Review Article

Post-COVID-19 Workplace Health: Addressing Musculoskeletal Concerns

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ABSTRACT: *This review aimed to delve into the intricate interplay between coronavirus disease 2019 (COVID-19) and the musculoskeletal system within the workplace context. It highlights the critical role of the musculoskeletal system in manual tasks, energy production, and physiological adaptations. The effects of COVID-19 on musculoskeletal health, particularly its prevalence and persistence, are thoroughly examined. Potential mechanisms underlying muscle damage are discussed, encompassing inflammation, vitamin D deficiency, hospitalisation effects, and treatment effects. This comprehensive analysis highlights the importance of addressing musculoskeletal concerns in the post-COVID-19 work environment, ensuring that the well-being and productivity of the workforce are prioritised.*

Keywords: *COVID-19, Ergonomics, Long COVID, Manual Handling, Musculoskeletal System, Occupational Health*

1.0 INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a viral infection caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the respiratory tract. SARS-CoV-2 can cause significant inflammatory and oxidative stress, damaging the pulmonary alveoli and leading to severe acute respiratory distress syndrome (ARDS), bilateral viral pneumonia, and respiratory failure (Xu et al., 2020; Zhou et al., 2020).

The skeletal muscle, the body's most significant tissue responsible for glucose metabolism, is one of the tissues damaged by SARS-CoV-2 (Nasiri et al., 2020; Zhu et al., 2020). Muscle soreness is one of the most common symptoms in hospitalised individuals after contracting SARS-CoV-2 infection during the first 3 days of infection (Nidadavolu & Walston, 2021; Paliwal, Garg, Gupta, & Tejan, 2020; Vacchiano et al., 2020). Meta-analytic investigations have demonstrated that myalgia (muscular tiredness) is the third most prevalent symptom in patients with SARS-CoV-2 symptoms (after persistent fever and cough). The duration of myalgia mainly depends on the severity of the condition (Akbarialiabad et al., 2021; Zhu et al., 2020). However, the exact mechanism and effects on the musculoskeletal system are poorly understood, especially among workers, and current data show that almost 10% of post-COVID-19 patients experience long COVID (Sivan & Taylor, 2020). Long COVID is defined as any illness in individuals who have either recovered from COVID-19 but with lasting effects or have had the usual symptoms for far longer than expected (Mahase, 2020). According to the Occupational Safety and Health Act (OSHA, 1994), employers are generally responsible for ensuring the safety, health, and welfare of workers, including workers with a history of COVID-19 (Kementerian Sumber Manusia, 1994). This review aimed to examine (i) musculoskeletal involvement at work, (ii) the effects of COVID-19 on the musculoskeletal system, and (iii) the possible mechanism of musculoskeletal damage among workers with a history of COVID-19.

2.0 MUSCULOSKELETAL DEMAND AT WORKPLACE

In the workplace, manual handling activities require employees to engage in various physical tasks. These tasks encompass actions, such as lifting, carrying, moving, and maintaining specific body postures. To accomplish these tasks effectively, the human body relies on the musculoskeletal system, which comprises bones, muscles, and connective tissues.

Within this complex system, each skeletal muscle has a highly organised structure consisting of numerous elongated muscle fibres. These muscles work in concert through the intricate interplay between actin and myosin, which occurs primarily within the sarcomere. The sarcomere is the fundamental unit responsible for muscle contraction and relaxation. It is crucial to understand the importance of the coordinated efforts of actin and myosin in the range of activities involved in manual handling, including eccentric contractions (muscle lengthening), concentric contractions (muscle shortening), and isometric contractions (muscle tension without length change) (Marieb & Keller, 2018). Fig. 1 shows the interaction between actin and myosin; both can slide against each other during the contraction process as actin filaments can curl around and slide along the stationary myosin rods (Grandjean & Kroemer, 1997).

