 was named by the World Health Organization (WHO) in February 2020 after many patients presented with an unknown respiratory virus with symptoms such as pneumonia without probable aetiology (Rothan & Byrareddy, 2020). COVID-19 was initially known as a respiratory virus that presented flu-like symptoms in its host that ranged between mild, moderate, and severe. Many infected were hospitalised with complications, and others were managed at home. The most common symptoms experienced included fever, cough, and fatigue (Huang et al., 2022; Wang, Tang & Wei, 2020). Other symptoms that followed and were reported included sputum, production, haemoptysis, diarrhoea, dyspnoea, and lymphopenia (Huang et al., 2022; Wang, Tang & Wei, 2020). Many more minor symptoms varied amongst the public and were reported as the virus developed. This was all dependent on the age and immune status of the patient (Rothan & Byrareddy, 2020). Studies showed that COVID-19 has the highest viral load on the upper respiratory tract from the initial onset to the first five days of the infection. This led to the conclusion that the most infectious days were just prior to and the first week of symptom onset (Ravi, Saxena & Panda, 2022).

In order to prevent the overload of healthcare systems, the government rolled out a nationwide lockdown on 27 March 2020 (Seidu et al., 2020).

2.3 Lockdown

Due to the high transmission rate of the virus, several strategies were put into place to halt its spread (Lim & Pranata, 2021). Strategies like lockdowns, restrictions on movement, social distancing and isolation periods were mandatory. The restrictions on movements resulted in mass events and organisations being cancelled, training facilities being closed, and competitions being postponed indefinitely at the time (Lim & Pranata, 2021). This, along with the infection of COVID-19, undoubtedly affected many people's lives and left the sporting community just as vulnerable as the general population (Szczypińska, Samełko & Guszkowska, 2021). Furthermore, it is understood that the restrictions on movement were not the only factor affecting the athlete's performance.

Many countries experienced different strategies to curb the virus. While Sub-Saharan countries experienced a delay in contracting the virus and relatively lower numbers to begin with, South Africa experienced a prompt and strict lockdown that extended for a period that included different levels. This included a harsh lockdown, followed by a curfew and then the hygienic processes of hand washing, face masks and social distancing (Haider et al., 2020). This may have differed from other countries strategies. However, this presented with a 2 month halt to any outdoor physical activity that long- distance road running would entail (Haider et al., 2020). On 01 May 2020, in which South Africa entered level 4, the population was able to exercise between 6am – 9am and not in groups (Haider et al., 2020). European countries on the other hand took different approaches. UK having started their lockdown later, Germany having applied their restriction promptly and seeing a positive effect by having fewer cases positive and Italy being on a strict lockdown but did not see an effect on their cases while experiencing the highest number of positive cases (Cascini et al., 2022).

2.4 Post-Acute Sequelae of COVID-19

In addition to the lockdown, the adaptive training of the active individual was further affected when they contracted the virus and needed to cease training together due to the active infection. Symptoms were categorised as asymptomatic and symptomatic. There were reported chronic complications of the virus for some that presented as long-standing symptoms of the virus. This was known as PASC, more commonly known as 'long-COVID' (Dixit et al., 2021).

SARS-CoV-2, or COVID-19, is not the only coronavirus strain to experience long-standing or lingering symptoms. SARS-CoV-1 and Middle East respiratory syndrome (MERS) also have reports of long-standing symptoms up to 6 months post-acute illness recovery (Ahmed et al., 2020). SARS-CoV 1 was reported to have suffered from long-term pulmonary complications, reduced diffusing capacity of lung for carbon monoxide (DLCO) and interstitial lung abnormalities (Wu, X., Dong & Ma, 2016). Cardiovascular abnormalities were also noted, i.e., hypotension (50.4%), tachycardia (71.9%), bradycardia (14.9%) and cardiomegaly (10.7%) (Yu et al., 2006). All of which influence the physical lives of survivors. Haematological abnormalities were noted during the illness period that possibly would have long-term consequences (Giannis, Ziogas & Gianni, 2020; Higgins et al., 2021). Psychosocial abnormalities included fatigue, musculoskeletal pain, psychological stress, and disturbed sleep for up to 2 years post-illness (Moldofsky & Patcai, 2011). In MERS, abnormalities were seen on chest radiographs up to 43 days post-discharge from the hospital for those who were hospitalised (Das et al., 2017). While MERS and SARS-CoV 1 reported neurological sequelae, MERS was reported to be more neuro-invasive, leaving some survivors vulnerable to paralysis, Guillian-Barre syndrome, ischemic stroke and neuropathy (Higgins et al., 2021; Wu, Y. et al., 2020).

Just like other coronavirus strains, lingering symptoms are reported by many individuals post-COVID. At the beginning of 2021, Hossein et al. reported that the debate on nomenclature and diagnosis assumptions on pathophysiology was to be avoided (Akbarialiabad et al., 2021). In addition, the criteria for the diagnosis were not widely studied (Akbarialiabad et al., 2021). It was seen that at this point, the explanation or reasoning for PASC presented as the ongoing state of systemic inflammation and oxidative stress leads to a weakened immune system and failure to eradicate the virus completely (Baig, 2020; Maciola et al., 2022). Systemic hyper-inflammation also shows effects on the neurological system, causing neurodegeneration and cognitive decline (Walker et al., 2017; Walker et al., 2018). While studies were still in process at this point, no new studies have negated the above.

PASC is broadly defined as signs, symptoms, and conditions that continue or develop after initial COVID-19 or SARS-CoV-2 infection. The National Institute for Health accepted "long COVID" or "long Haul COVID" as the term used for persistent symptoms of more than three weeks, while "chronic COVID" was used for persistent symptoms of more than 12 weeks (Greenhalgh et al., 2020). In addition, the most current ongoing definition of PASC states that the signs, symptoms, and conditions are present four weeks or more after the initial phase of infection; may be multisystemic; and may present with a relapsing-remitting pattern and progression or worsening over time, with the possibility of severe and life-threatening events even months or years after infection (Michelen et al., 2021). The Centre for Disease

Control (CDC) has most recently referred to PASC in 2023 as a "wide range of new, returning, or ongoing health problems people can experience four or more weeks after being infected with SARS-CoV-2, the virus that causes COVID-19" (CDC, 2023: Long COVID or Post-COVID Conditions | CDC). The length of PASC is still widely researched, and some studies have shown symptoms lasting up to 6–7 months (Yong, 2021). In a recent study, a participant reported fatigue symptoms almost 12 months after contracting COVID-19 without hospitalisation (Fanous, Zero & Rice, 2022).

COVID-19 patients reported to experience a variety of symptoms ranging from fatigue, dyspnea, breathless (Carfì, Bernabei & Landi, 2020; Cheng et al., 2021), palpitations (Dani et al., 2021; Ludvigsson, 2021), brain fog and lack of concentration (Østergaard, 2021; Theoharides et al., 2021), sleep disturbances (Mazza et al., 2020), headache (Dennis et al., 2021), orthostatic intolerance (Shouman et al., 2021), anxiety and post-traumatic stress disorder (Peluso et al., 2021), chest pain, joint pain (Carfì, Bernabei & Landi, 2020), sore throat (Cheng et al., 2021), and hair loss (Cheng et al., 2021). The most common and debilitating symptom reported has been fatigue, followed by dyspnea and myalgia (Davis et al., 2021; Yong, 2021). Fatigue is often seen in more female and younger participants and is associated with anxiety and post-traumatic stress disorder (PTSD) (Halpin et al., 2021; Townsend et al., 2021). As stated above, these post-COVID symptoms are not limited to patients who have been hospitalised (Logue et al., 2021). Furthermore, over 10% of asymptomatic or mildly symptomatic patients experienced persistent symptoms up to 8 months post-COVID infection (Logue et al., 2021).

2.4.1 Fatigue and related system disturbances

PASC-related fatigue can be a manifestation of many different aetiologies like cardiac, pulmonary, myopathy, neuropsychiatry, adrenal, sleep, gut dysfunction, and/or cytokine (Abbott, Summers & Niehaus, 2023). Data on fatigue following infection ranges from 10% to 35% up to 6 months post-infection (Sandler et al., 2021). Comparisons have been made between post-viral fatigue in PASC and chronic fatigue syndrome (CFS)/myalgia encephalomyelitis (ME) (Abbott, Summers & Niehaus, 2023). CFS is related to a culmination of symptoms from different organ systems, namely metabolic, neurologic and myofibrillar components (Maughan & Toth, 2014). CFS requires a thorough workup to rule out other etiologist; given its similarities to PASC, knowledge of pathophysiology and management of fatigue related to post-COVID sequelae is essential and still in the process of development.

