Functional and Psychological Changes in Post-COVID-19 Patients

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Keywords: COVID-19 ; coronavirus disease ; SARS-CoV-2 virus

1. Introduction

The COVID-19 virus was recognized worldwide by the World Health Organization in 2020, and the virus was able to spread rapidly worldwide [1]. So far, more than 98 million people have been infected with COVID-19, resulting in nearly 2.2 million deaths [2]. The world is still facing this virus, and it continues to a serious threat to everyone.

Symptoms such as muscle pain, fatigue, and weakness are reported in post-COVID-19 patients [3]. The exact action mechanisms of COVID-19 on patients is not determined. However, muscle changes such as necrosis and muscle atrophy are also reported [4]. Overproduction of proinflammatory cytokines in hypermetabolic conditions is associated with the oxidative stress induced by the virus, which produces corrosive molecules that cause severe damage to myocytes [5]. Considering that metabolic and inflammatory disorders linked with sedentarism are common in the elderly [6], myopathy associated with COVID-19 may even be more dangerous in the elderly population. It is noted that older people with COVID-19 are more likely to experience significant damage in muscle structure, especially in the latter stages of the disease [7][8]. Sarcopenic muscles and adipose tissue produce myokines and adipokines, which stimulate inflammation and oxidative stress, leading to hyper catabolism [9]. Recent studies provided evidence of skeletal muscle dystrophic injuries in COVID-19 patients [7][10]. This muscle atrophy after hospital discharge may reduce the physical performance of the patients, affecting their health and quality of life [10]. This decrease in physical function can be worrying after discharge from the hospital. Recently, evidence suggests that people with COVID-19 will experience mental health problems after discharge from the hospital [11]. Additionally, the level of stress and anxiety after discharge from the hospital is high in these patients. So, Mental health changes, such as decreased sleep quality after hospital discharge, can cause a number of problems. This factor can negatively impact the functioning of the immune system and psychological changes [11].

As exercise training leads to morphological adaptations (e.g., increased number of contractile proteins and mitochondria) [12], it can be considered as a potential strategy to be performed to counteract the deleterious effects of COVID-19 on muscle tissue [13][14]. Exercise may also modulate the immune system [15][16][17][18]. It was recently revealed that the new COVID-19 strain (Omicron) was able to pose serious risks, and this marks the beginning of a new COVID-19 wave [19]. It was also shown that Omicron can bypass the innate immune system, so it can be said that there is a possibility of recurrence of COVID-19 survivors [19].

2. Functional and Psychological Changes in Post-COVID-19 Patients

It was assumed that regular exercise may play a significant role in the health status (psychological and physiological) of patients after hospitalization [20]. The analyzed studies have shown that performing resistance and aerobic exercise after hospital discharge may improve functional and mental capacity.

The guidelines for exercise prescription aiming at health promotion and rehabilitation recommend performing both resistance and aerobic exercise [21][22]. Resistance exercise is of great importance among the approaches composing a training program. From a clinical perspective, the health benefits of resistance exercises are well-proven by over 30 years of research [23]. In summary, meta-analyses of short-term clinical exercise studies show that resistance training increases skeletal muscle mass and strength and improves the ability to perform daily life activities [24][25]. Resistance training is also shown to reduce the symptoms of depression and anxiety [26]. It was reported that resistance training alone or combined with aerobic exercise might increase muscle performance and improve quality of life [13][25][27][28][29]. Compared to aerobic exercise alone, resistance training combined with aerobic exercise may even induce higher effects on emerging health conditions, such as the prevention and/or treatment of sarcopenia and physical function maintenance [30][31]. The recent epidemiological studies showed that a combination of both exercises might be useful in preventing and/or managing several common chronic diseases [32][33].

The results of the present systematic research confirm these reports. Nambi et al. [33] examined resistance training combined with low- or high-intensity aerobic exercise in post-COVID-19 patients. The authors found a higher increase in handgrip strength, muscle growth, and quality of life for the low-intensity aerobic exercise group when compared to the high-intensity aerobic exercise group. Exercise intensity and volume were considered the main parameters for exercise prescription. Therefore, improving the quality of life along with physiological changes can be effective in returning to normal living conditions. Numerous studies showed that high-intensity aerobic and resistance training or long exercise sessions (≥1.5 h) may lead to temporary immune system suppression [14][34][35][36]. Due to the nature of COVID-19 disease, in which the immune system is involved, it is recommended to avoid immunosuppression induced by exercise. A recent study reported that three patients refused to continue the exercise protocol due to recurrence of infection [32]. The aerobic exercise was performed at low- and moderate-intensity in the continuous and interval mode, respectively (**Table 1**). According to Everaerts et al. [37], the training program was interrupted in four patients due to interfering medical problems (myasthenia gravis, lumbar discus hernia, severe cognitive dysfunction). Another study showed that a short training period (i.e., 10 days) induced significant improvements in physical performance in post-COVID-19 patients [38]. Exercise intensity ranged from 30 to 80% of 1RM for resistance exercises and from 3 to 5 of modified Borg scale for the aerobic exercise. According to the authors, there was no reinfection during the training period. Hermann et al. [39] also reported that none of the patients died or had to be taken back to the hospital after performing resistance and aerobic exercises. The aerobic exercise was performed at moderate intensity, 20 repetitions with the maximum tolerated load for the resistance exercises were completed. Furthermore, training sessions ranged from 30 to 90 min in all analyzed studies. Taken together, these studies suggest that resistance and aerobic exercises are feasible approaches to optimize recovery from COVID-19.

