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EVALUATION OF THE EFFECTS AND CONSEQUENCES OF INACTIVITY DURING AND AFTER THE COVID-19 PANDEMIC

(Review study)

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Abstract

Since the emergence of the coronavirus, deaths have begun to increase rapidly. The weak immune system is shown as the most important factor in the death of individuals who cannot resist the coronavirus. The effects of COVID-19 on the immune system and the role of physical activity in this process represent a critical interaction on health. In this context, understanding this relationship reveals measures that can be taken to both reduce the effects of the disease and optimize immune system functions. For this reason, it is noteworthy that there are individuals who turn to nutrition and exercise programs to strengthen their immune systems. The right exercises are low and moderate-intensity exercises. The potential effects of COVID-19 on the cardiovascular system and the role of physical inactivity on cardiovascular health are critical for both epidemic and general health management. It is recommended that the heart rate should not exceed 130-140. In people exposed to the COVID-19 virus, physical activity should be suspended according to the body guide, and if necessary, it should be restarted in a non-severe way under the supervision of a doctor. With the impact of the pandemic, restrictions, and social isolation, individuals' physical activity levels may decrease, but maintaining or improving healthy living habits during this period can have positive effects on both physical and mental health. Both healthcare professionals and individuals need to understand the systemic effects of lack of physical activity and the disease-causing muscle weakness, pain, and other musculoskeletal problems.

Keywords: COVID-19; Physical Activity; Exercise; Health; Sport.

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1. Introduction

Coronavirus disease (COVID-19), an infectious disease caused by Coronavirus 2 (SARS-Cov-2) which is the causative agent of severe acute respiratory syndrome was first detected in Wuhan, China, in December 2019 (Pan et al., 2020; Lake, 2020; Gabutti et al., 2020). In December, more than 6 million deaths were confirmed by the World Health Organization (WHO) (WHO, 2023).

Due to the COVID-19 pandemic, tens of thousands of patients have been hospitalized and millions of people were also forced to stay in a limited area. Possibly, inactivity (hospitalization and bed rest) and changes in lifestyle resulting from quarantine and physical inactivity may cause second-wave epidemics to impact the health and well-being of both those infected and the general population (Gasmi et al., 2020). To provide a general perspective on the potential effects of physical inactivity on human health during the fight against the COVID-19 epidemic worldwide, certain physical activity guidelines are recommended for people who have been negatively affected during and after the pandemic period and who have recovered from the infection (Woods et al., 2020).

The damage that coronavirus can inflict on a person is determined not only by factors such as age, gender, race, and medical conditions but also by the individual's lifestyle during the pandemic (Woods et al., 2020). In this study, information is given about the effects of the COVID-19 epidemic and physical inactivity on the immune system, respiratory system, cardiovascular, and musculoskeletal systems. In addition, the effect of COVID-19 on brain functions, good and proper nutrition during the pandemic, how exercising during and after the pandemic can help us protect ourselves against the virus epidemic are examined, and information is provided about what we should protect ourselves and how this can help us recover. Therefore, the study aims to evaluate the effects of inactivity during and after COVID-19.

2. Method

Collection of Data

Our study examines the effects and consequences of physical inactivity during and after the COVID-19 epidemic. To examine the evaluation, literature sources were scanned. A qualitative research method was used as the method, and subject-specific article studies and internet scanning were conducted.

Data Collection Tool

In this study created with the traditional compilation method; these issues were examined and evaluated based on studies conducted in the literature using the keywords COVID-19, physical activity effects, and exercise plan in Pub Med, Google Scholar, and Web Science databases.

3. Results

In this section, the effects of COVID-19 on different variables were researched and evaluated.

