Rehabilitation of patients after COVID-19 in post discharge period: two case study

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DOI: https://doi.org/10.5114/phr.2022.119746

Received: 22.11.2021 **Reviewed:** 17.02.2022 **Accepted:** 18.02.2022

Abstract

Background: SARS-CoV-2 is an acute infectious respiratory disease with a varied clinical presentation. Physiotherapy has a beneficial effect on increasing physical capacity, improving quality of life, and ameliorating the negative effects of the disease in patients after an acute respiratory distress syndrome (ARDS) incident. The first scientific reports are emerging which suggest that this applies equally to patients who have undergone COVID-19.

Aims: To present a proprietary rehabilitation procedure for patients in the post-acute phase of COVID-19. The therapeutic management included four components such as aerobic and resistance training, respiratory therapy in combination with Super Induction Stimulation (SIS).

Report of two cases: Two patients, approximately 50 years old, with SARS-CoV-2 infection were included in the study. Patients were admitted to the rehabilitation department in the post-acute phase and during the qualification for therapy they were examined with standardized tests and questionnaires. The main assessment tools were spirometry, 6-minute walk test (6MWT), and modified Borg scale. They were performed before the start of rehabilitation, after 2 and 4 weeks. Significant improvement in 6MWT scores was observed after therapeutic management. The distance increased at an average of 350%. Subjective feelings of fatigue and dyspnea also improved. Functional performance using the Barthel Index showed a mean improvement of 38%. Spirometry showed improvement in forced expiratory volume in one second / forced vital capacity (FEV1/FVC) at an average of 25%.

Summary: Patients with COVID-19 infection require intensive rehabilitation especially in the post discharge period. With the therapeutic program used, patients achieved significant improvements in all measured parameters. Moreover, the function of the respiratory system also improved, as demonstrated by spirometry.

Key words

physiotherapy, rehabilitation, COVID-19, SARS-CoV-2, spirometry, Super Induction Stimulation.

Introduction

SARS-CoV-2 infection is an acute respiratory disease with a varied clinical presentation. These range from an asymptomatic infection, through a mild or sparse infection with variable symptoms from multiple systems, to a severe course with associated pneumonia meeting diagnostic criteria for acute respiratory distress syndrome (ARDS) [1, 2]. According to the National Institute for Health and Care Excellence (NICE) guidelines, three stages of the disease are described in terms of the duration of infection symptoms. A distinction is made between acute COVID-19 in which the symptoms of the infection last up to 4 weeks, prolonged symptomatic COVID-19 – a subacute condition where symptoms persist over 4 to 12 weeks, and post-COVID-19 syndrome (so-called long COVID), during which symptoms developed during or after the infection are consistent with COVID-19 symptoms and last longer than 12 weeks, and for which there is no other explanation [3].

Physiotherapy has a beneficial effect on increasing physical capacity, improving quality of life, and ameliorating the negative effects of the disease in patients after an ARDS [4, 5]. The first reports are emerging which suggest that this applies equally to patients who have undergone COVID-19 [6]. In addition, respiratory physiotherapy is an important component of multidisciplinary treatment in people struggling with COVID-19 [7]. It is indicated that rehabilitation started immediately after leaving the Intensive Care Unit (ICU), implemented no later than within the first 30 days, has the greatest impact on recovery [8, 9].

Comprehensive rehabilitation that uses specialized airway clearance techniques such as: patient positioning, effective cough, drainage or Super Induction Stimulation (SIS) is able to contribute to avoiding severe respiratory complications in patients after COVID-19 [10, 11]. According to the World Health Organization (WHO), some patients require physiotherapy immediately after hospitalization. This is particularly the case for patients with severe COVID-19 disease who needed to be put on non-invasive mechanical ventilation (NIV) or invasive mechanical ventilation in the ICU or high-flow oxygen therapy in other wards [12]. Despite many efficacy and safety studies or rehabilitation recommendations of COVID-19 patients, it is difficult to find precise guidelines for the post-discharge physiotherapy management.

Aims

The aim of this article was to present a proprietary plan for rehabilitation management and return to fitness using two case studies in the post discharge treatment period (post-acute phase) of COVID-19 disease as an example.