Table 1. Training interventions characteristics of the included studies (n = 6).

Eligible Study	Subjects	Training Protocol	Training Period	Days/Week
Betschart et al., 2021	N = 12 (4 females and 8 males)	30 min of aerobic cycle exercise (two sessions of continuous mode [20–30% peak WR] followed by two sessions of interval mode [warm-up 4 min at 15% peak WR 4 × 4 min at 50% peak WR and 3 × 3 min at 20–30% peak WR, and cooling-down 3 min at 15% peak WR]) combined with six RE (three sets of 10–12 repetitions at 50–85% of 1RM).	8–12 weeks	2x
Dalbosco-Salas et al., 2021	N = 115 (44 males and 66 females; 57 post-hopitalization and 58 non-hospitalized).	Home-based exercise training is composed of warm-up (5 min), breathing exercises (3 min), aerobic and/or strength exercises (20–30 min), and stretching (5 min). Volume and intensity of aerobic and RE were not reported.	9 weeks	2–3x
Everaerts et al., 2021	N = 22 adults (7 females and 15 males) with muscle strenght or 6 min walk test below 70% of the predicted values	Aerobic exercise (treadmill, cycle ergometer, arm ergometer, and stair climbing or step), next to RE (leg press and chest press). The program started at 60–75% of maximal individual performance. Interval training was implemented if the patient was not able to cycle ≥10 min on 80% VO_{2peak}. Exercise intensity and duration increased progressively based on symptom scores (target Borg dyspnoea and fatigue score 4–6/10). The volume of the aerobic and resistance exercise was not reported.	12 weeks	3x
Hermann et al., 2021	N = 28 (15 female and 13 males; 112 in the post-ventilation group and 16 in the non-ventilation froup).	Aerobic exercise (outdoor walking, or cycle ergometer, and criteria for stopping or reducing exercise intensity was SpO2 <88%, Borg scale >6 or/and reaching their submaximal heart rate, duration was not informed) followed by RE (3 sets of 20 repetitions with the maximum tolerated load, number of exercises was not informed).	3–4 weeks	5–6x

Eligible Study	Subjects	Training Protocol	Training Period	Days/Week
Mayer et al., 2021	**N = 32 males (14 female and 18 males; 22 in the in-person treatment group and 10 in the telehealth treatment group).**	**In-person program: Aerobic exercise (15–30 min at an intensity of 4–6 on the modified Borg scale), RE (three sets of 10–15 repetitions at RPE of 5–6 of 10), breathing and mindfulness techniques. Telehealth program: walking (30 min at an RPE ≤ 4), strengthening exercises (not detailed), and breathing techniques**	**8 weeks**	**3–4x**
Nambi et al., 2021	**N = 76 males with post-COVID-19 sarcopenia (38 in the low-intensity aerobic group and 38 in the high-intensity aerobic group)**	**11 RE (3 sets of 10RM, 60 s of rest interval, combined with 30 min of low (40–60% of HRmax) or high-intensity (60–80% of HRmax) aerobic exercise (20 min on treadmill and 10 min on a cycle ergometer).**	**8 weeks**	**4x**
Udina et al., 2021	**N = 33 (19 females and 14 males; 20 in the post-ICU group and 13 in the non-ICU group)**	**2–4 RE (1–2 sets of 8–10 repetitions at 30–80% of 1RM) and 5–15 min of endurance exercise (cycle ergometer, steps or walking at an intensity of 3–5 of modified Borg scale) and two balance exercises (walking with obstacles, changing directions or on unstable surfaces).**	**10 days**	**7x**

RE: resistance training. RM: repetition maximum. HRmax: maximal heart rate. WR: work rate. ICU: intensive care unit. VO2peak: peak oxygen uptake.

The current systematic entry also showed that training programs composed of resistance and aerobic exercises increased muscle strength, reduced activity-induced shortness of breath and fatigue index, and improved functional independence and quality of life in patients after hospital discharge by COVID-19 [40]. Moreover, the remote supervision of exercise training seems to be an effective strategy for rehabilitating patients after COVID-19 infection [33]. However, no limitations here now. It is noted that none of the analyzed studies examined a control group. The included studies also did not provide the severity of the physical fitness level and the exercise experience of the patients. Other significant diseases of the patients involved in the analysis were also not informed. Additionally, it was not possible to perform a meta-analysis because the included studies have methodological heterogeneities. Mayer et al. [33]. also found that resistance and aerobic exercise can cause both positive physiological and psychological changes. Consequently, these results should be generalized with caution. Therefore, future high-quality randomized controlled trials evaluating the effects of exercise programs after hospitalization by COVID-19 are needed.

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