

# The Effects of Covid-19 in Respiratory Functions and Exercise Capacity: A Pilot Study in Young Adults

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**Abstract: Background:** The impact of coronavirus (COVID-19) on the pulmonary system and exercise capacity of young adults is important in terms of early detection of the existing or future chronic disease risk and secondary prevention. **Objective:** To compare the respiratory functions and exercise capacity of young adults who recovered from COVID-19 with healthy peers. **Methods:** Fifteen individuals (7 male, 8 female) aged 18-25 years, diagnosed with COVID-19 and at least 8 weeks passed after diagnosis (mean time:  $239.13 \pm 135.77$  days; min-max: 67-494 days) were included in the study. Age-sex matched 14 individuals (6 males, 8 females) without any diagnosis of COVID-19 and not been under quarantine because of COVID-19 were invited to the study as a control group. Respiratory functions (FEV1, FVC, FEV1/FVC, PEF) and mouth pressures (maximal inspiratory pressure-MIP, maximal expiratory pressure-MEP) were. Submaximal exercise capacity was evaluated with the "6-minutes walking test". The lower extremity muscle functions were determined with the "1-minute sit to stand test". **Results:** All subjects were treated at home and fatigue (46%), persistent (40%) cough were the most reported ongoing symptoms in subjects who had COVID-19. Ground-glass appearance consistent with viral pneumonia was detected in radiological imaging of 3 (20%) subjects. The 6-minutes walking distance ( $p=0.037$ ) and the number of sit-stands for 1 minute ( $p=0.007$ ) were significantly lower in patients who had COVID-19 than age-gender matched healthy controls. **Conclusion:** The results of our study show that exercise capacity and muscle strength may be affected in young adults with mild COVID-19 compared to their peers.

**Keywords:** COVID-19, Respiratory Functions, Exercise Capacity, Prevention.

## 1. INTRODUCTION

The novel coronavirus (COVID-19) is a multisystem disease that is commonly characterized by fever, cough, dyspnea, the pain of muscles and joints, fatigue, headache, diarrhea, and loss of taste and smell. These symptoms can reveal a wide variety of clinical conditions ranging from a mild cold to severe acute respiratory distress syndrome (ARDS) that can cause death, as well as being asymptomatic, especially in young individuals [1,2].

Fatigue, dyspnea, muscle pain, and weakness are the most frequently reported symptoms in COVID-19, regardless of disease severity [2]. Paneroni *et al.* showed a high rate of decrease in muscle strength and low physical performance in the post-acute period in the patients who had had pneumonia due to COVID-19 with no previous locomotor disability [3]. These changes pose a risk for decreased exercise capacity, fatigue, and cardiovascular problems in individuals who had COVID-19 [4]. The evaluation and routine follow-up are recommended in the non-infectious period (6-8 weeks) even in asymptomatic cases after COVID-19 to address individual rehabilitation needs and to identify physiological limitations [5]. It was stated that parameters such as respiratory functions, exercise capacity, functional capacity, musculoskeletal function, and level of activity should be considered in the evaluation. The 1 minute sit to stand test (SST) and 6-minute walking test (6 MWT) are recommended for the evaluation of lower extremity muscle functions and exercise capacity in hospitalized patients due to COVID-19 [6, 7].

A healthy young population ensures that national heritage can be carried to the future with the increase in

economic labor, brainpower, military power, and production capacity in the country [8]. In the analysis of the World Health Organization (WHO), which included approximately 8.5 million cases with COVID-19, the infection rate in young individuals aged 15-24 was reported to be 9.6% between January and July 2020 [9]. The healthy growth of the young population, which constitutes a large part of the population has an important place in the development of society in the long term. Greenhalgh *et al.* underlined that in addition to full recovery and recovery of long COVID symptoms, it is also necessary to aim returning to economic productivity in their study [10].

Current studies focus on the functional disabilities of patients with moderate to severe COVID-19. Current studies focus on the functional disabilities of patients with moderate to severe COVID-19. Evaluation of COVID-19-induced exposures in young adults, regardless of the severity of the disease, and early determination of the risk of existing or future chronic diseases are of great importance in terms of secondary prevention. Our study aims to examine the respiratory functions and exercise capacity of young adults who had COVID-19 comparing with healthy age-gender matched peers.