Report of two cases

Two patients who attended the rehabilitation unit at the Origin Centre Krakow between March and May 2021 took part in the study.

Case study 1

A 47-year-old overweight male with diagnosed hypertension and gastric ulcer disease. Hardly physically active. He was admitted to the hospital rescue unit (HRU) with an acute respiratory failure caused by the SARS-CoV-2 virus. The patient reported a high fever, severe shortness of breath, a dry cough, and a general weakness over the past week. High-flow oxygen therapy (60 l/min) was used in the initial phase of ICU treatment. As his condition deteriorated, mechanical lung ventilation (percutaneous tracheotomy with Griggs method) and extracorporeal membrane oxygenation (ECMO) therapy were incorporated. Imaging revealed fine-focal thickening of the pulmonary parenchyma and thickening of the interlobular septa. The patient was admitted to the inpatient rehabilitation unit at the Origin Centre Krakow in the post-acute phase. The patient was receiving passive oxygen therapy, with a flow rate of 4 l/min. Patient in full verbal-logical communication, auto- and allopsychically oriented.

Case study 2

A 50-year-old male with known hypertension. Hardly physically active. The patient was admitted to the HRU after losing consciousness, which was triggered by sudden, acute dyspnea. SARS-CoV-2 virus infection was confirmed. In the ICU, high-flow oxygen therapy (60 l/min), mechanical lung ventilation (percutaneous tracheotomy with Griggs method), and ECMO therapy were administered. The patient left the HRU in the post-acute phase and was admitted to the inpatient rehabilitation unit at the Origin Centre Krakow. The patient received passive oxygen therapy, with a flow rate of 2 l/min. Patient in full verbal-logical communication, auto- and allopsychically oriented.

Patient assessment

Prior to rehabilitation, patients were objectively assessed with standardized tests measuring: exercise tolerance, using a 6-minute walk test; subjective feelings of fatigue and dyspnea at rest and during physical activity, using a modified Borg scale; arterial blood oxygen saturation, using a pulse oximeter; and daily living activities, using the Barthel Index. In addition, a pulmonary functional assessment was conducted based on spirometry. In both cases, the tests were performed three times: before the therapeutic management, after 2 weeks, and after the rehabilitation plan (4 weeks).

Assumptions and parameters of therapeutic management

Given the varied clinical presentation and plurality of COVID-19 symptoms, therapeutic management was divided into three main parts, i.e., physical training, respiratory therapy, and patient education (**Figure 1**). The physical training consisted of two components: aerobic and resistance training, with two procedures each. These trainings were performed daily according to the parameters shown in **Table 1** and **Table 2**. Respiratory therapy, which included breathing exercises and stimulation using the SIS apparatus, was performed on a daily basis in an unchanged form, according to the recommendations described below. The management also included patient education, which focused on discussing the course of the disease, possible complications, exercise instruction, and provided further rehabilitation recommendations. Saturation was monitored during exercise. Therapy was discontinued when arterial blood oxygen saturation levels fell by more than 4 percentage points from the patient's baseline [13]. The therapeutic program lasted four weeks, with one day a week without physiotherapy intervention for patient's recovery.