3.1. COVID-19 and the impact of physical inactivity on structure

The SARS-CoV-2 virus causes COVID-19, which is characterized by the main symptoms of fever, dry cough, myalgia, and fatigue (Yuki et al., 2020). Because this virus is new to the human immune system, we are dependent on the dispositions of our innate immunity to cope with the infection. Like most viral infections, if we get over the infection, within weeks, we develop virus-specific antibodies and cell-mediated immune responses. In most cases, our immune system's response to exposure to this virus gives us long-term protection against reinfection or, if reinfected, symptoms of the disease are much milder. Public health to prevent the spread of SARS-CoV-2 recommendations (i.e. stay-at-home orders, closure of parks and gyms) have the potential to reduce daily physical activity (PA). These recommendations are unfortunate because daily exercise can help fight disease by strengthening our immune system and eliminating some comorbidities such as obesity, diabetes, hypertension, and heart conditions that make us more susceptible to severe COVID-19 disease (Siordia, 2020). An early epidemiological study suggested that intense, prolonged exercise was associated with an increase in upper respiratory tract infections (Nieman et al., 1990). This study led to the concept of the inverse J theory, where prolonged, high-intensity exercise increases susceptibility to infection, while moderate exercise reduces it (Nieman, 1994). Many studies have supported the theory regarding individual immune parameters, including those specific to viral defense. For example, salivary lactoferrin and secretion rate increase after moderate exercise increased up to 2 hours (Svendsen et al., 2016). Mucosal lactoferrin is important because by binding and blocking host receptors, it can prevent DNA and RNA viruses from establishing infecting cells. Conversely, low levels or secretion rates of salivary immunoglobulin A, which can bind to and inactivate viruses, have been shown to be associated with upper respiratory tract infection in some athletes who train intensely (Gleeson et al., 2012). Additionally, because PA and exercise cause profound mobilization of leukocytes in the blood and tissues (Rooney et al., 2018), it is theorized that being physically active increases immune surveillance against all types of disease-causing organisms and substances, including viruses (Woods et al., 2020).

The pandemic process experienced worldwide has necessitated a series of measures to protect public health. Among these measures, following social distance and hygiene practices meticulously has an important place. Disruption of PA and exercise routines and reduced physical fitness may increase susceptibility to infection and, if prolonged, may certainly increase some of the comorbidities associated with poor COVID-19 outcomes. It does not make sense to engage in very intense prolonged exercise if you are not used to this type of activity, as long exercise sessions can lead to decreased immune responses. Less than It is good practice to start exercising at intensities and durations and gradually progress. It is good practice to start exercising at lower intensities and durations and gradually progress. For example, walking is the most natural and practical form of exercise and is beneficial to many organ systems (Woods et al., 2020). In today's conditions, people need to exercise, regardless of their age, so that they can healthily continue their lives (Taşkın, 2019). To live a healthy life and strengthen the immune system, it is necessary to include exercise in our daily routine.

3.2. COVID-19, physical activity and respiratory system

As the clinical course of the COVID-19 pandemic continues to be investigated, many COVID-19 patients develop respiratory failure and require mechanical ventilation (MV) to maintain adequate pulmonary gas exchange. In this context, a recent report reveals that ∼54% of patients hospitalized with COVID-19 experience respiratory failure, and >30% require MV (Zhou et al., 2020).

Although MV is often a life-saving intervention, an undesirable consequence of prolonged MV is the rapid development of respiratory muscle weakness due to diaphragm muscle atrophy and contractile dysfunction (collectively referred to as ventilator-induced diaphragm dysfunction, VIDD). VIDD is clinically important because diaphragmatic weakness is a significant contributor to the inability to wean patients from the ventilator (Dres, 2018). Many COVID-19 patients often require long periods on a ventilator, which increases the risk of weaning problems (Vassilakopoulos and Petrof, 2004). Although many organ systems adapt in response to endurance exercise training, the structural and functional properties of the lungs and respiratory do not change due to exercise training (McKenzie, 2012). Specifically, endurance exercise training promotes numerous biochemical changes in the diaphragm muscle that result in a phenotype that is protected against a variety of challenges, including prolonged MV (Power et al., 2020). Small amounts of endurance exercise training for up to 10 consecutive days provide significant protection against VIDD (Smuder, 2012; Smuder, 2019; Morton, 2019).

3.3. The impact of COVID-19 and physical inactivity on the cardiovascular system

PA is critical for cardiovascular health and is considered essential during the pandemic. Part of the strategy to reduce the spread of the virus is social isolation, but social isolation carries lower coronary artery risk with potential long-term consequences (Booth, 2000; Lightfoot, 2011). The effects of inactivity promote genes that are harmful to health. Inactivity for any reason reduces heart health, increasing the long-term risk of coronary artery disease and sudden cardiac death (Norman, 1958; Morris and Crawford, 1958). Current studies on daily steps and other exercise measures show that regular PA improves cardiovascular health and that those with higher fitness levels have better exercise stress test results (Mandsager et al., 2018; Lee et al., 2019).