## 2. MATERIALS AND METHODS

Fifteen subjects aged 18-25 who were diagnosed as COVID-19 based on a positive SARS-CoV-2 real-time reverse transcriptase-polymerase chain reaction (RT-PCR) on nasal swabs and at least 8 weeks since diagnosis were included in the study. Fifteen aged and gender-matched subjects those never diagnosed as COVID-19 and not quarantined because of high risk were invited to the study. Subjects who had a diagnosis of any cardiac, pulmonary or systemic disease before COVID-19, orthopedic or neurologic disabilities,

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included in a physiotherapy and rehabilitation program in the last 3 months, lack of cooperation and whose fever was  $>38^{\circ}\text{C}$ , resting blood pressure was  $< 90 / 60$  mmHg or  $> 140 / 90$  mmHg or oxygen saturation was  $\leq 95\%$  excluded from the study.

The study was approved by the Ethics Committee of the University (2015-KAEK-47-21-03) and was conducted according to the Helsinki Declaration. All participants signed an informed consent form.

Demographic characteristics of the participants including age, gender, weight, height, body mass index (BMI), and smoking status were recorded. The time of COVID-19 diagnosis based on the RT-PCR test were recorded. The respiratory functions and respiratory muscle strength of the participants were measured. Submaximal exercise capacity was assessed with the "6 MWT". The lower extremity functional capacity was evaluated with the "1-minute SST".

### ***Spirometric Evaluation***

All patients underwent a spirometric evaluation to determine forced expiratory volume in the first second (FEV<sub>1</sub>), forced vital capacity (FVC), FEV<sub>1</sub>/FVC and peak expiratory flow (PEF) using a mini spirometer (Contec Mini Spirometre-SP10, China). The acceptance criteria of the American Thoracic Society/European Respiratory Society was used for spirometric measurements [11].

### ***Respiratory Muscle Strength***

Maximal inspiratory (MIP) and expiratory pressures (MEP) were measured using RP Check MD Diagnostic (United Kingdom) device. Maximal inspiratory pressure was assessed from the residual volume and MEP was assessed using the total lung capacity [12].

### ***Six Minutes Walking Test***

Exercise capacity was evaluated with 6MWT in accordance with the American Thoracic Society/European Respiratory Society criteria [13]. Walking distance (6MWD), initial-final modified Borg dyspnea and leg fatigue scores [14], blood pressure (Beurer GmbH, Germany), heart rate, and oxygen saturation (MaProlinx GmbH, Germany) were recorded.

### ***1-minute Sit to Stand Test***

The 1-minute STS test was performed with a standard chair height of 46 cm without armrests. The patient was instructed to be seated upright on the chair. The subject sat with the knees and hips flexed to  $90^{\circ}$ , feet placed flat on the floor hip-width apart, and the hands crossed to the shoulders. Subjects were instructed that if required, they can take a break and resume the test as soon as possible. Each get-up from the chair was checked if a complete sit-to-stand-to-sit sequence was achieved [15]. The time was controlled using a chronometer and the number of repetitions was counted and checked by two researchers.

All assessments were performed by the same researchers who were blind to the groups. Appropriate rest periods were given between assessments to avoid the limited effect of fatigue on tests. In all tests, attention was paid to the use of materials suitable for pandemic conditions, mask-distance and hygiene rules. The spirometry and mouth pressure assessments were conducted according to the recommendations of ERS spirometry guideline during the COVID-19 pandemic [16].