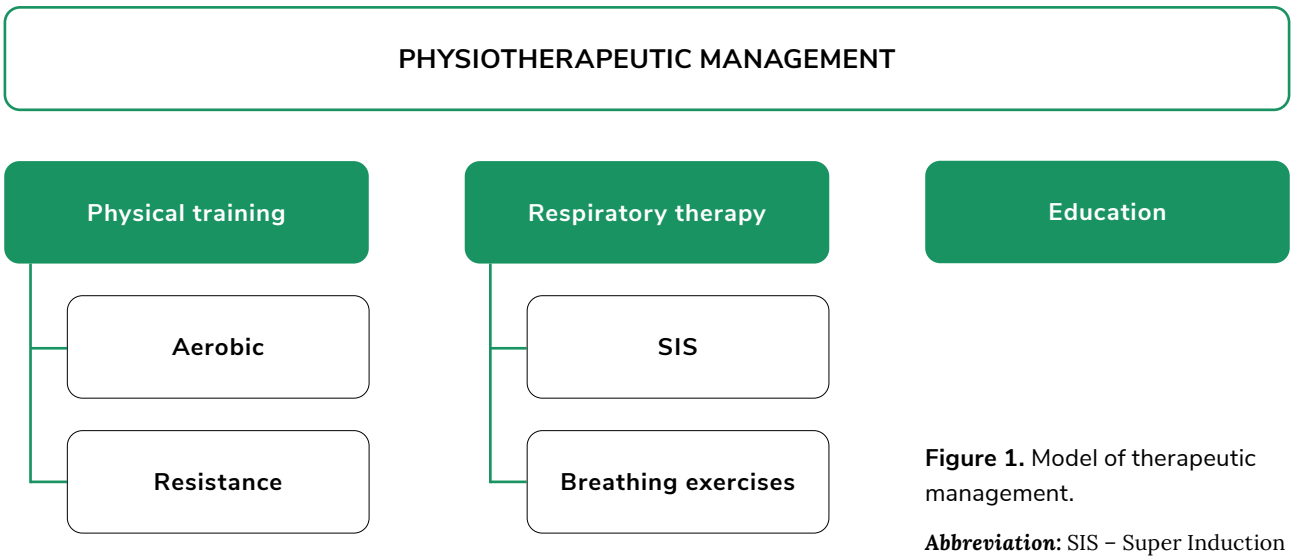

Figure 1. Model of therapeutic management.

Abbreviation: SIS – Super Induction Stimulation.

Physical training – aerobic component

There were two aerobic training procedures (procedure A and B), which differed in the mode of training carried out - continuous or intermittent, the equipment used for therapy, the type of work, and the intensity. The parameters and workloads of both procedures are detailed in **Table 1** [14]. The aerobic exercises were chosen to vary in terms of starting position and the difficulty of the task being performed. During the first days of the treatment program, patients specifically performed aerobic training, intermittently, due to their high susceptibility to fatigue. On subsequent days and sessions, aerobic training routines were rotated to gradate the difficulty of the therapy (**Figure 2**).

Figure 2. Example of aerobic exercise using an anti-gravity treadmill.

Table 1. Aerobic training parameters.

Procedure	A	B
Training mode	Intermittent aerobic training	Continuous aerobic training
Type of work	Initial: 30 s activity, 30 s break Target: 3 min activity, 30 s break	Constant work
Equipment used	March training Bicycle ergometer	Antigravity treadmill
Intensity	Initial: Low - 40-50% HRmax Target: Moderate - 60-70% HRmax	
Duration	Initial: 12-15 min Target: 40 min (including breaks)	Initial: 10-12 min Target: 30 min
Progression	Increasing intensity of the training unit by 5-15% every session	

Notes: HR and SpO_2 constantly measured during the training unit.

Abbreviations: HRmax – maximum heart rate; SpO_2 – saturation.

Physical training – resistance component

Resistance training parameters were selected individually for the patient based on the 1-RM unit and exercise tolerance. Particular attention was paid to instructing correct technique for resistance exercises, as well as correct breathing patterns and avoiding the Valsalva maneuver. In the described rehabilitation procedure, two resistance training procedures were distinguished: a strength and endurance mode (procedure C) and an endurance mode (procedure D) (**Figures 3** and **4**). The parameters of both procedures were described in **Table 2**.

Figure 3. Example of resistance exercise using the pull column (starting position – left photo and ending position – right photo).