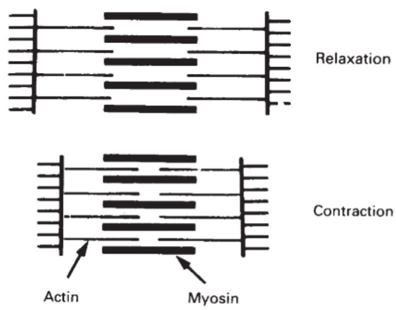

Figure 1: Model of Muscle Contraction Adapted From Kroemer & Grandjean (2009)

Every muscle movement requires energy from the food intake. Foods comprise macronutrients and micronutrients that work synergistically to meet the body's physiological demands. Carbohydrates, proteins, and fats are converted into energy through various pathways.

Manual handling involves muscle activity required to break down adenosine triphosphate (ATP) to contract or relax. In our muscle cells, mitochondria are energy-producing factories that ensure that our body has a continuous supply of ATP to work (Marieb & Keller, 2018). There are three primary sources of ATP in the muscles: creatine phosphate, oxidative phosphorylation (aerobic metabolism), and anaerobic glycolysis (anaerobic metabolism) (Ministry of Health Malaysia, 2017). Thus, the body can automatically adapt to the physiological demands during physical movements at work. A commonly observed manifestation of COVID-19 is diminished appetite and gustatory impairment (Hossain et al., 2021). This symptom can lead to a decrease in dietary intake, consequently perturbing the equilibrium of macronutrients indispensable for the generation of ATP, a pivotal energy currency that enables muscular contractions during occupational activities. Macronutrients include carbohydrates, proteins, and fats, all of which play integral roles in facilitating the body's capacity to produce ATP.

At the beginning of work activity, most of the energy provided to the musculoskeletal system comes from the creatine phosphate system and anaerobic metabolism when muscles have insufficient oxygen for aerobic metabolism. Our metabolic system requires approximately 1–3 min of adaptation before any changes occur (Wickens, Lee, Liu, & Gordon-Becker, 2014). Prolonged usage of anaerobic metabolism produces lactic acid, an accumulation of lactic acid-induced muscle fatigue and soreness. Excessive lactic acid accumulation interferes with pH, calcium release, troponin C sensitivity, and cross-bridge cycling, thereby reducing the ability of the muscle to generate force (Tidball, 2011). The ability to generate muscle force can reduce worker productivity, particularly during strenuous manual handling activities. However, during low-to-moderate manual handling tasks, energy may originate from aerobic metabolism. Subsequently, the body adapts to metabolic demands, and several physiological changes occur. For example, the respiratory system can increase the breathing frequency. By increasing the breathing frequency, lung capacity can be increased along with oxygen uptake ('Your lungs and exercise', 2016). Simultaneously, the circulatory system adapts by increasing the heart rate to increase the cardiac output. Increased cardiac output means that more blood is pumped out from the heart, and more oxygen with essential nutrients reaches the muscles for force generation activity (Marieb & Keller, 2018). With oxygen available, our cells use glucose to produce energy, carbon monoxide, and water as by-products. Both by-products can be disposed of through breathing, sweating, and urination.

Aerobic metabolism is energy efficient for the musculoskeletal system because the fuel sources for this reaction are glucose, pyruvic acid, free fatty acids, and amino acids (Hargreaves & Spriet, 2020). In addition, the aerobic metabolism produces more energy than the other two energy-generating systems. Failure of the system to adapt and supply critical nutrients during multiple tasks at work may cause physiological changes, such as musculoskeletal disorders, and reduce cognitive ability. The efficiency of the body in replenishing essential nutrients for muscle activity also depends on the training level of the worker, age, sex, medical history, nutritional status, and work environment (Abdelhamid & Everett, 2000).