### ***Data Analysis***

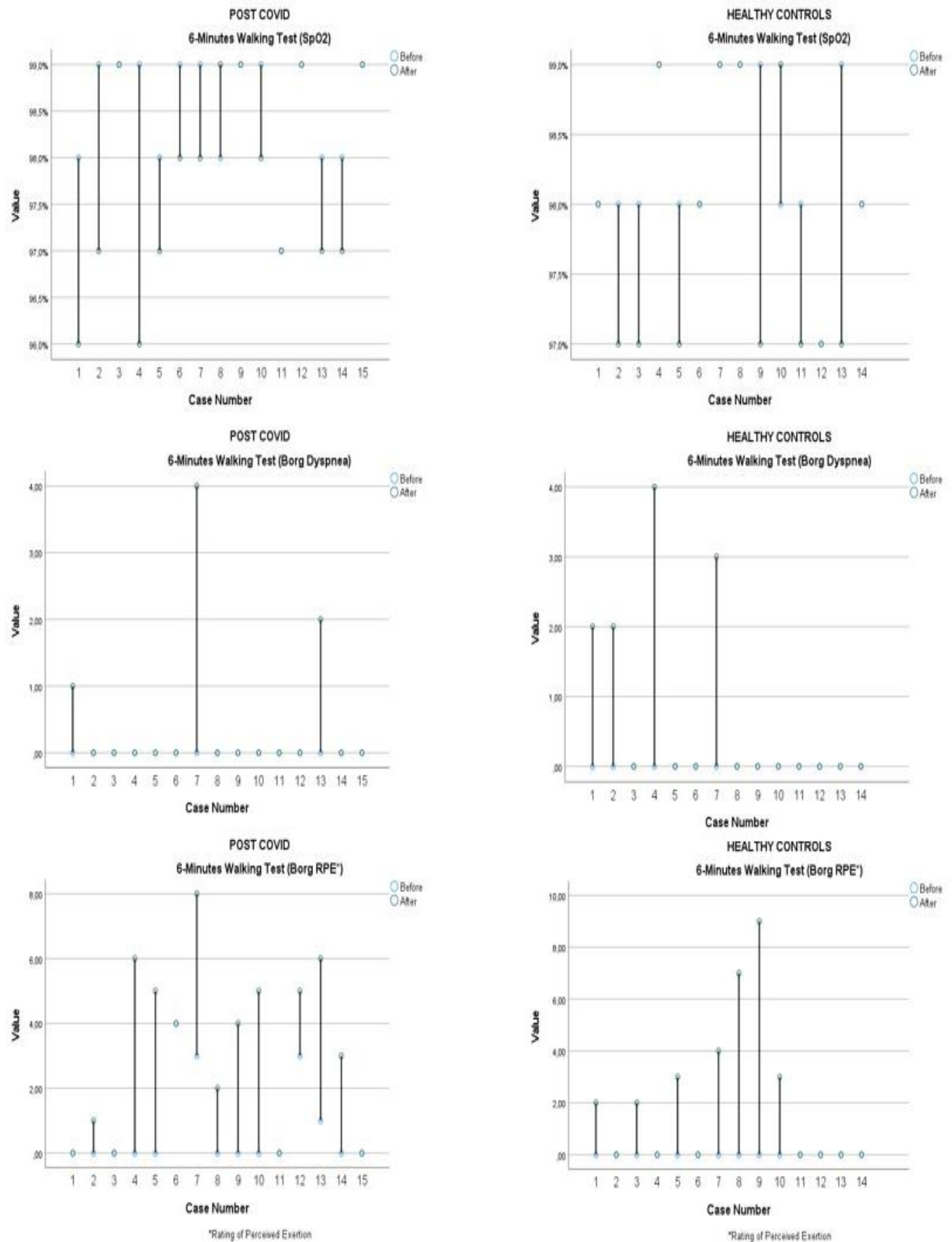
Data were evaluated using the Statistical Package for Social Science for Windows version 23.0 and by analyzing descriptive statistics. Shapiro–Wilk test and histograms were used to determine the normality distribution of the data. Comparisons between patients and healthy controls were analyzed using Mann–Whitney U test for continuous variables and the Chi-square test for categorical variables because of non-normal distribution. A p-value  $< .05$  was considered statistically significant.

## **3. RESULTS**

Thirty subjects were included in the study. One subject from the control group was excluded because of high resting blood pressure. Fifteen subjects from the COVID-19 group (8 women, 7 men) and fourteen subjects (8 women, six men) from the control group were completed all assessments. No adverse events were observed during the assessments.