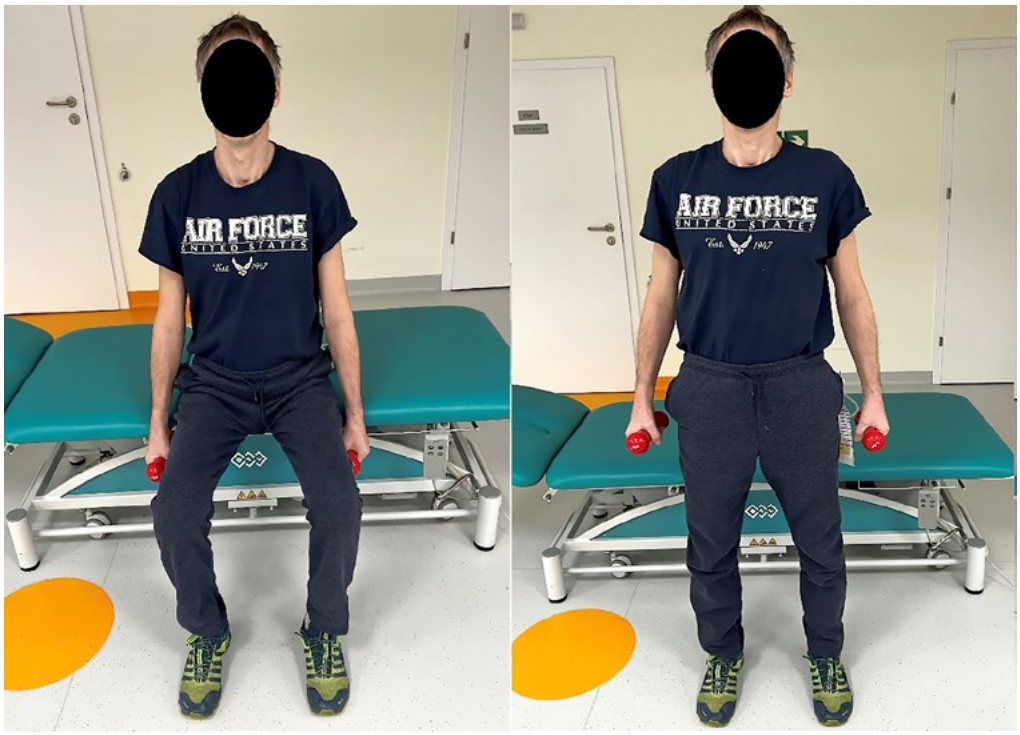

Figure 4. Example of free resistance exercise using dumbbells (starting position – left photo and ending position – right photo).

Table 2. Resistance training parameters.

Procedure	C	D
Training mode	Strength-endurance	Endurance
Type of work	70-85% 1-RM	30-80% 1-RM
Equipment used	8-12 repetitions of a given exercise in series	20-30 repetitions of a given exercise in 1-3 series
Intensity	1-3 min between series	1 min between series
Duration	Initially: 10-15 min Target: 30 min	Initially: 10-15 min Target: 30 min

Notes: 1-RM, in which it is able to perform one repetition.

Abbreviations: 1-RM – one rep max.

Respiratory therapy – Super Inductive Stimulation

Therapy employing the protocols attached to the SIS device was one of the key elements of pulmonary rehabilitation in patients following COVID-19 infection. The applications, protocols, and treatment parameters used were in accordance with the manufacturer's recommendations [15]. The aim of the therapy was to myostimulate the respiratory muscles: diaphragm and intercostal muscles, improve blood circulation and tissue trophism, minimize or prevent fibrosis within the lungs and accelerate the evacuation of retained secretions in the bronchial tree [11]. Two protocols were used in the therapeutic management: improving circulation and tissue tropics, improving respiration. These protocols were performed once a day throughout the patient's stay at the rehabilitation center. Overall time per treatment was 40 minutes. Therapy began with a protocol to improve circulation and tissue tropics. The patient was in the lateral recumbent position. The coil applicator was placed on the dorsal side of the trunk between the 1st and 6th rib (**Figure 5**).

Figure 5. Protocol for improving circulation and trophic tissue conditions using Super Induction Stimulation therapy.

The procedure was performed on both the right and left side of the trunk. The application was performed with variable frequency modulation, with f_1= 75 Hz, f_2= 15 Hz, each for 2 s. A respiration improvement protocol was then implemented. First, the diaphragm was stimulated in the supine position (abdominal muscles and diaphragm relaxed by flexing the knee and hip joints) (**Figure 6**). The applicator was directed bilaterally to the space under the lower ribs. During the breathing protocol, the intercostal muscles were also stimulated in the left lateral recumbent position from the posterior-lateral side. The treatment was performed with variable frequency modulation, with f_1= 50 Hz, f_2= 5 Hz, each for 2 s. The duration of each application was 8 minutes. The intensity of the treatment was set individually depending on the motor response and comfort of the patient, but no more than 8% of the maximum intensity of stimulation.