Muscle aches accompanying influenza and coronavirus infections are well-known symptoms and are a result of direct and indirect damage to tissue. Muscle aches are likely caused by a combination of direct tissue infection and the inflammatory response of cytokines released to fight the viral invasion. Excessive release of cytokines (cytokine storm) is the dark side of the immune response responsible for tissue damage beyond direct viral infection. Although both the heart and peripheral muscle are infected with viruses, heart muscle infection has both short and long-term consequences. COVID-19 is no different and, as a new virus, it can trigger more extensive tissue damage in the heart. Infection of the heart muscle leads to myocarditis with the potential for acute myocardial infarction, heart failure, and/or arrhythmia (Inciardi et al., 2020; Bonow et al., 2020; Yang and Jin, 2020). During the acute infection phase, the adrenergic release may trigger acute coronary syndrome or fatal arrhythmias (Sribhutorn et al., 2016). Systemic viral infections also cause an inflammatory reaction that irritates the lining of the arteries. Inflammation in the coronary arteries allows ruptures in the tissue that holds plaques in place, leading to clot formation and plaque rupture, resulting in fatal arrhythmia or local hypoxia and death of heart tissue. Plaque rupture is a common cause of sudden cardiac arrest and death, both at rest and during exercise. Muscle sores caused by viral infection can trigger potentially fatal post-infectious and fatal exercise-related arrhythmias (Thompson, 2021).

During the COVID-19 pandemic, PA and exercise will play both a positive and negative role in individual health outcomes. On the negative side, COVID-19 infection increases the risk of cardiac

injury and cardiac death during exercise, and the increased risk may extend into the post-infection period. PA is not recommended during any systemic viral disease because the inflammatory reaction in muscle cells and coronary artery walls puts the affected person at risk of sudden cardiac death during and after infection. Data from postmortem analysis shows this is also true for COVID-19 patients (Inciardi et al., 2020; Yang and Jin, 2020). On the positive side, because every human being feels the need to move due to his biological structure, (Singh, 1991; Singh, 2004; Peker et al., 2019) regular PA and exercise promote cardiorespiratory fitness and longevity. Our advice to healthy individuals during and after the COVID-19 pandemic is to remain physically active and engage in socially distanced exercise when healthy, to stop exercise when signs or symptoms of infection develop, and to return to PA and exercise slowly following recovery. Social distancing requires some changes in perspective when exercising. During exercises such as running or cycling, a person following directly behind the infected person must be at a distance of 5-20 m to stay in the fresh air and breathe (Blocken et al., 2020).

Table 1. General Recommendation for Improving Human Health Against COVID-19

	Aerobic exercise (MICT)		Anaerobic exercise (RT and HIIT)	
	Exercise duration	**Exercise frequency**	**Exercise duration**	**Exercise frequency**
A initial target for normal population	≥150 min/wk; ≥30 min per time	3–5days/wk	4 × 4 min (3 min recovery); 4 × 5 min (3 min irecovery); 3 × 5 min (3 min recovery); 10 × 30 s (1 min recovery); etc.	Should to be tailored individually with professional characteristics
	10,000 steps/day; 64–170 steps/min with at least 10 min duration	Everyday	-	-
For weight loss purpose	>250 min/wk; >30 min per time	>5 days/wk	4 × 4 min (3 min recovery); 4 × 5 min (3 min recovery); 3 × 5 min (3 min recovery); 10 × 30 s (1 min recovery); etc.	Should to be tailored individually with professional characteristics

RT, resistance training; MICT, moderate-intensity continuous training; HIIT, high intensity interval training.

The table above provides a general recommendation for improving human health against COVID-19 (Wang et al., 2020).

Once fully recovered, it is reasonable for individuals with mild infections to gradually resume PA and exercise to return to pre-infection fitness. For people with more severe COVID-19 disease, returning to PA may require testing or imaging before exercise. If exertion-related symptoms such as palpitations, chest pain, exercise intolerance, or shortness of breath occur during return to exercise, evaluation with cardiac imaging and stress testing may be indicated to rule out COVID-19 cardiac injury before progressing to higher PA levels (Woods et al., 2020).