The mean time after the positive RT-PCR test was  $239.13 \pm 135.77$  days. 5 (33%) of the subjects who had COVID-19 did not receive any medical treatment during the disease, all subjects were treated at home. Seven (46%) of the patients stated that fatigue, 6 (40%) cough, 4 (26.7%) dyspnea, 4 (26.7%) muscle-joint pain complaints continued after the disease. Ground-glass opacities consistent with viral pneumonia was detected in radiological imaging in 3 (20%) cases.

The subjects in both groups were similar in terms of demographic characteristics ( $p > 0.05$ ). The 6-MWD ( $p = 0.037$ ,  $Z = -2.095$ ) and the number of sit-stands in 1 minute ( $p = 0.007$ ,  $Z = -2.667$ ) were found to be significantly lower in the cases who had COVID-19 than the control group. Although the mean pulmonary function test parameters, MIP and MEP were decreased in subjects who recovered from COVID-19, there was no statistically significant difference with controls ( $p > 0.05$  for all) (Table 1).



**Figure 1:** The differences in SpO<sub>2</sub>, leg fatigue and dyspnea perception in the 6 MWT were also similar between the groups ( $p>0.05$  for all)

**Table 1:** Demographic and clinical features of the subjects.

	Subjects recovered from COVID-19 n (%) or mean±SD	Age-gender matched healthy controls n (%) veya mean±SD	p
Age (years)	21.73±2.01	21.64±0.74	0.847
BMI (kg/m2)	22.36±2.82	21.69±2.42	0.780
Smoking status			
Smoker	3 (% 20)	5 (% 35)	0.344
Non-smoker	12 (% 80)	9 (% 64)	
Spirometry			
FEV1 (pred %)	89.93±9.39	91.64±9.69	0.646
FVC (pred %)	89.66±24.42	93.42±10.76	0.914
FEV1/FVC (%)	0.83±0.10	0.84±0.06	0.780
PEF (pred %)	74.53±18.51	80.71±16.23	0.354
Mouth pressures			
MIP (cmH2O)	92.33±18.39	105.28±22.45	0.146
MEP (cmH2O)	101.80±25.88	120.85±26.47	0.051
6-minutes walking test			
6-minutes walking distance (m)	574.60±47.45	616.14±49.22	0.037
Δ SpO2 (%)	-0.80±1.01	-0.50±0.85	0.451
Δ Heart rate (beat/min)	45.53±17.13	47.07±19.03	0.533
Δ BORG dyspnea	0.46±1.12	0.78±1.36	0.652
Δ BORG leg fatigue	2.53±2.29	2.14±2.87	0.477

SD: Standard deviation, BMI: Body mass index, FEV1: Forced vital expiratory volume-1. Second, FVC: Forced vital capacity, PEF: Peak expiratory flow, MIP: Maximal inspiratory pressure, MEP: Maximal expiratory pressure, Δ: posttest- pretest

## 4. DISCUSSION

The results of our study show that exercise capacity and lower extremity functional capacity may be adversely affected in young adults who recovered from COVID-19 compared to their peers.

The COVID-19 is a systemic disease that mostly affected the pulmonary system. There is still little known about the respiratory and functional sequelae in long term. Most of the studies investigating the pulmonary sequelae after COVID-19 were reported normal spirometry [17-20] but reduced diffusing lung capacity for carbon monoxide (DLCO) [21]. Lv *et al.* reported lower FVC and FEV1 with preserved FEV1/FVC ratio that suggested restrictive patterns in patients with severe disease (14 days after discharge) [22]. Vittaca *et al.* found that FVC was lower in survivors of COVID-19 associated pneumonia or interstitial lung disease patients than COPD patients [23]. In our study, % predicted FEV1, FVC, FEV1/FVC and especially PEF were under the normal range in subjects who had COVID-19 but there was no statistically significant difference with their peers. This finding needs further investigation, including the DLCO assessment and

considering adverse effects of quarantine and smoking status of healthy controls.