2.4.2 Systemic inflammation

There are inferences made that SARS-Cov-2 acts as a physiological stressor, causing systemic inflammation, impacting hypothalamic dysfunction, and causing damage to the cardiac, pulmonary, neurological, and myofascial systems (Mackay, 2021). These impacts all translate and can lead to fatigue. Systemic inflammation is seen in patients with a higher marker of pro-inflammatory cytokines IL-2 and IL-6 (Broderick et al., 2010; Garcia et al., 2014). A study done on the post-viral infection fatigue following the Epstein-Barr virus found these markers elevated in those experiencing fatigue compared to those who recovered directly after the infection (Broderick et al., 2010). Similar pro-inflammatory cytokines, IL-2, IL-6 and C-reactive protein (CRP) were identified in those experiencing post-viral fatigue following COVID-19 (Evans et al., 2022). These potential pro-inflammatory states have been hypothesised as the reason for post-viral fatigue following COVID-19 (Abbott, Summers & Niehaus, 2023).

In addition to systemic inflammation, COVID-19 has had an effect on other systems like cardiac, pulmonary, myofascial and neurological systems (Abbott, Summers & Niehaus, 2023). All of which affect the general population and, importantly, the athletic population.

2.4.3 Pulmonary and cardiac function

Fibrosis has been the current long-term effect seen on lung imaging. This would subsequently cause impaired lung function and is seen months after infection (Huang et al., 2022). The reduced capacity of gaseous exchange and increased respiratory effort can be an attributing factor to post-viral fatigue, dyspnea and cough (Abbott, Summers & Niehaus, 2023). The cardiac system has its controversy; where a study done by Puntmann et al. suggests that 78% of their participants presented with cardiac involvement, and 60% showed signs of myocarditis, irrespective of previous cardiac conditions (Puntmann et al., 2020). Alternatively, Malek did not negate this but found that the results were a lot less than the above (Akbarialiabad et al., 2021). Given this controversy, there is evidence to identify cardiac inflammation in healthy recovered COVID-19 patients (Daniels et al., 2021). The cardinal symptom of cardiac dysfunction is fatigue, which links the cardiac system to post-viral fatigue in PASC (Abbott, Summers & Niehaus, 2023).

2.4.4 Neurological and gut dysfunction

Coronaviruses have been known to invade neurological tissues and subsequently alter cognition, behaviour, mood and function (Penninx, 2021). Recent data and hypotheses exist on the neuropsychiatric sequelae of COVID-19 in relation to post-viral fatigue (Ortelli et al., 2021; Penninx, 2021; Renaud-Charest et al., 2021). However, inconclusive, controversial results need further investigation (Abbott, Summers & Niehaus, 2023). Oretelli et al. describes that after the evidence obtained from the study, no patient had evidence of major depression, but results were in line with minor depression figures (Ortelli et al., 2021). Fatigue and apathy were closely linked to mood disturbances where apathy was greater linked to depressive symptoms (Ortelli et al., 2021).

Sleep and gut dysfunction are also seen as potential attributes of post-viral fatigue. New literature links gut microbiome to chronic fatigue syndrome, and similar results and studies are emerging for PASC (Abbott, Summers & Niehaus, 2023). Insomnia and fatigue are seen in acute COVID-19 infections and up to 6 -10 months post-infection (Becker et al., 2021).

2.4.5 Myalgia and skeletal muscle system

Critical illness myopathies have been reported in many case reports of severe COVID-19 (Tankisi et al., 2020). In a cross-sectional study, it was found that there was a high number of COVID-19 patients who experienced skeletal muscle weakness and reduced physical performance without prior muscular issues (Paneroni et al., 2021). An example would be that 86% of participants were seen to have weakness in the quadriceps muscle, and 76% were seen to have weakness in their biceps muscle (Paneroni et al., 2021). In those recovering from COVID-19, myopathic changes were seen in 55% of the 20 participants, yet nerve conduction studies appeared normal in this study (Agergaard et al., 2021). In Figure 2.1, we see these myopathic differences using quantitative electromyography measurements in patients compared to healthy controls in the study done by Agergaard et al. in 2021.

From this, the motor unit potential was analysed. From the conclusion of the study, it was determined that while long-term COVID may not cause large fibre neuropathy, myopathic changes are seen. These myopathic changes may contribute to the cause of physical fatigue in long-term COVID-19 patients (Agergaard et al., 2021).

There were studies that found that many COVID-19 survivors reported a reduction in functional and muscular performance and dyspnea (Curci et al., 2020; Zampogna et al., 2021). In reports done which undertook biopsy investigation, inflammatory myopathy and critical illness myopathy were consistently found in those who died because of severe COVID-19 (Duarte-Neto et al., 2020; Suh et al., 2021).

2.5 Effects of COVID-19 on Physical fitness, Return to sport, Performance

While physical activity is essential in maintaining good health and is associated with reducing the risk of contracting severe COVID-19, this was difficult to maintain during these times (Sallis et al., 2021).

A constant outflow of research emerges with respect to the COVID-19 pandemic and the sporting world. Many different avenues are being explored and understood. Therefore, further research is needed to validate and add to the body of knowledge on this relatively fresh topic of interest. There were many unknowns at the time when it came to the effects of COVID-19 on the population, specifically the sporting population. Fast-forward three years, and more studies are investigating the effects of COVID-19 on the sporting population.

Many sports were analysed in studies, which were used as a research base linked to the endurance nature of running. While soccer does combine anaerobic and different speed bursts, studies have looked at the effect COVID-19 has had on the anaerobic and aerobic capacity of soccer players. Savicevic et al., 2021, analysed a team of professional soccer players by assessing their match-running performance using high-intensity accelerations and decelerations in comparison to their pre-COVID tests. Results showed a decrease in performance (Savicevic et al., 2021). In another study by Parpa and Michaelidis in 2022, they looked at the aerobic capacity of professional soccer players. This study more accurately represents performance by looking at maximal oxygen consumption (VO2 max) value, velocity at VO2 max, heart rate and running time (Parpa & Michaelides, 2022). This was compared to pre-COVID values and was tested at 60 days post-infection to determine the recovery of the athlete's aerobic capacity. Major differences in the results proved the athlete had not fully recovered to the pre-infection state by two months post-infection (Parpa & Michaelides, 2022). These studies' results relate to endurance runners as soccer players push their cardiorespiratory workload to a high limit for ninety minutes at a time. In addition, endurance runners have an aspect of anaerobic training intervals to improve their speed within their long-distance running. There are limitations to how this is done with professional athletes who have access to many advanced interventions that the general population may not have. Hence, while the results are important and valid, a more relatable and generalised approach needs to be taken to provide input from recreational athletes.

Running is a sport that can be used for recreational, endurance, and ultra-endurance athletes. Scheer et al., 2021 looked at the effects of COVID-19 on endurance and ultra-endurance athletes by monitoring the endurance running finishes and events during the pandemic. When compared to pre-COVID results, there was a significant decrease in the number of finishes, finishing times and events overall (Scheer et al., 2021). While these studies were in the early stage of research in this field, they provided a backbone for more questions about the cause of this decline. Alfonseca et al. (2022) had a similar approach to their study. They looked at running training, running times, and running distance in 2020 compared to 2019.

Interestingly, results showed a decrease in the first half of 2020, which is linked to the restrictions placed on the worldwide population (Alfonseca et al., 2022). However, the authors expected a turn of events going into the year's second half, with running training being more achievable. That was not the case; there was still a significant decline (Alfonseca et al., 2022). The authors recommended a few reasons to believe injury, illness, or lack of interest are the causative factors (Alfonseca et al., 2022).

2.6 Conclusion

Following the body of knowledge presented in the literature review, there is a gap in research specifically in South Africa. The number of studies done within the region is limited. Furthermore, while the studies above provided important information, it is a novel topic that needs many avenues to be studied. Considering the effects COVID symptoms have had on the population, the PASC symptoms experienced along with the effect on the physically active population; there are interesting research questions to be studied. In this study we aim to do this by meeting the objectives of this study.

Chapter 3 Methodology

3.1 Study design

The study utilised a quantitative cross-sectional descriptive design to identify the effects of COVID-19 on runners in Cape Town. Using this study design allows multiple variables to be evaluated and multiple groups to be analysed and compared (Cardenas, 2019; Kumar, 2012). This is appropriate for this study as there are many variables to consider in reaching the objectives of the study.

3.2 Recruitment

Two-stage sampling was used, whereby running clubs were initially identified, followed by convenient sampling of road runners in South Africa. Contact was made with each club's communications representative and secretaries to explain the research's purpose and aim. A request to access running club members was sent to the chairperson (Appendix C). After permission was granted by the chairperson of each club, members of running clubs in the Cape Town Metropolitan area were invited to participate in the study through e-coms (electronic communication) within each club. E-coms is the use of electronic communication via email threads or WhatsApp groups. The consent form was sent (Appendix A), and those who agreed to take part were deemed participants in the study.