3.4. The impact of COVID-19 and physical inactivity on the musculoskeletal system

Daily PA is required to stay healthy. Our body constantly senses the internal environment and reacts to these changes (Hawley et al., 2014). The increased demands of contracting skeletal muscles during exercise represent a major challenge to body homeostasis and cause multiple responses in many organs. The metabolic rate of skeletal muscle can increase 100-fold with activation compared to resting conditions. Temporary acute responses occur to support the energy needs of working muscle fibers and to meet the PA and exercise challenges in our organism. As a result of the accumulation of activity sessions, the organism adapts to metabolic demands. PA and exercise adaptations refer to the long-term changes that occur in our bodies as a result of PA and exercise movements. Cardiac hypertrophy or resting bradycardia are two well-known examples of these adaptations (Hamilton, 2018). However, the musculoskeletal system, one of the largest tissues in the body, is the main target of exercise training. Plasticity describes the ability of our muscles to adapt to changes in activity and work demands. The adaptive event involves the entire muscle fiber structure, from the sarcolemma to the mitochondria, including myofibrils, extracellular matrix, and capillaries surrounding the muscle fibers (Pette, 2001).

Exercise is one of the most commonly prescribed treatments for both health and disease (Vina et al., 2012). However, western social lifestyle behaviors encourage physical inactivity. This situation has greatly worsened due to the control measures implemented by countries to control the expansion of the COVID-19 epidemic. Large numbers of people have been asked by health authorities to quarantine for extended periods, and this advice poses a significant challenge to staying physically active. Several models have given us information about the effects of inactivity on the musculoskeletal system; bed rest and limb immobilization are extreme experimental models. Reducing daily walking steps may indicate a more physiological pattern of reduced PA reflecting long-term incarceration risk (Bowden et al., 2019). The decrease in insulin sensitivity caused by physical inactivity in skeletal muscle contributes to the distribution of energy substrates to other tissues, which increases central fat accumulation (Rabøl et al., 2011). The body needs regular muscle activity throughout the day, whereas some of the most powerful mechanisms that regulate disease susceptibility, such as mitochondrial function and lipoprotein metabolism, are downregulated during physical inactivity (Hamilton, 2018). Mitochondrial homeostasis ensures that mitochondria, which are important for energy production and cellular functions in cells, remain in a healthy state. Muscle inactivity can affect mitochondrial functions because regular physical activity can promote mitochondrial adaptations.

Research shows that disruption of mitochondrial homeostasis due to muscle inactivity can lead to organic and systemic inflammation, an important mechanism for COVID-19 pathogenesis (Jackman and Kandarian, 2004; Ji et al., 2020).

3.5. COVID-19 infection and brain function

Although the main risks of COVID-19 are injuries to the upper and lower respiratory tract, other organs have also been affected by this viral infection. Entry of SARS-CoV-2 into human tissues is believed to be facilitated via angiotensin-converting enzyme 2 (ACE-2), but due to the weak absence of ACE-2 receptors in the central nervous system (CNS), the CNS is resistant to such viruses (Gu et al., 2005). As a matter of fact, when SARS-CoV-2 type viruses were administered intranasally to mice, it was shown that the virus settled in the thalamus and brainstem and was significantly lethal. This suggests that the CNS may be one of the targets of SARS-CoV-2. It is suggested that the virus can reach the CNS via trans-synaptic pathways through neural circuits (Li et al., 2013). Patients infected with SARS-CoV-2 have reported severe neurological symptoms manifesting as acute

cerebrovascular diseases, impaired consciousness, and skeletal muscle symptoms (Li et al., 2020). One of the most common protections against virus infections is quarantine. However, social isolation often causes psychological and mental disorders such as acute stress disorder, fatigue, detachment from others, irritability, insomnia, distractibility, fear, and anxiety. Data show that depression, anxiety, and post-traumatic disorders have significant effects on the immune system, resulting in mast cell activation, and increased production of cytokines such as IL-1, IL-37, TNFα, IL-6, and C-reactive protein (Dowlati et al., 2010).