In the literature, it was suggested to assess exercise capacity and functionality in subjects who had COVID-19 even in young and asymptomatic subjects for determining long-term clinical results of COVID-19 [24, 25]. A standardized exercise test can determine the level of effect on the functionality and observe the provocation of the fatigue and dyspnea symptoms with exercise. A limited number of studies investigated the exercise capacity at follow-up with 6 MWT [17, 19, 26, 27]. Rogliani *et al.* reported that predicted 6MWD (101.89%) were in the normal range in mild to moderate COVID-19 patients at follow up [19]. However, dyspnea perception after 6 MWT was significantly increased (median 1.5). Vittaca *et al.* documented that individuals who had COVID-19 walked < 70% of predicted in 6MWT and this performance similar to individuals with interstitial lung disease [23]. In the study of Fugleberg *et al.*, 50 % of patients demonstrated desaturation during 6 MWT but 79 % were unable to reach the predicted 6MWD at the time of discharge [26]. Van der Borst noted that 16 % of the patients were desaturated and 22% walked below the predicted distance at three months of discharge [27]. In contrast, Daher *et al.* reported that

none of the patients were desaturated during the 6 MWT at 60 days following discharge [17]. The population of these studies were dominantly aged over 50 /years and hospitalized due to COVID-19. Although the covered distance was in the normal range [28] we observed a significant difference in 6MWD (-42 meters) between young adults recovered from COVID-19 and their age-gender matched peers. None of the subjects was desaturated during the test and leg fatigue and dyspnea change after the test were similar. We believe that this difference arises from the different lower extremity muscle functions that can limit walking endurance.

The muscular impairment predominantly in the lower extremity was reported after discharge in subjects who had COVID-19 [21, 29-31]. Clavario *et al.* found reduced quadriceps force production in 86 % of COVID-19 patients (mean age: 61.7/year) at discharge [29]. Tanriverdi *et al.* investigated the extra-pulmonary functions including quadriceps muscle testing in subjects (mean age: 39.2/year) who recovered from mild to moderate COVID-19 [30]. It was reported that 24 % of the subjects who recovered from mild COVID-19 represented quadriceps muscle weakness. Baririch *et al.* focused on mid-term (3-6 months from hospital discharge) functional sequelae in COVID-19 survivors (mean age: 57.9/year) [31]. The mean 1 minute sit to stand repetition was 19.72. In our study, the sit to stand repetition in 1 minute was 26.13±6.02 which was under the normal range in subjects who had COVID-19. In addition, the sit-to stand repetition in 1 minute was found lower than the age-gender matched peers. Our findings are in line with previous results and point out that lower extremity muscle function after COVID-19 may persist despite young age and non-severe disease severity.

This study has some limitations. The sample size is small and the time after the positive RT-PCR test range is relatively large. The respiratory functions were only evaluated using a spirometer, dynamic respiratory volumes were not assessed. Future studies should be examined the duration of this exposure comparatively, by increasing the number of cases, compared to the time elapsed after COVID-19.

To the best of our knowledge, this is the first study that compared the respiratory functions including respiratory muscle strength and exercise capacity of young adults who recovered from COVID-19 with their age-gender matched healthy peers. Our results showed that exercise capacity and muscle strength may be affected in young adults recovered from mild COVID-19 compared to their peers. These findings emphasized that the need for rehabilitation in post-COVID-19 subjects is not limited to pulmonary rehabilitation, and there may be a need for programs within the scope of preventive rehabilitation, especially for young individuals participating in economic production.