Furthermore, roadrunners not linked to a running club were also recruited by advertisements on social media posts via Instagram, WhatsApp, and emails. Clicking on a link took those interested to the form page with the necessary information preceding it.

3.2.1 Inclusion and Exclusion Criteria

Roadrunners in the Cape Town Metropole area over the age of 18 years were included in the sample participants. The roadrunners that participated in 5km-42km running categories prior to and including July 2019 were included in the study. Runners must have a tracking device in order to answer the questionnaire.

3.2.2 Population and Sample Size

Correspondence with Athletics South Africa, specifically Western Province athletics, was done to obtain the number of registered runners in the Western Cape province and Cape Town, specifically at the beginning of 2020 (Appendix B).

Figures were derived from all the registered permanent members with Western Province athletics in Cape Town, specifically at the beginning of 2020, to guide the calculation of the running population and the sample size for this study. According to the secretary of Western Province Athletics, an estimated 16,000 runners were permanently registered members of the ASA at the beginning of 2020 (iOL, 2020). This was the number that was used to calculate the population sample. The large number improves the diversity of results to represent the study accurately (Kumar, 2012).

Table 3.1: Sample size calculation based on the Confidence Level Percentage

CONFIDENCE LEVEL	80%	90%	95%	99%
SAMPLE SIZE	163	268	376	640

The sample size calculation was done using *Raosoft Calculation software* and used the following parameters:

- A marginal error of 5%
- Response distribution of 50%
- Confidence level of 80%, 90%, 95% and 99%
- A population group of 16 000

A 99% confidence interval reduces the marginal error with a larger sample size. However, the expected sample size was not reached and provided a limitation to the study.

3.3 Instrumentation

3.3.1 Questionnaire

The questionnaire was developed on Google Forms that included the following section: (see Appendix D).

- Demographic information such as age (Appendix D section 1)

- List of covid 19 symptoms developed from literature (Côrte et al., 2020; Davis et al., 2021; Gupta & McCarthy, 2021; Lima et al., 2021; Martin, Champ & Franklin, 2021; Sallis et al., 2021; Sarto et al., 2020; Yong, 2021).
- PASC symptoms developed from literature Couzin-Frankel, 2022; Davis et al., 2021; Dixit, 2021; Fanous, Zero & Rice, 2022; Sallis et al., 2021; Toresdahl et al., 2022; Yong, 2021).
- Running information from tracking device e.g. HR, distance, running pace, the RPE and the 5 km time trial before and after covid (Emeran A, 2022)

3.3.2 Tracking Devices

A tracking device was used in which it would track the data from an activity such a run. This can be in the form of a watch, chest strap and smartphone. Information was gathered from participants' reference to their tracking device applications and submission of this tracking device data to create a proxy measure of performance. The parameters included resting heart rate, the individual's usual race distance and relative time to complete this distance prior to infection, at two weeks post-infection and four weeks post-infection. Considerations of a time trial of 5 km distances prior to infection, two weeks post-infection, and four weeks post-infection were included. Calculated and estimated VO2 max values (later excluded after the pilot study, see reliability and validity section) and a 5 km time trial was also expected from these devices. Using the rate of perceived exertion was used based on the collected RPE from tracking data in its simplest from weak, moderate, neutral, strong and very strong. Using tracking device data allows the recall bias to be reduced as well as individual comparison between the time intervals between pre-infection and post-infection times.

3.4 Reliability and Validity

To ensure the reliability and validity of the questionnaire, the following was ensured:

- External validation: Content validity was obtained by consulting a panel of experts (Kumar, 2012). This ensured the appropriate questions and accurate testing were carried out for the population group.
- Internal validation: A pilot study of approximately ten people who were not part of the sample group was used. A test-retest approach was conducted with the

pilot study to ensure face and content validity (Kumar, 2012). Amendments to the questionnaire were made where necessary after this validation. The participants of the pilot study had the same requirements as the main study and were not included in the final study.

- Close-ended quantitative questions and tracking device data were used to counter recall bias.

Reliability was determined by the questionnaire and symptom checklist being developed from previous research. In addition, tracking devices provided reliability of results to ensure the elimination of recall-bias. Tracking device data established the individuals results when looking back at specific time frames by providing the participant with data rather than relying on their memory.

After the pilot study was concluded, necessary changes were made to ensure content and face validity. Changes included adjustments were made to the presentation of race-pace values. In addition, an adjustment to the COVID-19 question allowed this question to be featured at the start of the questionnaire. To ensure reliability, tracking device data and answer options were used to remove recall bias. In addition, VO2 max values were removed due to the understanding of its inaccuracy as well as the inability to track this on many watches or phone data.

3.5 Procedure

Running clubs were first identified and contact was made with each club's communications representative and secretaries to explain the research's purpose and aim. A request to access running club members was sent to the chairperson (Appendix C). After permission was granted by the chairperson of each club, members of running clubs in the Cape Town Metropolitan area were invited to participate in the study through e-coms (electronic communication) within each club. E-coms is the use of electronic communication via email threads or WhatsApp groups. The consent form was sent (Appendix A), and those who agreed to take part were deemed participants in the study.

Furthermore, roadrunners not linked to a running club were also recruited by advertisements on social media posts via Instagram, WhatsApp, and emails. Clicking on a link took those interested to the form page with the necessary information preceding it.

This link remained opened for 5 months in which roadrunners in South Africa had access to fill out this form and partake in the study. Reminder emails were sent to the secretaries of the running clubs and links were sent via social media posts.

3.5.1 Data Management

Once ethical approval and permission from the running clubs were obtained, the electronic questionnaire was distributed via email and WhatsApp groups to runners within these running clubs. Furthermore, social media advertisements were circulated within the Cape Town region. This was done from May 2023 to September 2023. Once all questionnaires were answered, the Google Forms data was transferred onto an Excel spreadsheet providing the raw data set. Seventy-six responses were collected. The consent for the study was collected as part of the form. Data was sorted in two parts; firstly, the participants were removed based on inclusion and exclusion criteria and their ability to answer the necessary questions. Secondly, variables that were not necessary for the data analysis aim and objectives of the study were excluded.

Data was stored on a password-protected database on OneDrive during the research period and will be stored five years after the research has been conducted. The data management was done in accordance with the University of Cape Town Data Management Policy (2018).

3.6 Data Analysis

The Excel spreadsheet was imported to Statistica version 13 for analysis. Descriptive statistics was used to generate frequency tables. Non-parametric tests were used to test for differences in running performance and resting heart pre- and post-COVID infection. Using Statistica version 13, descriptive statistics was used to analyse the means and frequencies of the results (Josephsen et al., 2007). The means and mode of the data set are most appropriate to determine the central tendency based on the results nominal and ordinal categorical nature. The variability of the results was accounted for by using measurements of range, standard deviation, and variance where applicable. The effects of COVID-19 and PASC on a proxy measure of running performance were determined.

3.7 Ethics Considerations

A departmental review was conducted by the Department of Health and Rehabilitation Sciences (DHRS) at the University of Cape Town (UCT). Following departmental review, this protocol was submitted to and approved by the Human Research and Ethics Committee (HREC) (Appendix F) with the HREC reference number 100/2023. The study complies with the Declaration of Helsinki (JAMA, 2013).

3.7.1 Informed consent

Autonomy was practised across all participants in which the participant had the right to decide whether he/she would like to be part of the study, and in any case that the participant opted to withdraw from the study, they were able to do so. This was explained along with a description of the study, the risks and benefits of the study and the main purpose of the study in the informed consent (Appendix A). This allowed the study to be voluntary.

3.7.2 Professionalism

This study communicated with participants in a professional manner. All measurement tools used were developed from research done by healthcare professionals.

3.7.3 Anonymity

All identification was anonymous, and number systems were used, i.e., no names were captured.

3.7.4 Risks of the study

There were no identified risks in this study.

3.7.5 Benefits of the study

All results were relatable to those roadrunners, specifically local road runners, in South Africa. All participants had the option to request the results of the study should they be interested.

3.7.6 Protection of Personal Information Act (POPIA)

Recruitment and data collection was done in accordance with the POPI Act. The data was stored on a password-access laptop in a password-access folder and will be stored for five years after the study has been completed after which it will be deleted.

3.8 Conclusion

This methodology assisted in gaining results that aligned with the objectives of the study. The appropriate sections analysed in accordance with the methodology is presented in the following section of the results.

Chapter 4 Results

This section of the thesis will present the findings linked to the following objectives:

1. To determine the prevalence of runners in South Africa that had COVID-19 from the period March 2020 – December 2022.
2. To determine the duration of COVID-19 symptoms experienced by the runners who tested positive within this period, in South Africa.
3. To determine the distance raced most often prior to COVID-19 by the runners in South Africa.
4. To determine the race pace at pre-infection, two weeks post-infection and four weeks post-infection.
5. To determine the heart rate at pre-infection, two weeks post-infection and four weeks post-infection.
6. To determine the most common symptom affecting return to running after COVID-19.
7. To describe mean time taken to return to pre-COVID running performance.
8. To determine the most common symptom of PASC experienced by the runners who experienced PASC.