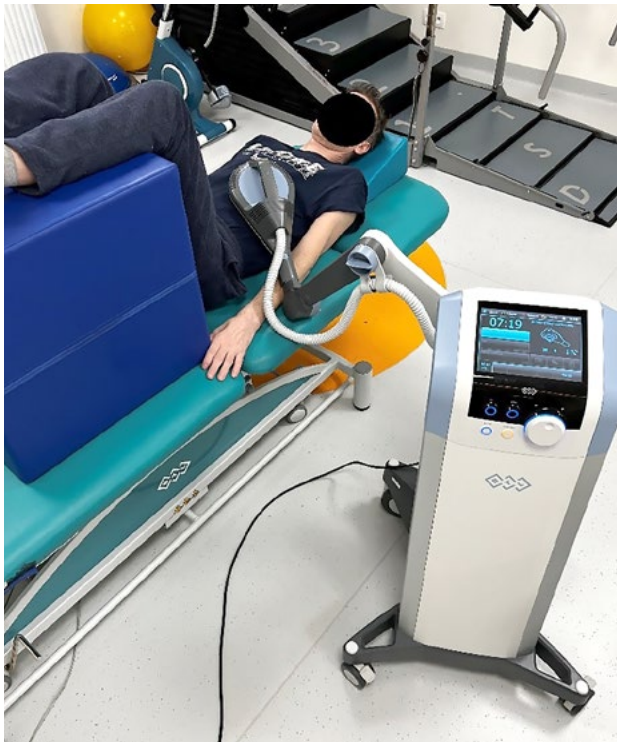

Figure 6. A breathing improvement protocol targeting the diaphragm using Super Induction Stimulation therapy.

Respiratory therapy – breathing exercises

Therapy with the SIS device was complemented by breathing exercises actively performed by the patient. The intensity of the exercises depended on the patient's abilities, while the target was to perform 4-8 repetitions of each exercise. Therapist manual resistance, resistance bands, or weights were used as load progressions. Exercises were mainly based on the Proprioceptive Neuromuscular Facilitation (PNF) concept to support overall physical fitness, as well as to increase chest mobility and improve breathing efficiency (**Figure 7**). Exercise supported the mechanism of opening collapsed alveoli and removing excess secretions from the patient's airways [16, 17]. Due to the individual needs of the patients and their complaints, the techniques described in **Table 3** were performed in addition to the breathing exercises [13].

Figure 7. Example of a breathing exercise using a diaphragmatic grip.

Table 3. Breathing techniques.

Type of intervention	Aim
Chest springing	• relieving tension occurring in the respiratory muscles (diaphragm, intercostal, pectoral) • improving the elasticity of the chest • improving blood circulation and lung elasticity
MAC	• increasing the expiratory airflow, through chest or abdominal compression
Vibration techniques	• fragmentation and displacement of secretions from peripheral to central parts of the lungs
PNF manual breathing stimulation lower ribs, diaphragm and unilateral techniques)	• mobilization of the ribs and spine • improvement of respiratory parameters • regulation of muscle tension

Abbreviations: PNF – proprioceptive neuromuscular facilitation; MAC – manually assisted cough.

Education

An integral component of therapeutic management was patient education aimed at increasing knowledge and awareness of possible complications following SARS-CoV-2 virus infection and presenting ways to minimize their negative impact on daily functioning. Patient education focused on reviewing the patient's current medical condition, explaining dyspnea including learning how to adopt positions to facilitate breathing, discussing what chronic fatigue syndrome is after a viral infection, presenting a therapeutic management plan with an explanation of exercise selection and treatment parameters, and selecting a physical activity that will be suitable for the patient after leaving the center. An information booklet in line with WHO guidelines, translated by the National Association of Physiotherapists, titled "Support in Self-Rehabilitation after COVID-19", was used during patient education [18].