The muscle adapts to changes in its mechanical environment by modifying gene expression and protein stability, thereby affecting its physiological functions and mass. Skeletal muscle constantly adapts to changes in its mechanical environment. However, mechanical stress frequently exceeds the parameters that cause adaptation, resulting in acute injury rather than adaptation. A healthy individual's adaptation process through injury–repair regeneration is based on several theories as explained by Tidball (2011). These include (i) activation of proteases and hydrolases that contribute to muscle damage, (ii) activation of enzymes that drive the production of mitogens for muscle and immune cells involved in injury and repair, and (iii) enabling protein–protein interactions that promote membrane repair. However, COVID-19 may impair injury repair and regeneration in workers.

3.0 EFFECTS OF CORONAVIRUS DISEASE 2019 (COVID-19) ON THE MUSCULOSKELETAL SYSTEM

The relationship between SARS-CoV-2, the virus responsible for COVID-19, and its predecessor, SARS-CoV-1, which causes severe acute respiratory syndrome (SARS), is of significant interest. Both the viruses primarily target the respiratory system; however, their effects extend to multiple organ systems, including the musculoskeletal system. Drawing from epidemiological findings during the 2002–2004 SARS pandemic, it became evident that patients with moderate and severe SARS often experienced a range of musculoskeletal issues. These include myalgia, muscle dysfunction, and conditions, such as osteoporosis (OP) and osteonecrosis. Although the two viruses are not identical, computational biology and in vitro experimental studies have highlighted a substantial similarity in their pathological responses to SARS-CoV-1 and SARS-CoV-2 infections (Disser et al., 2020).

Musculoskeletal issues have become a prevalent concern in individuals affected by COVID-19, with back pain being the most reported problem (Jacob et al., 2022). This observation emphasises the strong association between COVID-19 and musculoskeletal symptoms, particularly the noteworthy presence of back pain. Interestingly, this study also revealed a significant association between musculoskeletal symptoms and underlying health conditions, including hypertension, diabetes, and obesity.

Another study by Jeyaraman, Selvaraj, Jeyaraman, Gollahalli Shivashankar, & Muthu (2022) among 2334 participants found a higher occurrence of musculoskeletal symptoms in individuals who were not vaccinated against COVID-19 than in those who were vaccinated. The study also found that musculoskeletal scores were significantly higher in males, those with lower educational attainment, individuals with comorbidities, and those who had not received the COVID-19 vaccination than their counterparts. The same study revealed a range of musculoskeletal symptoms associated with COVID-19, including joint pain, muscle soreness, new-onset back pain, fatigue, inflammatory joint conditions (symmetrical or polyarticular), reactive joint problems, OP, femoral head osteonecrosis, nerve-related disorders, myositis, and muscle diseases.

There were significant differences in physical assessment post COVID-19 infection. Individuals affected by COVID-19 experience persistent alterations in their range of motion, such as an increase in sitting-to-standing time, reduction in walking speed, and notable changes in gait patterns, even after the completion of an 8-week recovery period (Kowal et al., 2023). This was supported by another study by Karasu, Karataş, Yıldız, & Günendi (2023), who demonstrated that the use of a comprehensive set of outcome measures, such as the hand grip strength, five-times sit and stand test, modified Borg scale, Barthel index, and visual analogue scale, for myalgia improved the physical assessment over time but did not return to typical standards.

4.0 POSSIBLE MECHANISM UNDERLYING MUSCULOSKELETAL SYSTEM DAMAGE OF COVID-19

Known to be associated with substantial systemic inflammation, COVID-19 can cause severe cytokine responses in some individuals, particularly those with a previous infection history (Welch, Greig, Masud, Wilson, & Jackson, 2020). However, the underlying mechanisms that cause muscle wasting in patients with COVID-19 are unknown (Ali & Kunugi, 2021). Hence, some researchers have theorised that the development of muscle sarcopenia in patients with COVID-19 may be associated with various factors. These factors include inflammation, vitamin D levels, body weight fluctuations, duration of hospitalisation, dietary intake alterations, prolonged periods of bed rest, diminished physical activity, COVID-19 treatment regimens, and subsequent recovery processes (Nidadavolu & Walston, 2021; Perez et al., 2023; Pescaru et al., 2022; Welch et al., 2020).