It should be noted that not all the sections were answered every participant. Hence, the change in responding ‘n’ values.

4.1 Sample Demography

Seventy-six participants completed the questionnaire.

Most participants were in the age category 18–35 years. The mean Body Mass Index (BMI) was 24.6 (SD = 3.4, Range: 16–33). The race distance that common was 10km. Fifty-three participants reported having tested positive for COVID-19. Of those who had tested positive, 26 reported having experienced PASC.

Table 4.1: Demographic information of the sample population of roadrunners

Age Category	COVID TEST NEGATIVE	COVID TEST POSITIVE	Row TOTAL
69-80	1	0	1
50-69	1	14	15

36-49	2	14	16
18-35	2	25	27
All Groups	**6**	**53**	**59** **MISSING = 17**

The remaining 17 did not provide their ages as they were asked to conclude their questionnaire if they tested negative. These participants did not disclose their age category prior to concluding their participation in the questionnaire.

4.2 Prevalence of runners that had COVID-19, duration of COVID-19, distance raced most often, race/heart pace, 5km time trial and RPE

Most of the sample population experienced symptoms of COVID-19 for a period of 1-2 weeks, with the next most common timeframe being 3-4 weeks; see Figure 4.1. Runners, in general, are of a healthy population, and it is likely that the state of infection remains for a common period of 1-2 weeks regardless. There are missing 22 participants in this result due to those who tested negative as well as those who did not fill out this field.

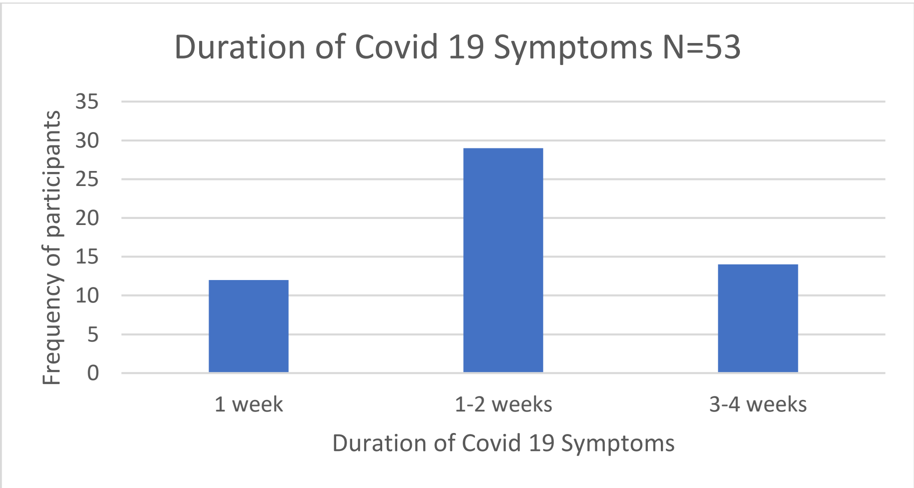

Figure 4.1: The duration of the COVID-19 symptoms in those who tested positive

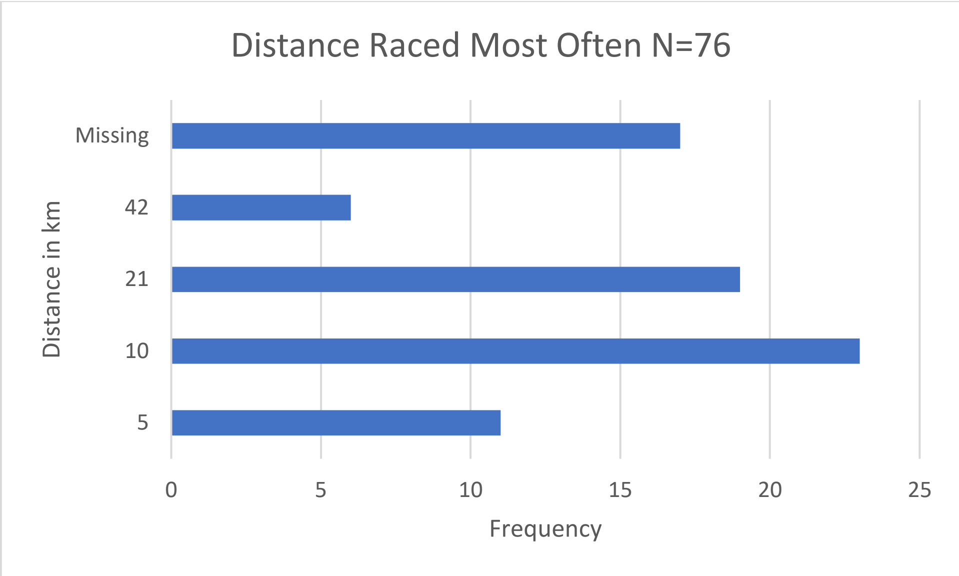

Figure 4.2: The distance raced most often within the sample population of roadrunners

Of the 76 participants, the most raced distance was 10km, with 21km, 5km, and 42km following, respectively; see Figure 4.2. The missing values represent those who did not complete this section of the questionnaire due to not testing positive for COVID-19.

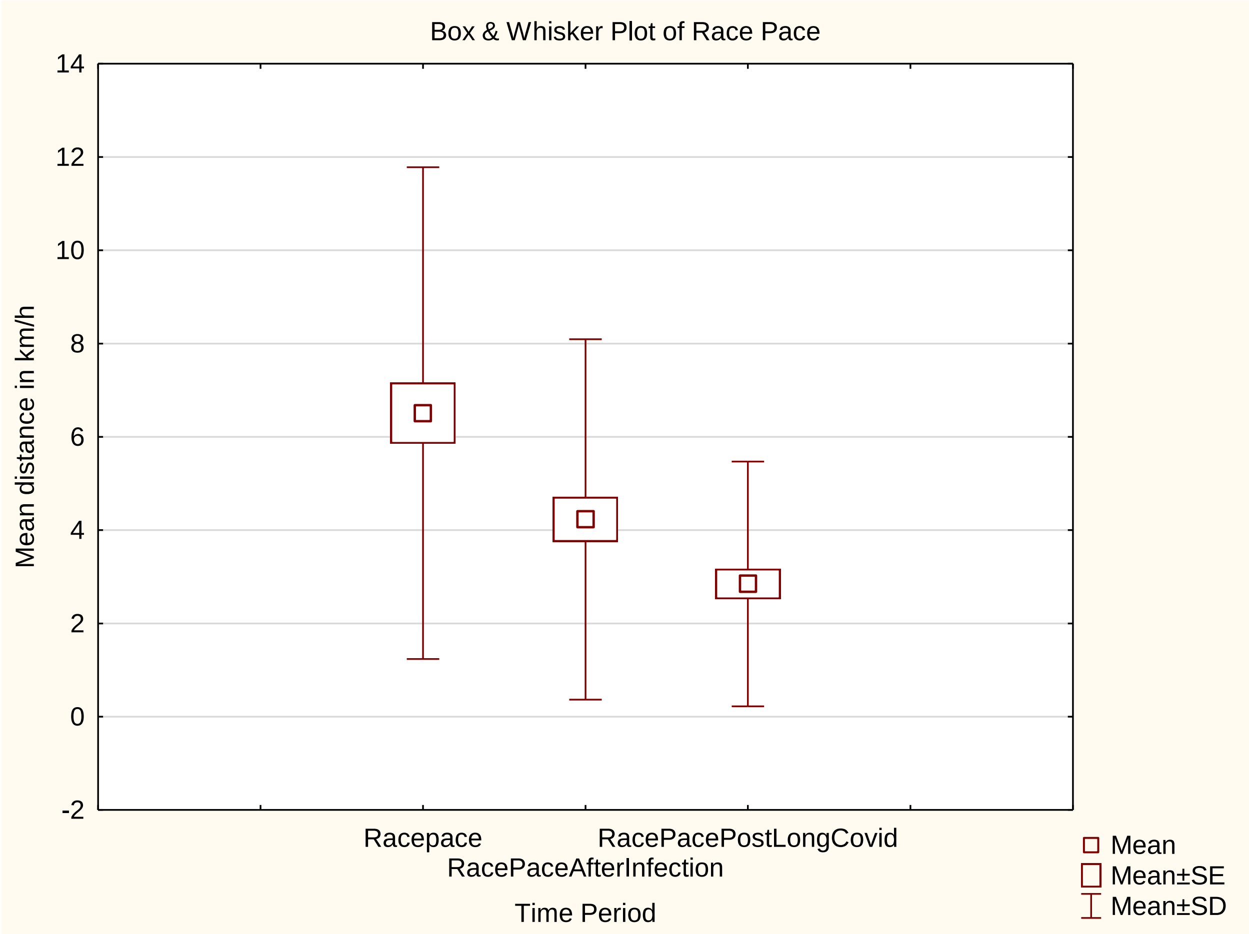

Figure 4.3: The race pace of the roadrunners at pre-infection, two weeks post-infection and four weeks post-infection (n = 6525)

These results suggest that there are significant differences ($p < 0.05$) in race-pace among the different conditions (pre-infection, two weeks post-infection, and four weeks post-infection), as indicated by the Friedman ANOVA.