Results

At the end of the 4-week therapeutic management, improvements were observed in all parameters examined in both cases. The results of the 6-minute walk test, during the final assessment, improved by 300 (Case study 1) and 240 meters (Case study 2), respectively. This means an increase in covered distance by an average of 350%. In addition, the number of breaks during the study dropped to zero. This indicates a significant improvement in exercise tolerance and respiratory capacity. The level of fatigue and dyspnea present was assessed using the modified Borg scale (resting and exercise measurements). After one month of training, subjective feelings of fatigue and breathlessness, measured at rest, completely disappeared in both cases. In contrast, physical activity decreased from 8 points to 2 points (Case study 1) and from 8 points to 3 points (Case study 2). The patients' functional capacity was measured using the Barthel scale, with a maximum possible score of 100 points. During the initial assessment, Case 1 and Case 2 scored 65 and 50 respectively, while after one month of therapy there was an improvement to 100 and 85 points, correspondingly. Arterial blood oxygen saturation levels were also assessed using a pulse oximeter. During the final assessment, normalization of resting and exercise saturation levels was observed in both cases. These results

are presented in **Table 4**. Moreover, parameters in the respiratory function test significantly improved. The analysis of the spirometry results demonstrated improvements in: vital capacity (by an average of 21.5%), increased forced expiratory volume in 1 second (by an average of 53.6%), and the ratio of increased forced expiratory volume in 1 second to vital capacity (by an average of 25%). **Table 5** shows the exact values of the spirometry test before and after the therapeutic intervention.

Table 4. Parameter changes of the tests performed before and after the therapeutic intervention.

	Case 1		Case 2	
	Before therapy	**After therapy**	**Before therapy**	**After therapy**
Exercise tolerance assessment (6MWT)	Distance walked: 90 m. Breaks: 3	Distance walked: 360 m. Breaks: 0	Distance walked: 30 m. Breaks: 3	Distance walked: 300 m. Breaks: 0
Assessment of arterial blood oxygen saturation (POT)	Resting SpO2: 90-93% Exercise SpO2: 88-91%	Resting SpO2: 99% Exercise SpO2: 98-99%	Resting SpO2: 90-95% Exercise SpO2: 86-92%	Resting SpO2: 99% Exercise SpO2: 96-98%
Assessment of the occurrence of fatigue and dyspnea (MBS)	Resting: 3 points During physical activity: 8 points	Resting: 0 points During physical activity: 2 points	Resting: 4 points During physical activity: 8 points	Resting: 0 points During physical activity: 3 points
Assessment of activities of daily living (BI)	65 points	100 points	50 points	85 points

***Notes*: *Characteristics of* 6MWT:** normative test score of 600-700 m for a particular age group; Assessment of arterial blood oxygen saturation: normal saturation value - 95-99%; ***Characteristics of* MBS:** 0 - fatigue not felt, dyspnea not present, 0.5 - minimal fatigue, dyspnea barely felt, 1 - very little fatigue, dyspnea barely felt, 2 - little fatigue, dyspnea slightly felt, 3 - fatigue of medium degree, dyspnea moderately felt, 4 - fatigue quite high, dyspnea relatively severe, 5, 6 - fatigue high, dyspnea severe, 7, 8, 9 - fatigue very high, dyspnea very severe, 10 - fatigue very, very high, dyspnea almost maximum, +10 - maximum fatigue, dyspnea unbearable; ***Characteristics of* BI:** 0-20 points. - patient's condition "very severe", 21-85 pts. - patient's condition "moderately severe", 86-100 pts. - patient's condition "light".

***Abbreviations*:** 6MWT – 6-minute walk test; POT – pulse oximetry test; MBS – modified Borg scale; BI – Barthel Index; HRmax – maximum heart rate; SpO2 – saturation.

Table 5. Parameter changes of the spirometry performed before and after the therapeutic intervention.