## REFERENCES

- [1] Ozma MA, Maroufi P, Khodadadi E, Köse Ş, Esposito I, Ganbarov K, *et al.* Clinical manifestation, diagnosis, prevention and control of SARS-CoV-2 (COVID-19) during the outbreak period. *Infez Med.* 2020;28(2):153-165.
- [2] Li LQ, Huang T, Wang YQ, Wang ZP, Liang Y, Huang TB, *et al.* COVID-19 patients' clinical characteristics, discharge rate, and fatality rate of meta-analysis. *J Med Virol* 2020;92(6):577-583.  
<https://doi.org/10.1002/jmv.25757>
- [3] Paneroni, M., Simonelli, C., Saleri, M., Bertacchini, L., Venturelli, M., Troosters, T., Ambrosino N., Vitacca, M. Muscle strength and physical performance in patients without previous disabilities recovering from COVID-19 pneumonia. *American Journal of Physical Medicine & Rehabilitation.* 2020;100(2):105-109.  
<https://doi.org/10.1097/phm.0000000000001641>
- [4] İnal İnce D, Vardar Yağlı N, Sağlam M, Çalık Kütükcü E. COVID-19 Enfeksiyonunda Akut ve Post-Akut Fizyoterapi ve Rehabilitasyon. *Türk J Physiother Rehabil.* 2020; 31(1):81-93.
- [5] Barker-Davies RM, O'Sullivan O, Senaratne KP, Baker P, Cranley M, Dharm-Datta S, Norman J. The Stanford Hall consensus statement for post-COVID-19 rehabilitation. *British Journal of Sports Medicine.* 2020;54(16): 949-959.  
<https://doi.org/10.1136/bjsports-2020-102596>
- [6] Spruit MA, Holland AE, Singh SJ, Tonia T, Wilson KC, Troosters T. COVID-19: interim guidance on rehabilitation in the hospital and post-hospital phase from a European Respiratory Society-and American Thoracic Society-coordinated international task force. *European respiratory journal.* 2020;56 (6).  
<https://doi.org/10.1183/13993003.02197-2020>
- [7] Klok FA, Boon GJAM, Barco S, *et al.* The Post-COVID-19 Functional Status scale: a tool to measure functional status over time after COVID-19. *Eur Respir J.* 2020; 56: 2001494.  
<https://doi.org/10.1183/13993003.01494-2020>
- [8] Sustainable Development Goals Indicators, Global Database  
<https://unstats.un.org/sdgs/indicators/database/?indicator=3.7.2>
- [9] World Health Organization. Coronavirus disease ( COVID-19): situation report. 2020;198.
- [10] Greenhalgh T, Knight M, A'Court C, Buxton M, Husain L. Management of post-acute covid-19 in primary care. *BMJ.* 2020; 370(11):3026.  
<https://doi.org/10.1136/bmj.m3026>
- [11] Miller MR, Hankinson J, Brusasco V, *et al.* Standardisation of spirometry. *Eur Respir J.* 2005;26(2):319–338.  
<https://doi.org/10.1183/09031936.05.00034805>

[1] Ozma MA, Maroufi P, Khodadadi E, Köse Ş, Esposito I, Ganbarov K, *et al.* Clinical