Figure 4.4: The resting heart rate of roadrunners at pre-infection, two weeks post-infection and four weeks post-infection

The Kendall's Coefficient of Concordance is relatively high (0.63942), indicating a substantial level of agreement among the observed variables (resting heart rates at different time points). The low p-value ($p < 0.005$) suggests that there are statistically significant differences in resting heart rate among different time points (prior to infection, two weeks post-infection, and four weeks post-infection).

Table 4.2. The 5 km time trial pre-infection, 2 and 4 weeks after infection

		5 km time trial pre-infection.	5 km time trial 2 weeks post-infection.	5km time trial 4 weeks post-infection.
N	Valid	55	38	24
	Missing	21	38	52
Median		28.00	35.00	35.00
Std. Deviation		5.318	8.867	8.805

The above results show the average time taken to complete the time trial. Missing figures were high in 2 weeks and 4 weeks post-infection. These include those who did not fill out the field due to being COVID negative, not having the data available to them or not being able to run the 5km time trial at this point. Of those who provided their results; the figures at pre-infection ranged from 17minutes – 44 minutes, at 2 weeks post-infection it ranged from 23 min – 60 min, and at 4 weeks post-infection it ranged from 15 min – 55 min. This shows the progression of the time of the 5 km time trial.

Table 4.3 The rating of perceived exertion of the race chosen above at pre-infection, 2 weeks post-infection and 4 weeks post-infection

		Frequency pre-infection	Frequency 2 weeks post-infection	Frequency 4 weeks post-infection
Valid		17	27	38
	Moderate	13	9	11
	Neutral	18	7	5
	Strong	22	9	8
	Very strong	4	10	2
	Weak	2	14	12
	Total	76	76	76

The above results show the rate of perceived exertion of the course of the individuals chosen race distance in figure 4.2 above. The missing figures include those that have tested negative for COVID-19. It is evident that from ‘strong’ being the predominant choice at the pre-infection time, at 2 weeks and 4 weeks post-infection, ‘weak’ has become the more common answer amongst those who experienced COVID-19 or Long-Covid.

4.3 The most common symptom, time taken to return to pre-infection performance, PASC

From the participants who experienced COVID and those experiencing PASC, there were symptoms experienced when returning to running that affected their performance. Shortness of breath was seen as the most common symptom experienced by participants when returning to running, followed by muscle aches, fatigue, cough, tachycardia, headaches, weakness, joint pain, fever, and chest pain; see Figure 4.5.

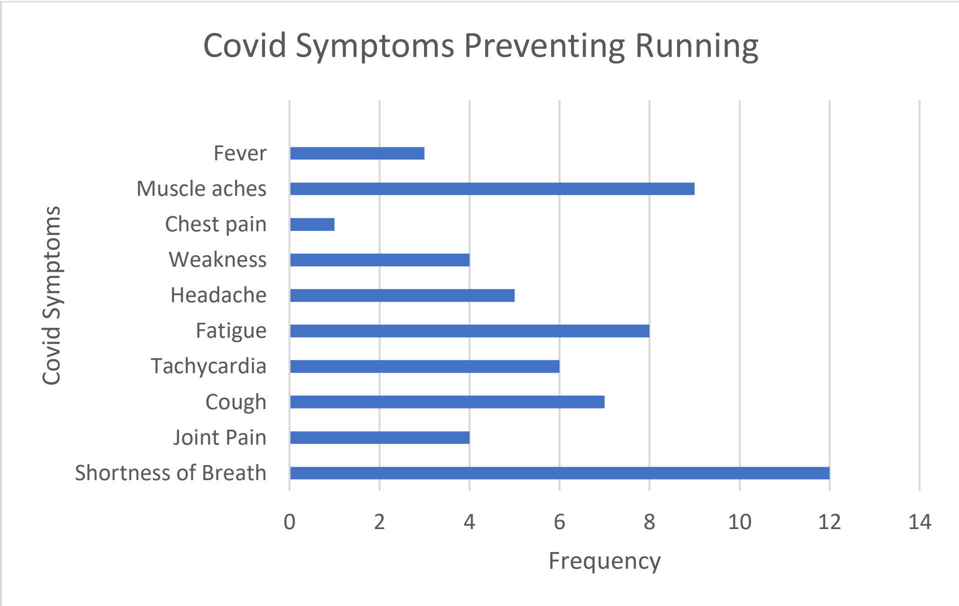

Figure 4.5: The most common symptom experienced by the roadrunners when returning to running

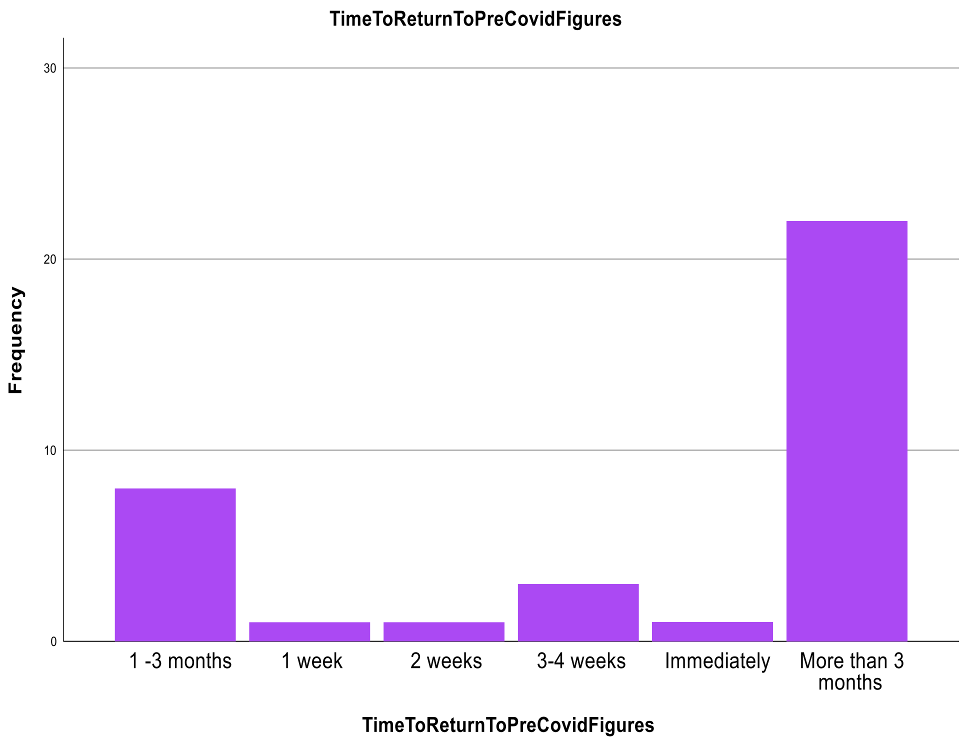

Figure 4.6: The time taken to return to pre-infection running performance

Given Figure 4.6 shows the symptoms experienced when returning to running, participants were then asked to choose an appropriate timeframe for their return to pre-COVID running performance. Most of the participants felt that it took them more than three months to return to their pre-COVID performance. Following this was 1-3 months, 3-4 weeks, and jointly one week, two weeks and immediately.

4.3.1 PASC

Of those who had tested positive, 26 reported having experienced PASC. The most common symptoms were fatigue (73.1%), shortness of breath (65.4%), post-exertional malaise (53.8%) and muscle pain (23.1%).

4.4 Conclusion

The above results were collated and analysed against the objectives set out at the beginning of the study. A further in-depth analysis is discussed in the following section discussing the correlation of the results with the objectives of the study.

Chapter 5 Discussion

Following the results obtained, the following results were analysed and correlated against the objectives of the study as well as current research.

5.1 Sample

The study was adequately presented through many forums to invite participants to join. Feedback on the questionnaires was received from seventy-six participants. This sample size is low compared to the sample size calculation. The study was circulated actively for a period of five months (May 2023 – September 2023). This period should have been adequate to obtain a high number of runners; unfortunately, the study could not reach the target sample size. This could limit the study's generalisation of the results to the population. This would serve as a recommendation for further studies.

5.1.1 Demographics

Runners were anonymous in answering the questionnaire. Fifty-three participants tested positive for COVID-19, and twenty-six of these participants experienced PASC. The ages of the participants ranged between 18–80 years of age. The group of runners between 18 and 35 were most predominant, with twenty-six participants. The group's mean BMI was 24.6 (SD = 3.4), which is within a healthy range.