4.1 Inflammation

Patients with COVID-19 who require critical care usually have high serum inflammatory cytokine levels (Huang et al., 2020). High concentrations of serum cytokines decrease messenger ribonucleic acid translational efficiency because of eukaryotic translation initiation factor 4E alterations (Lang, Frost, Nairn, MacLean, & Vary, 2002). High cytokine concentrations negatively affect muscle protein synthesis and anabolic resistance. To overcome anabolic resistance, patients are required to consume more protein. Aging is associated with increased cellular deterioration. Although aging cells have slowed their growth, they also secrete several inflammatory cytokines that may be exaggerated among ill and aged individuals (Coppé, Desprez, Krtolica, & Campisi, 2010; Foletta, White, Larsen, Léger, & Russell, 2011; Trinity et al., 2021).

4.2 Vitamin D Deficiency

Vitamin D deficiency should be significantly considered when examining the multifaceted factors contributing to muscle atrophy, particularly in type II muscle fibres (Ceglia, 2009). Moreover, there has been speculations regarding the role of vitamin D deficiency in influencing the immune system response to respiratory infections, with growing recognition that the deficiency itself may be a consequence of inflammation rather than its cause (Ceglia, 2009; Hansdottir & Monick, 2011). In this context, vitamin D deficiency is increasingly being considered a biomarker of heightened inflammation. Although some studies have drawn the association between low vitamin D levels and the development of COVID-19, establishing a direct causal association remains elusive as multiple confounding factors need to be considered (D'avolio et al., 2020; Hastie et al., 2020).

OP is characterised by a decline in bone mass accompanied by alterations in bone tissue microarchitecture, resulting in increased bone fragility and a heightened risk of fractures. In the assessment of OP, the significance of nutritional elements, such as calcium and vitamin D, cannot be understated. Notably, the risk of fractures attributable to OP a decade after its onset is substantial, reaching 40% (Moga et al., 2022).

4.3 Body Weight

Obesity plays a significant role in COVID-19 outcomes, as evidenced by a higher risk of hospitalisation, critical care admission, and fatality (Public Health England, 2020). This increased risk may be attributed to the association between obesity and elevated systemic inflammation, which may exacerbate the effect of acute illness on muscle metabolism. Moreover, the concept of sarcopenic obesity, characterised by reduced muscle mass and increased fat mass (Zamboni, Mazzali, Fantin, Rossi, & Di Francesco, 2008), adds complexity. Sarcopenic obesity is associated with ectopic fat and intramyocellular lipid deposition, both of which have the potential to detrimentally affect muscle structure (Batsis & Villareal, 2018). These factors may collectively contribute to a significant decline in muscle function and quantity among individuals with obesity and catabolic diseases (Welch et al., 2020). This interplay among obesity, inflammation, muscle metabolism, and body composition underscores the multifaceted nature of the effect of COVID-19 on individuals and provides valuable insights for further studies and clinical considerations (Vimercati et al., 2021).

4.4 Hospitalisation Period

The most significant changes in muscle function are observed among hospitalised patients who require extensive critical care (Disser et al., 2020). These changes are caused by systemic inflammation, prolonged bed rest, muscle relaxants to aid prone positioning, and the risk of viral spread (Luo et al., 2020). Acute sarcopenia has been documented in previously fit and active individuals but has shown significant decreases in muscular function during hospitalisation. This also results in a state of induced fragility, which makes them more vulnerable to stressful events in the future (Clegg, Young, Iliffe, Rikkert, & Rockwood, 2013; Mira et al., 2017). In addition, frailty weakens the immune system, rendering patients more vulnerable during recovery (Mira et al., 2017).