- [12] ATS/ERS. Statement on respiratory muscle testing. *Am J Respir Crit Care Med*. 2002;166(4):518–624.  
<https://doi.org/10.1164/rccm.166.4.518>
- [13] ATS. Statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med*. 2002;166(1):111–117.  
<https://doi.org/10.1164/ajrccm.166.1.at1102>
- [14] Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*. 1982;14(5):377–381.  
<https://doi.org/10.1249/00005768-198205000-00012>
- [15] Bohannon RW. Sit-to-stand test for measuring performance of lower extremity muscles. *Percept Mot Skills*. 1995; 80:163–166.  
<https://doi.org/10.2466/pms.1995.80.1.163>
- [16] Recommendation from ERS Group 9.1 (Respiratory function technologists /Scientists) Lung function testing during COVID-19 pandemic and beyond. 2020. Date last updated: 09 May 2020.
- [17] Daher A, Balfanz P, Cornelissen C, Müller A, Bergs I, Marx N et al.: Follow up of patients with severe coronavirus disease 2019 (COVID-19): pulmonary and extrapulmonary disease sequelae. *Respir Med* 2020, 174.  
<https://doi.org/10.1016/j.rmed.2020.106197>
- [18] Mo X, Jian W, Su Z, Chen M, Peng H, Peng P et al.: Abnormal pulmonary function in COVID-19 patients at time of hospital discharge. *Eur Respir J*. 2020; 55.  
<https://doi.org/10.1183/13993003.01217-2020>
- [19] Rogliani P, Calzetta L, Coppola A, Puxeddu E, Sergiacomi G, D'Amato D, Orlacchio A. Are there pulmonary sequelae in patients recovering from COVID-19? *Respiratory Research*. 2020;21(1):1-4.  
<https://doi.org/10.1186/s12931-020-01550-6>
- [20] Bellan M, Soddu D, Balbo PE, Baricich A, Zeppegnio P, Avanzi GC et al. Respiratory and psychophysical sequelae among patients with COVID-19 four months after hospital discharge. *JAMA network open*. 2021;4(1), e2036142-e2036142.  
<https://doi.org/10.1001/jamanetworkopen.2020.36142>
- [21] Thomas M, Oliver J. P, James H. H. "Pulmonary function and COVID-19." *Current opinion in physiology*. 2021;21:29-35.  
<https://doi.org/10.1016/j.cophys.2021.03.005>
- [22] Lv D, Chen X, Wang X, Mao L, Sun J, Wu G et al. Pulmonary function of patients with 2019 novel coronavirus induced pneumonia: a retrospective cohort study. *Ann Palliat Med* 2020; 9:3447-3452.  
<https://doi.org/10.21037/apm-20-1688>
- [23] Vitacca M, Paneroni M, Brunetti G, Carlucci A, Balbi B, Spanevello A, Ambrosino N. Characteristics of COVID-19 Pneumonia Survivors With Resting Normoxemia and Exercise-Induced Desaturation. *Respiratory Care*. 2021 Aug 24; respcare.09029. doi: 10.4187/respcare.09029. Online ahead of print.  
<https://doi.org/10.4187/respcare.09029>
- [24] Kajal P, Straudi S, Yee SN, Fayed N, Melvin JL, Sivan M. Applying the WHO ICF Framework to the Outcome Measures Used in the Evaluation of Long-Term Clinical Outcomes in Coronavirus Outbreaks. *Int J Environ Res Public Health*. 2020;17(18):6476.  
<https://doi.org/10.3390/ijerph17186476>
- [25] Josephine N, Fuglebjerg U, Jensen TO, Hoyer N, Rysør CK, Lindegaard B, Harboe ZB. Silent hypoxia in patients with SARS CoV-2 infection before hospital discharge. *Int J Infect Dis*. 2020;99:100-101.  
<https://doi.org/10.1016/j.ijid.2020.07.014>
- [26] Fuglebjerg NJU, Jensen TO, Hoyer N, Rysør CK, Lindegaard B, Harboe ZB: Silent hypoxia in patients with SARS CoV-2 infection before hospital discharge. *Int J Infect Dis*. 2020; 99:100-101.  
<https://doi.org/10.1016/j.ijid.2020.07.014>
- [27] Van den Borst B, Peters J, Brink M, Schoon Y, Bleeker-Rovers C, Schers H et al.: Comprehensive health assessment three months after recovery from acute COVID-19. *Ann Med*. 2020; 0:1-14.  
<https://doi.org/10.1093/cid/ciaa1750>
- [28] Casanova C, Celli BR, Barria P, Casas A, Cote C, de Torres JP, Jardim J, Lopez MV, Marin JM, Montes de Oca M, Pinto-Plata V, Aguirre-Jaime A. On behalf of the Six Minute Walk Distance Project (ALAT). The 6-min walk distance in healthy subjects: reference standards from seven countries. *European Respiratory Journal*. 2011;37:150-156.  
<https://doi.org/10.1183/09031936.00194909>
- [29] Clavario P, de Marzo V, Lotti R, Barbara C, Porcile A, Russo C et al. Assessment of functional capacity with cardiopulmonary exercise testing in non-severe COVID-19 patients at three months follow-up. *MedRxiv*. 2020.  
<https://doi.org/10.1101/2020.11.15.20231985>
- [30] Tanriverdi A, Savci S, Kahraman BO, Ozpelit E. Extrapulmonary features of post-COVID-19 patients: muscle function, physical activity, mood, and sleep quality. *Irish Journal of Medical Science* 2021. 1-7.  
<https://doi.org/10.1007/s11845-021-02667-3>
- [31] Baricich A, Borg MB, Cuneo D, Cadario E, Azzolina D, Balbo PE, et al. Midterm functional sequelae and implications in rehabilitation after COVID-19: a cross-sectional study. *Eur J Phys Rehabil Med* 2021. 199-207.  
<https://doi.org/10.23736/s1973-9087.21.06699-5>