Comorbidities were not commonly seen in this sample population; there were seven participants across all age groups who experienced comorbidities—four with respiratory conditions, two with diabetes and one with an autoimmune disease. There were not enough participants to make an inference on the effect of the comorbidities as a result of their COVID-19 experience. The results showed inconsistent results in declaring comorbidities affecting their experience of COVID-19 and PASC in this particular sample group. In research, similar findings were seen where it was expected that those with asthma would have worsened complications, but there was not a lot of evidence to suggest a significant difference between those with asthma and those without (Palmon, Jackson & Denlinger, 2022).

5.2 COVID-19

The seventy-six participants were divided into those that tested positive for COVID-19 and those that did not. Fifty-three participants tested positive for COVID-19 (69.7%).

5.2.1 The most common symptom experienced of COVID-19

Fever and headaches were the most common symptom experienced by this sample population (53.8%). In skeletal muscle-related symptoms, 43.1% of participants experienced muscle pain, 32.3% experienced joint pain, 52.3% of participants experienced fatigue, and 47.7% experienced weakness. While this is the common systemic response to infection, it was the predominant symptom of COVID-19 (Soares et al., 2022). In a study done by Emeran et al. (2022), they discovered the most common symptoms of acute COVID-19 infection were headaches, body aches, and fatigue (Emeran A, 2022). This study was based on a similar sample population of runners and cyclists. None of the participants in the study experienced asymptomatic COVID-19.

Skeletal muscle symptoms are commonly seen in COVID-19 and PASC patients, predominantly in more severe cases and admitted patients (Soares et al., 2022). However, in the study, there were only two hospitalised participants, yet the majority of the others experienced these symptoms. These symptoms can range from mild to severe. The underlying reasoning and mechanism are unclear. However, it has been found that other factors like hypoxeamia, systemic inflammation, extended periods of bed rest, and medications could relate to these symptoms (Pleguezuelos et al., 2021).

Respiratory and cardiac symptoms were noticed in this sample population. 41.5% experienced a tight chest, 23.1% had chest pain, 21.5% had dyspnea, and 20% had tachycardia. This can be explained by the virology of the virus and its multiplication, adaptation, and modification to cell tissue and its effect thereon (Ravi, Saxena & Panda, 2022).

5.3 PASC

Twenty-six of the participants experienced PASC symptoms more than four weeks after the initial infection. There has been evidence of many patients who have persistent symptoms after acute infection that last several months (Huang et al., 2022). There have been inferences of certain biological drivers for the reasoning of persistent symptoms; however, nothing has been mutually exclusive, and no inference can be made thereof (Proal & VanElzakker, 2021).

5.3.1 The most common symptom experienced by PASC

In this study, it was found that the sample population experienced predominant symptoms in accordance with the research done (Akbarialiabad et al., 2021; Davis et al., 2021; Dennis et al., 2021; Su et al., 2022). Fatigue was the most common symptom; 73.1% of participants experienced this. Fatigue is the predominant symptom seen in those experiencing symptoms up to 7 months post-infection (Davis et al., 2021). Fatigue is followed by post-exertional malaise, headaches and brain fog (Davis et al., 2021). It is seen that some patients meet the criteria of chronic fatigue syndrome in PASC experiences that have a range of symptoms on their own (Komaroff & Lipkin, 2021). Noticeably, post-exertional malaise was noted in 53.8% of the participants, brain fog in 53.8%, and headaches in 50% of participants.

In this study, shortness of breath had a high prevalence among the participants, with 65.4% experiencing this. Nevertheless, in studies, it was more likely to be lower on the scale of PASC symptoms (Proal & VanElzakker, 2021). Other respiratory symptoms and cardiac symptoms were chest pain (15.4%), palpitations (7.7%), tachycardia (38.5%), bradycardia (3.8%), and an irregular heartbeat (19.2%). The difference in the ranking of symptoms compared to other studies could be due to factors like environment, small sample size, and the severity of the disease. However, regardless of the difference in prevalence, they are common symptoms experienced and listed under PASC.

Other symptoms are noted in this study and literature. Skeletal muscle symptoms included joint pain (26.9%) and muscle pain (23.1%).

5.4 Impact on Running Performance

5.4.1 Analysis of the race pace before, two weeks and four weeks post-infection

The race pace was noted before, two weeks and four weeks post-infection to monitor any changes in this time. Referencing Figure 4.3, a drop-off of lower race pace values and predominantly higher pace figures was observed. In addition, there are many of the participants who did not run their distance by then to note their race pace. The values shown in Figure 4.3 represent the average race pace for the chosen distance in different conditions (pre-infection, two weeks post-infection, and four weeks post-infection). The substantial increase in race-pace post-infection is notable. It is seen that the race pace at two weeks post-infection is significantly higher when compared to pre-infection. The race pace at four weeks post-infection still increases further when compared to pre-infection while being slightly higher than two weeks post-infection.

5.4.2 Analysis of the RPE before, two weeks and four weeks post-infection for the above race pace

Looking at the rate of perceived exertion shows a significant difference over the three timeframes. Significantly, the choice of 'strong' was the most common choice at the pre-infection stages for the individual's chosen race pace. As the two-week post-infection mark is analysed, a shift in the other options becomes predominant, with 'weakness' being the most common. At four weeks post-infection, 'weakness' is the predominant choice, while 'strong' is the lesser choice.

5.4.3 Analysis of the resting heart rate of each runner before, two weeks and four weeks post-infection

Although there is a trend of higher heart rate figures at two weeks and four weeks post-infection, the results are inconclusive. It can be noted that the resting heart rate is significantly higher at points of two weeks post-infection compared to pre-infection; see Figure 4.4. While the resting heart rate figure has a marginal reduction at four weeks post-infection, it is significantly higher compared to pre-infection. Looking at the results on an individual basis may be necessary. In addition, the heart rate on a watch is less accurate when compared to a chest strap. Hence, from a relative aspect, a trend is observed, but the value of the data may be inaccurate. Studies done by Emeran et al. (2022) looked at the peak heart rate during training in running and cycling. They found a decline in peak heart rate during the relevant intensities (Emeran A, 2022). However, the recommendation from this article advised that not looking at resting heart rates and time trials posed a limitation to the study (Emeran A, 2022).

5.4.4 Analysis of the 5 km time trial before, two weeks and four weeks post-infection

A 5 km time trial was one of the measures used as a proxy measure of performance due to the basis of a time trial. It is the maximum effort put into a 5 km run that is not a race. This indicates the effort available to the runner two weeks and four weeks post-infection compared to their pre-infection measures.

Within the study, runners who had a maximum of 44 minutes for their time trial pre-infection were identified. At two weeks post-infection, the maximum time increased to 60 minutes with the addition of four runners who were unable to run this distance. Furthermore, those who experienced PASC saw a maximum of 55 minutes at four weeks post-infection, as well as two runners who were unable to complete this distance at this time.

5.5 Analysis of the time taken to return to pre-infection running parameters

There is limited evidence on the return to sports time amongst research, specifically in running. A current study on elite hockey players in 2023 looked at the return to play and time to return to play (Lyng et al., 2023). Another study was done on National Basketball Association players (n = 15). In these two studies, the return to play performance and time to return to play were not seen to be affected by COVID-19 at one- and two weeks post-infection. However, it is important to take into account that these are elite athletes at younger ages; there is a significantly lower risk of complications from COVID-19, as described in the study (Lyng et al., 2023).

In reference to returning to running, this current study looked at recreational runners of various ages. The only other study done on endurance sports was one conducted on cyclists and runners by Emeran et al. (2022). This study's training interruption time was significantly longer in the COVID-19 group. The reduction in training variables was seen in both COVID-19 and non-COVID groups; however, they did attribute limitations to their study (Emeran A, 2022). To the best of the researcher's knowledge, this was the only other study to date looking at recreational endurance athletes using GPS data.

In this study, recommendations from the above study were accounted for, and it was found that the majority of the participants experienced a return to running performance timeline of more than three months (22 participants) and between 1 and 3 months (8 participants). A smaller number had a return to running performance within 1–4 weeks. The deduction can be made that the infection affected the runner's return to running in this sample population.

5.6 Analysis of the most common symptoms affecting the return to running

Previous studies that looked at recreational runners could not attribute to the reasoning behind the reduction in training parameters. The reasoning was inconclusive. In this study, the most affected aspect of return to running was questioned, and fatigue was the most common symptom noted, with shortness of breath being the second most common symptom. This is in correlation with other studies that have shown that fatigue is the most prominent symptom experienced as a lingering effect of COVID-19 (Davis et al., 2021; Huang et al., 2022; Su et al., 2022; Zachary Abbott, 2023).