4.5 Dietary Intake

According to previously mentioned studies, inflammation is associated with catabolic states and anabolic resistance in patients with COVID-19, increasing nutritional demand, particularly for proteins. Despite this, several patients with COVID-19 cannot fulfil their most basic needs, such as food. Loss of taste and smell is a well-known sign of COVID-19, which can occur in up to two-thirds of all viral infections (Meng, Deng, Dai, & Meng, 2020) and results in reduced appetite. Furthermore, the elevation of proinflammatory cytokine levels, such as those observed in COVID-19, is related to leptin production and anorexia (Grunfeld et al., 1996). When the symptoms of anorexia in old age are combined, older individuals become more vulnerable to the effects of these conditions. Sarcopenia is also associated with the weakening of masticatory muscles, which may aggravate diminished food intake (Cox et al., 2020; Yoshida & Tsuga, 2020).

4.6 Bed Rest and Reduction of Physical Activity

Several individuals admitted to hospitals with COVID-19 are forced to stay in bed for extended periods and have limited physical activity levels. This may have been exacerbated by the isolation policies that restrict the movement of patients with COVID-19. Among those who do not require hospitalisation, patients with COVID-19 experience extreme fatigue (Huang et al., 2020; Zhu et al., 2020), which may limit their physical activity levels (Greenhalgh, Knight, A'Court, Buxton, & Husain, 2020). Restrictions placed on daily activities during the COVID-19 pandemic also contribute to reduced physical activity levels among patients (Kirwan et al., 2020). Furthermore, bed rest has been related to reducing muscle mass, strength, and aerobic performance even among healthy participants (Kortebein, Ferrando, Lombeida, Wolfe, & Evans, 2007; Kortebein et al., 2008).

4.7 Treatment of COVID-19 and Recovery Process

The use of dexamethasone may increase the rate of survival among patients with COVID-19 (The Recovery Collaborative Group, 2021). When combined with bed rest, medically induced hypocortisolemia causes more muscle loss than bed rest alone (Bodine et al., 2001; Paddon-Jones et al., 2006). Therefore, dexamethasone may increase the likelihood of acute sarcopenia in patients who are already at risk. In a previous study, a loss in lean muscle mass was observed in patients with ARDS during the year following their discharge from critical care (Chan et al., 2018). This indicates a long-lasting effect that prevents the formation of new muscles following severe acute illness. Sepsis-induced muscle regeneration in mice is severely limited, with increased fibrosis and decreased number of functioning satellite cells. As a result of sepsis or COVID-19, it is hypothesised that the body's ability to synthesise muscle is impaired, resulting in prolonged side effects of acute muscle wasting (Chan et al., 2018).

5.0 CONCLUSION

The intricate association between COVID-19 and the musculoskeletal system presents a multifaceted challenge, particularly in the workplace. The effects of this viral infection on skeletal muscle, coupled with the dynamics of manual handling activities, underscore a critical association that demands further attention and action. The effects of COVID-19 on musculoskeletal health extend beyond myalgia and acute symptoms. The long COVID phenomenon has emerged as a relatively uncharted territory, affecting a substantial portion of the workforce. Employers, as per OSHA (1994), bear the responsibility of safeguarding the health and welfare of their employees, including those with a history of COVID-19.

Understanding the complex mechanisms by which COVID-19 damages the musculoskeletal system is crucial. Inflammation, vitamin D deficiency, body weight fluctuations, hospitalisation duration, dietary intake alterations, and reduced physical activity levels contribute to the multifaceted challenge of musculoskeletal damage after post-COVID-19. These factors intersect and increase the risk of acute sarcopenia and other types of musculoskeletal damage.

Addressing this issue requires a holistic approach that encompasses adequate nutritional support, rehabilitation programmes, and close monitoring of post-COVID-19 workers. Collaborative efforts among healthcare providers, employers, and policymakers are essential to mitigate the long-term musculoskeletal consequences of COVID-19 and ensure the continued well-being and productivity of the workforce in the post-pandemic era. This study underscores the urgency of recognising the musculoskeletal dimensions in the fight against the long-term effects of COVID-19.

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