3.6. The relationship between the COVID-19 virus and proper nutrition

Nutrition is an important factor for human health, including maintaining a strong immune system. However, current research shows that no single food or dietary supplement can prevent or treat COVID-19. On the contrary, improper intake, especially an overdose of dietary supplements, can be more harmful than beneficial. Clinical data shows that patients who die from COVID-19 are mostly elderly people with complications from other diseases and aging-related malnutrition (Laviano et al., 2020). It is undisputed that a balanced diet, getting enough vitamins and minerals, and avoiding processed foods are beneficial to the immune system. Making a nutrition plan in this direction will be appropriate in the protection and recovery processes from COVID-19 (Yücel et al., 2022). The immune system functions through special cells and actively protects the body against pathogenic organisms (bacteria, viruses, fungi, parasites). Healthy nutrition is extremely important in strengthening the immune system of individuals and protecting them against COVID-19 infection (Pekcan, 2020; Sönmez and Beyhan, 2021). Foods containing antioxidants, vitamins, and minerals can make the body resistant to infections. Nutrients containing vitamin A, vitamin C, vitamin D, vitamin E, and zinc are necessary for the better functioning of the immune system. As a result, a healthy diet is an important part of supporting the immune system and maintaining overall health during COVID-19.

3.7. Physical activity after COVID-19

Physical activity is important during and after COVID-19 to support the recovery process, increase energy levels, and maintain overall health.

After the COVID-19 outbreak, modern digital communication, social media platforms, personal video calls (Taşkın, 2023; Dumford et al., 2023) and appropriate exercises at home will have a positive effect on our general feeling of well-being.

Return to exercise after COVID-19 infection should occur gradually, with people with no or minimal symptoms aiming to return to pre-infection exercise habits within approximately 7-14 days (Hughes et al., 2022).

If you have been doing regular PA or exercise after COVID-19 and want to further improve cardiovascular and muscular fitness, it is not prudent to suddenly start a resistance exercise training program combined with intense aerobics or engage in unusually high-intensity prolonged exercise (Woods et al., 2020).

4. Discussion

The COVID-19 pandemic has brought about an extraordinary period experienced around the world. This epidemic has radically affected not only the healthcare sector but also our social, economic, and individual lives. The measures taken during the epidemic have caused several restrictions to change people's daily lives. One of these restrictions is the restriction or limitation of physical activities. The physical inactivity experienced during the epidemic and its aftermath has had significant effects on our health.

When the effect of COVID-19 and physical inactivity on the immune system is examined, the COVID-19 epidemic leaves various effects on the immune system. Physical inactivity can have a negative impact on the functions of the immune system. The fact that the immune systems of individuals who exercise and have sports habits are also developed is thought to make it easier to overcome this process (Karabulak, 2022). Maintaining physical activity levels becomes of paramount importance to improving immune function in the general population (Damiot et al., 2020).

Physical inactivity during the COVID-19 epidemic can reduce these positive effects and weaken the immune system's defense mechanisms.

When the effect of COVID-19 and physical inactivity on the cardiovascular system is examined, measures such as staying at home and social isolation due to the epidemic have distanced individuals from physical activities. This situation had negative effects on the cardiovascular system. Lack of regular exercise can reduce blood circulation, cause the heart muscle to weaken, and negatively affect vascular health.

Cardiovascular system diseases have the highest mortality rate all over the world. COVID-19 directly or indirectly affects the cardiovascular system. It increases morbidity and mortality in case of concomitant cardiovascular disease (Hiçerimez and Enç, 2021). Considering the harmful health effects of a sedentary lifestyle and the introduction of restrictions on physical activities, cardiovascular diseases have increased (van Bakel et al., 2021).

When examining the effects of COVID-19 on physical activity and the respiratory system, COVID-19 generally has direct effects on the respiratory system. It recommended that low-intensity exercise and moderate physical activity should be part of rehabilitation programs for COVID-19 patients (Dinh-Xuan et al., 2023). There are indications that individuals who engage in physical activity may increase clinical outcomes such as improvement of respiratory functions and shortening of the time spent in hospital in COVID-19 patients (Yang et al., 2022).