		FVC	FEV1	FEV1/FVC	ERV	IRV	TV
Case 1	Before	3.17 l	2.11 l	66.5%	0.78 l	1.3 l	0.39 l
	After	3.91 l	3.3 l	84.4%	1.1 l	2.0 l	0.45 l
Case 2	Before	2.98 l	1.96 l	65.8%	0.67 l	1.2 l	0.32 l
	After	3.59 l	2.94 l	81.9%	0.98 l	1.9 l	0.4 l

***Abbreviations*:** FVC – forced vital capacity, FEV1 – forced expiratory volume in 1 second, FEV1/FVC – quasi-Tiffeneau index, ERV – expiratory reserve volume, IRV – inspiratory reserve volume, TV – tidal volume.

Discussion

Over the past year, there have been many reports relating to the improvement of patients after COVID-19. These articles are mainly in the form of expert recommendations, consensus statements by specialist teams or clinical case reports. These studies are mostly a collection of observations and requirements for daily practice [1, 19]. Unfortunately, there is still a lack of precise and practical guidelines that can be directly implemented in the therapeutic management of COVID-19 patients in the post-acute phase. As mentioned by Matthias Hermann et al. [20], it should also be borne in mind that patients with comorbidities, i.e., cardiovascular disease, diabetes, obesity, undergo SARS-CoV-2 infection more severely. Therefore, they may require longer and more intensive rehabilitation. The cases presented by the authors and the beneficial effects of the physiotherapeutic intervention carried out indicate the necessity of implementing cardiopulmonary therapy in patients after COVID-19 in the post-acute phase. Furthermore, as the results show, as little as four weeks of rehabilitation is able to significantly improve a patient's condition. We can find similar results in the study conducted by Liu et al. [21], which focused on the pulmonary rehabilitation of adults after COVID-19 infection. The participants were subjected to breathing muscle exercises, effective coughing exercises, diaphragm training and stretching exercises over a period of six weeks. Patients were assessed using the 6-minute walk test, spirometry, ADL scale, and quality of life questionnaire. The biggest statistically significant changes were found in the spirometry and the 6-minute walk test. There was a significant increase in forced expiratory volume in 1 second (FEV1) and an increase in the distance covered during the walk test. Therefore, the 6-week rehabilitation has been found to significantly improve respiratory function after COVID-19 [21]. Similar results were reported by Giansanti and Maccioni [22], where a significant improvement in the performance of the 6-minute walk test was obtained after 6-9 weeks of pulmonary rehabilitation. Furthermore, the researchers believe that it is reasonable to complement respiratory rehabilitation with SIS therapy. This is confirmed by the results of a study conducted by Silantyeva [23]. The aim of this research was to evaluate the effectiveness of the use of a SIS in patients following COVID-19 infection in the post discharge period. The main tool used for assessing statistical significance was the spirometry test. There was a significant improvement in the pseudo-Tiffeneau index which was 78.6% on average before therapy but increased to 86.6% after the SIS intervention. The author indicated that the SIS method is a highly effective treatment in the healing process after severe COVID-19-associated pneumonia. However, it is important to remember that COVID-19 is not just a respiratory disease, and thus a therapy consisting of respiratory rehabilitation alone, according to the researchers, is not the optimal form of patient improvement. Iannaccone et al., [24] similarly, highlighted the role of physical training in COVID-19 patients. They observed that the disease causes a significant loss of physical fitness and muscle strength. It can cause impaired balance and even cognitive impairments. When providing rehabilitation, they suggested endurance training on a cycle ergometer considering the intensity of the effort. Resistance training with rubber bands was carried out to rebuild muscle mass and strength. Furthermore, it has been suggested that psychological support is an important factor when assessing cognitive impairments and functions [24].

Summary

The initial evaluation of the proprietary therapeutic plan carried out is very promising. In both cases that qualified for the rehabilitation program, improvements were observed in all examined aspects: increased physical and respiratory capacity,

reduced dyspnea and general fatigue, improved functional capacity, and improved lung function. More patients have been included in a given treatment program, allowing data to be completed and further analyses to be performed. In subsequent research, the authors plan to carry out a statistical analysis for a larger sample with a control group in which the SIS intervention was excluded from the procedure.

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