Chapter 6 Conclusion, Limitations and Recommendations

6.1 Main Study Results

This study has shown interesting results within the sample population. While several factors were seen to be affected by the infection when compared to two- and four-week post-infection measurements, another factor would most likely need to be determined as well. Environment, vaccination, and lockdown restrictions are all to be determined as an effect of these measures.

A significant decline in a proxy measure of performance parameters was noted in the 5 km time trial, RPE measures, race pace, and resting heart rate from the results. The symptoms runners experienced were noted in research by other studies and are taken as the common symptoms affecting return to life and sport. This study has the potential to be taken forward on a bigger scale to provide a generalisation of the results to the public.

COVID-19 is clearly a multi-factorial systemic infection that has a wide range of symptoms. However, specific symptoms of the infection have lasting effects on the population, and some may need further medical attention.

6.2 Limitations

The small sample size does not allow for generalisation of the findings. The confidence level could not be reached due to the limitation in sample size. A further limitation of the study was the absence of gender as a variable. The research relied on recall and could explain the high level of missing data. Limitations to this study include the absence of gender as a variable to determine the differences between genders. In addition, there was a sample size compared to the targeted sample population, and data was missing. All can serve as recommendations to strengthen the results of the targeted objectives.

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6.3 Recommendations

A study that remains open for a longer period to work with different runners who have presented with COVID more recently may assist with the accurate recollection of results and allow for more time to collect a greater sample size. A prospective study would provide significantly better data and better monitoring of participants to determine better associations including in person monitoring and more progressive tracking device data availability. Working together with health professionals like doctors, laboratories, or hospitals to identify participants who may be testing positive for COVID-19. Working with runners from the start of their symptoms will help log their accurate tracking data in real-time when returning to running and prevent any recall bias.

Taking the results of the most common symptom affecting return to running – shortness of breath – and conducting a further study to look deeper into this. This will determine the cause and effect of the symptom experienced most frequently. In addition, those with the equipment to conduct lab work should include VO2 max levels and cardiorespiratory readings to accurately represent performance.

Lastly, acknowledging different aspects of the virus would be a good study to consider. Aspects like vaccination, comorbidities, environmental factors, and different strains of the virus. These could lead to multiple studies to investigate in the future.

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List of Appendices

Appendix A: Informed Consent

<u>**UNIVERSITY OF CAPE TOWN**</u>

FACULTY OF HEALTH SCIENCES

DEPARTMENT OF HEALTH AND REHABILITATION SERVICES

DIVISION: PHYSIOTHERAPY

Dear participant

Thank you for considering being part of this research. Usraa Gani is an MSc Student who will be conducting this research as part of her thesis. This research is supervised by A/Prof. Soraya Maart (UCT) and A/Prof. Phillipe Gradidge (WITS). To be a part of the research, we need to obtain permission to use the information that you provide to us. We would like to explain the research in more detail so you can make a comfortable decision.

The research topic is as follows: **Exploring the impact of COVID-19 on the athletic performance of roadrunners in the Cape Town area.**

The reason for conducting this study stems from the lack of extensive knowledge of this area of concern among runners in South Africa. We are aware of studies done internationally, across multi-sport disciplines and at various points in the past two years. We believe this research could add to the pool of knowledge by focusing on road running as a sport and a relatable study by being conducted locally in South Africa.

We will conduct the research by asking you a series of questions dating back to 2020 at the beginning of the pandemic. The questions will provide options for answers, and you will pick the one that best suits you. Screenshots of your tracking device data will also be required. This should not require more than 15-20 minutes of your time.

Ethical considerations will be in accordance with the Declaration of Helsinki:

Informed consent

Autonomy will be practised across all participants in which the participant will have the right to decide whether he/she would like to be part of the study, and in any case, that the participant would like to withdraw from the study, they will be able to do so. This is explained in the informed consent form, along with a description of the study, its risks and benefits, and its main purpose. This allows the study to be voluntary.

Professionalism

This study will communicate with participants in a professional manner. All measurement tools used will be developed from the search of healthcare professionals. The study questionnaire was self-developed by a qualified healthcare professional.

Anonymity

All identification will be anonymous, and number systems will used. If credit is needed for any quotations used by participants, permission will be obtained from the participant.

Risks of the study

If any feelings of anxiety and fear stem from recalling this vulnerable time, participants may choose to remove themselves from the study.

Benefits of the study

All results will be relatable to those roadrunners, specifically local roadrunners, in South Africa. Therefore, participants will have the results summarised and shared with them.

POPI Act

Recruitment and data collection will be done in accordance with the POPI Act. The data collected will be stored on a password-access laptop in a password-access folder for five years after the study has been completed. Discarding information will be cleared through all processes in which it was stored.

By agreeing, you accept to be a part of the research stated above and will provide information as truthfully as possible.

☐ I agree.

____

Signature

Contact information for any queries or questions:

"The UCT FHS Human Research Ethics Committee can be contacted on 021 406 6338 in case participants have any questions regarding their rights and welfare as research subjects on the study."

Researcher: Usraa Gani
Email: usraa.gani@gmail.com

Supervisor: A/Prof. Soraya Maart (UCT)
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Supervisors: A/Prof. Philippe Gradidge (WITS)
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Appendix B: Email To Athletics South Africa

<u>UNIVERSITY OF CAPE TOWN</u>

FACULTY OF HEALTH SCIENCES

DEPARTMENT OF HEALTH AND REHABILITATION SERVICES

DIVISION: PHYSIOTHERAPY

Dear Athletic South Africa

I, Usraa Gani, am a first year Master's candidate at the University of Cape Town. As my research topic, we are looking to recruit Cape Town roadrunners. Many struggles have been noticed in the athletic population on return to activity post-COVID infection as well as the post-lockdown period of detraining. This led to the development of the topic: The effect of COVID-19 on athletic performance.

To conduct the research, I need a close estimate of the number of registered road runners in Cape Town at the beginning of 2020 in order to calculate the sample size and ensure the credibility of the research results. We will conduct the research on the runners by determining the differences experienced prior to, during, and after COVID-19 through a series of close-ended quantitative questions. I humbly request your assistance in this regard by providing me with a figure of the number of roadrunners in the Cape Town region at the beginning of 2020.

Contact information for any queries or questions: The UCT FHS Human Research Ethics Committee can be contacted at 021 406 6338 in case participants have any questions regarding their rights and welfare as research subjects in the study.'

<u>Researcher:</u> Usraa Gani

Email: usraa.gani@gmail.com

<u>Supervisor:</u> A/Prof. Soraya Maart (UCT)

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Appendix C: Email to the Running Club Chairperson

<u>UNIVERSITY OF CAPE TOWN</u>

FACULTY OF HEALTH SCIENCES

DEPARTMENT OF HEALTH AND REHABILITATION SERVICES

DIVISION: PHYSIOTHERAPY

Dear Chairperson of (insert running club name)

I, Usraa Gani, am a first year Master's candidate at the University of Cape Town. As my research topic, we are looking to recruit Cape Town roadrunners. Many struggles have been noticed in the athletic population on return to activity post-COVID infection as well as the post-lockdown period of detraining. This led to the development of the topic: The effect of COVID-19 on athletic performance.

I would humbly like to request a platform (WhatsApp or Email threads) to reach the roadrunners of your running group that have been running prior to COVID-19. We will conduct the research on the runners by determining the differences experienced prior to, during and after COVID-19 through a series of quantitative open-ended and close-ended questions. We will have the questionnaire as a Google form to make it easily accessible to runners. We will also develop a questionnaire that would acquire nothing more than 15 minutes of the runner's time to accommodate the busy lifestyles of many. All participants will be taken through the process and will have the right to retract their participation in the research. Results from the research will be communicated to participants with requests from those who are interested.

We humbly request your consideration to participate in the research as it is a growing field of knowledge. The more we add to this knowledge, the more the management of sports performance and recovery will grow.

We appreciate your time.

Contact information for any queries or questions:

"The UCT FHS Human Research Ethics Committee can be contacted on 021 406 6338 in case participants have any questions regarding their rights and welfare as research subjects on the study."

Researcher: Usraa Gani
Email: usraa.gani@gmail.com

Supervisor: A/Prof. Soraya Maart (UCT)
Email: Soraya.maart@uct.ac.za

Supervisors: A/Prof. Philippe Gradidge (WITS)
Email : philippe.gradidge@wits.ac.za

Appendix D : Questionnaire

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES

DEPARTMENT OF HEALTH AND REHABILITATION SERVICES

DIVISION: PHYSIOTHERAPY

QUESTIONNAIRE:

GENERAL

What is your age?

What is your height?

What is your weight?

Do you have any of the following?

- Kidney disease
- Diabetes
- Heart disease
- Respiratory conditions (Asthma, COPD, anything respiratory-related)
- Autoimmune conditions

Please use your tracking device data from 2 weeks prior to infection to answer the questions below:

What would be the distance that you race most often?

- 5km
- 10km
- 21km and above

What was your average race pace for the distance that you have chosen above?