When the relationship between COVID-19 and proper nutrition is examined, it emphasizes the importance of strengthening general health and supporting the immune system. Proper nutrition ensures that the body gets the nutrients it needs, which can strengthen the immune system. All nutrients can be used as supplements in the fight against COVID-19 (Bakan et al., 2020). It is known that healthy nutrition has positive effects on the immune system, while inadequate and unbalanced nutrition disrupts immune system functions and increases susceptibility to infections. Therefore, in the prophylaxis and/or treatment of COVID-19, ensuring that people have an adequate and balanced diet and meet their vitamin and mineral needs; the immune system needs to maintain its normal functions (Kuru and Üstün, 2021).

When the effect of COVID-19 and physical inactivity on the musculoskeletal system is examined; COVID-19 and physical inactivity have various adverse effects on the musculoskeletal system. COVID-19 disease usually presents with symptoms such as weakness, fatigue, and shortness of breath. These symptoms may limit patients' daily physical activities and require prolonged bed rest.

Inactivity causes muscle weakness, atrophy, and joint stiffness. These negative effects on the musculoskeletal system cause patients to lose their general functions and have difficulty performing daily living activities.

COVID-19 infection severely affects function and mobility due to its impact on the musculoskeletal system (Said et al., 2022). Short and long-term musculoskeletal complications of the SARS-CoV-2 virus can be predicted in patients with moderate and severe COVID-19 (Gumucio et al., 2019). When COVID-19 infection and its effect on brain function are examined, the virus affects not only the respiratory system but also the nervous system, causing various neurological symptoms.

As a result of the studies conducted, the neurological damage caused by COVID-19; loss of taste and smell, headache, myalgia, cerebrovascular disorders, intracranial hemorrhage, encephalitis, encephalopathy, seizure, acute ischemic stroke are some of the neurological complications (Seçgin and Akyol, 2023). Since the early weeks of the COVID-19 pandemic, it has been clear that this condition often causes neurological symptoms, from headaches and brain fog to paralysis and paralysis. Neurological complications can also affect people with mild COVID-19 symptoms (Marshall, 2023).

When the impact of the COVID-19 epidemic on physical activity is examined, the epidemic has created various effects on physical activity. However, these effects can vary widely and vary between individuals.

Maintaining a regular physical activity routine in a reasonably safe environment is considered an appropriate strategy for healthy living and fitness during the coronavirus outbreak (Dogan and Cengizhan, 2021). To get through the pandemic process with the least damage, one should try to stay active at home. Making exercise programs planned taking into account personal characteristics a part of life will provide holistic effects that will protect and improve health in every aspect (Arslan and Ercan, 2020).

5. Conclusion

As a result, findings point to the fact that regular exercise can increase immune function and create a more resistant immune system against disease. Physical inactivity can negatively affect cardiovascular health. Not exercising regularly can have negative effects on the cardiovascular system, which can increase the possible effects of diseases such as COVID-19. In this context, it shows that regular physical activity can have a positive effect on the cardiovascular system, thus creating a more resistant state against virus infections.

The effects of COVID-19 on physical activity and the respiratory system are quite complex. The effects of physical activity on this process may lead to the thought that it may create an extra burden in a situation where the respiratory system is already strained during infection. However, it is also known that regular and controlled physical activity can strengthen the respiratory system and increase lung functions.

The impact of COVID-19 infection on the musculoskeletal system can negatively affect musculoskeletal health due to factors such as systemic inflammation, muscle weakness, and joint pain

caused by the disease. Therefore, post-infection rehabilitation and appropriate treatment strategies are important in preventing musculoskeletal complications and supporting the healing process.

It is suggested that proper nutrition can support immune system functions and provide better resistance to disease. In this context, a balanced nutritional habit has a positive effect on the body's effectiveness in fighting infections.

The impact of COVID-19 infection on brain functions includes potential neurological effects that may lead to changes in cognitive functions in individuals.

During the COVID-19 pandemic, its impact on physical activity may have generally decreased due to restrictions, social isolation, and other pandemic measures. However, while this may increase health problems due to physical inactivity in individuals, it is also possible to maintain or increase the level of physical activity with alternative methods such as exercises that can be done at home and online sports programs.

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