- 4.00km/h – 4.5km/h
- 4.5km/h - 5.0km/h
- 5.0km/h – 5.5km/h
- 5.5km/h – 6.0km/h
- 6.0km/h – 6.5km/h
- 6.5km/h – 7.0km/h
- 7.0km/h – 7.5km/h
- 7.5km/h – 8.0km/h

Describe your rating of the perceived effort of the race you have chosen above.

- Weak
- Moderate
- Neutral
- Strong
- Very strong

What was your calculated VO2 max reading from your tracking device for this distance race?

What was the time achieved from your latest 5 km time trial prior to infection?

What was your calculated VO2 max reading from your tracking device for this time trial?

What was your resting heart rate prior to infection?

Please provide your tracking device data from 2 weeks before infection.

<u>COVID-19 and Post- Acute Sequelae of COVID-19 (PASC/long COVID):</u>

Have you tested positive for COVID-19 since December 2020?

- Yes
- No

What was the duration of your infection period?

- One week
- Two weeks
- 3-4 weeks

Were you hospitalised?

- Yes
- No

Did you stop training completely during your infection period?

- Yes
- No

Please choose your symptoms experienced using the symptom checklist at the end of the questionnaire:

SYMPTOMS	tick
Fever	
Headaches	
Cough	
Fatigue	
Joint pain	
Muscle aches	
Tightness of chest	
Chest pain	
Muscle spasm	
Palpitations	
Tachycardia (high heart rate)	
Bradycardia (low heart rate)	
Night sweats	
Chills	

SYMPTOMS	tick
Eating Disorders	
Dyspnoea (short of breath)	
Weakness	
Diarrhoea	
Anosmia (Loss of smell)	
Ageusia (Loss of taste)	
Vertigo/balance issues	
Heightened allergies	
New allergies	
Shingles	
Hospitalisation (oxygen support)	
Hospitalisation (no oxygen support)	
ICU admission	
ASYMPTOMATIC (no symptoms)	
Anxiety	
Depression	
Irritability	
Aggression	

Did you experience any PASC(long COVID) (symptoms that presented 3-4 weeks after initial positive test)

- Yes
- No

Please choose the symptoms that you experienced as PASC(long COVID) using the symptom checklist at the end of the questionnaire:

SYMPTOMS	tick
Post-exertional Malaise	
Fatigue	
Shortness of breath	
Chest pain	
Muscle pain	
Headaches	
Brain fog	

SYMPTOMS	tick
Joint pain	
Headaches	
Chills	
Memory issues	
Palpitations	
Dizziness	
Tachycardia (high heart rate)	
Bradycardia (low heart rate)	

How long did you wait to return to running after your infection?

- Immediately
- 4-5 days
- One week
- Two weeks

Which of the symptoms in the checklist affected you the most in your return to running? In order of most to least.

1.
2.
3.
4.
5.

What was your race pace for your race distance (chosen above) within two weeks post-infection?

- 4.00km/h – 4.5km/h
- 4.5km/h - 5.0km/h
- 5.0km/h – 5.5km/h
- 5.5km/h – 6.0km/h
- 6.0km/h – 6.5km/h
- 6.5km/h – 7.0km/h
- 7.0km/h – 7.5km/h
- 7.5km/h – 8.0km/h
- Did not run my race distance.

Describe your rating of perceived effort of your race distance (chosen above) two weeks post-infection:

- o Weak
- o Moderate
- o Neutral
- o Strong
- o Very strong

What was your calculated VO2 max reading from your tracking device for this distance two weeks post-infection?

What was your time achieved from your 5 km time trial at two weeks post-infection? **Using tracking data results**

What was your resting heart rate two weeks post-infection? Using tracking data results

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What was your calculated VO2 max reading from your tracking device for this time trial?

<u>PASC (LONG COVID) – please only answer if you experienced symptoms 3-4 weeks post-infection:</u>

What was your race pace for your race distance four weeks post-infection?

- o 4.00km/h – 4.5km/h
- o 4.5km/h - 5.0km/h
- o 5.0km/h – 5.5km/h
- o 5.5km/h – 6.0km/h
- o 6.0km/h – 6.5km/h
- o 6.5km/h – 7.0km/h
- o 7.0km/h – 7.5km/h
- o 7.5km/h – 8.0km/h
- o Did not run my race distance.

Describe your rating of the perceived effort of your race you have chosen above at four weeks post-infection:

- Weak
- Moderate
- Neutral
- Strong
- Very strong

What was your calculated VO2 max reading from your tracking device for this distance post-infection?

What was your time achieved from your 5 km time trial at four weeks post-infection? Using tracking data results

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What was your calculated VO2 max reading from your tracking device for this time trial?

What was your resting heart rate four weeks post-infection? Using tracking data results

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How long did it take you to return to your pre-infection 5 km time trial?

- Immediately
- One week
- Two weeks
- 3-4 weeks
- 1 -3 months
- More than three months

Please provide your tracking device data from the time of infection to 4 weeks after infection.

This is the end of the questionnaire. Thank you for participating!

Appendix E: Symptom Checklist

Symptom checklist (COVID-19) developed from the literature that covers cardiovascular, systemic, immune and autoimmune, and muscular symptoms (Davis et al., 2021):

SYMPTOMS
Fever
Headaches
Cough
Fatigue
Joint pain
Muscle aches
Tightness of chest
Chest pain
Muscle spasm
Palpitations
Tachycardia (high heart rate)
Bradycardia (low heart rate)
Night sweats
Chills
Eating Disorders
Dyspnoea (short of breath)
Weakness
Diarrhoea
Anosmia (Loss of smell)
Ageusia (Loss of taste)
Vertigo/balance issues
Heightened allergies
New allergies
Shingles
Hospitalisation (oxygen support)
Hospitalisation (no oxygen support)
ICU admission

ASYMPTOMATIC (no symptoms)
Anxiety
Depression
Irritability
Aggression
Depersonalisation/derealisation
Anger
Sense of doom
Brain fog
Confusion
Memory loss

Symptom checklist PASC (LONG COVID), 3–4 weeks after initial onset of the virus. This checklist was developed from symptoms reported in the literature (Davis et al., 2021):

SYMPTOMS
Post-exertional Malaise
Fatigue
Shortness of breath
Chest pain
Muscle pain
Headaches
Brain fog
Joint pain
Headaches
Chills
Memory issues
Palpitations
Dizziness
Tachycardia (high heart rate)
Bradycardia (low heart rate)

Appendix F: Ethical Approval and Renewal

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room 45 E-52-E-Floor- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-submissions@uct.ac.za
Website: www.health.uct.ac.za/home/human-research-ethics

06 April 2023

HREC REF: 100/2023

A/Prof S Maart
Department of Health & rehab Sciences
F-45 OMB
Email: soraya.maart@uct.ac.za
Student: Usraa.gani@gmail.com

Dear A/Prof Maart

PROJECT TITLE: A CROSS-SECTIONAL STUDY ON THE EFFECTS OF COVID-19 ON ROADRUNNERS IN CAPE TOWN-
MASTERS CANDIDATE-MISS USRAA GANI

Thank you for your response letter, addressing the issues raised by the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30 April 2024.

Please submit a progress form, using the standardised Annual Report Form (FHS016) if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Miss Usraa Gani will also be involved in this study.

Please quote the HREC REF 100/2023 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

Signed by candidate

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE

Federal Wide Assurance Number: FWA00001637. Institutional Review Board (IRB) number: IRB00001938 NHREC-registration number: REC-210208-007

HREC/ref 100.2023

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2020), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

HREC/ref 100.2023

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938) **This serves as notification of annual approval, including any documentation described below.**			
☑ Approved	Annual progress report	Approved until/next renewal date	30.4.2025
☐ Not approved	See attached comments		
Signature Chairperson of the HREC/ Designee	Signed by candidate	Date Signed	11/5/2024

Note: Please email this form and supporting documents (if applicable) in a combined pdf-file to hrec-enquiries@uct.ac.za.

Please use the latest form found on our website:
http://www.health.uct.ac.za/fhs/research/humanethics/forms

HUMAN RESEARCH ETHICS COMMITTEE
- 9 MAY 2024
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN

Comments to PI from the HREC

Principal Investigator to complete the following:

1. Protocol information

Date (when submitting this form)	30 APRIL 2024		
HREC REF Number	100/2023	Current Ethics Approval was granted until	30April2024
Protocol title	A CROSS-SECTIONAL STUDY ON THE EFFECTS OF COVID-19 ON ROADRUNNERS IN CAPE TOWN		
Protocol number (if applicable)			
Are there any sub-studies linked to this study?		☐ Yes	X☑ No
If yes, could you please provide the HREC Reference number for all sub-studies? **Note:** A separate FHS016 must be submitted for each sub-study.			
Principal Investigator	A/PROF. SORAYA MAART		