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Post-COVID-19 rehabilitation in the post-hospitalization period – case study

Postępowanie rehabilitacyjne po przebytej chorobie COVID-19 w okresie poszpitalnym – opis przypadku

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Abstract

Aim of the research work. The main goal of the research work was to show an author's plan of physiotherapeutic intervention for people suffering of COVID-19 in the post-acute stage. The therapeutic procedure highlighted pulmonary rehabilitation, aerobic and resistance training and patient's education.

Case study. The research work was performed on a 62-year old woman, who was diagnosed with infection by SARS-CoV-2 virus. The patient was admitted to ICU with acute ARDS in a heavily severe condition. The medical history showed obesity, chronic ischemic heart disease, arterial hypertension and cardiac arrest (2011). The patient was admitted to the rehabilitation unit in the post-acute stage of infection, and was using passive oxygen therapy with oxygen flow set to 4 l/min. During the qualification for therapy the patient was tested using a questionnaire which consisted of clinical tests such as 6MWT, MRC, 30CST and FIM scale. Furthermore, the lungs were examined using spirometry. Identical measurements were being used every 2 weeks of the therapy process. After 8 weeks of physiotherapeutic procedure there was a significant increase of score in 6-MWT which upgraded by 750%. Systematic improvement was also visible in dyspnoea and fatigue, which completely surceased after finishing the therapeutic process. Functional state of the patient improved considerably which is shown by 30CST score, improved by 380%. Spirometry score analysis shows FVC, FEV1 and Tiffeneau-Pinelli index improve respectively by 40%, 53% and 9.6%.

Summary. The therapeutic program based on pulmonary rehabilitation, aerobic and resistance training and patient's education looks very promising. Implemented procedure contributed to the patient's relatively quick recovery to a pre-COVID-19 state. Patient's physical and pulmonary efficiency were noticed, exertional tolerance increased, dyspnoea and fatigue gave way which all combined led to improved functional efficiency. Pulmonary system function was also enhanced which was demonstrated by spirometry.

Key words:

SARS-CoV-2, COVID-19, physiotherapy, rehabilitation

Streszczenie

Cel pracy. Celem pracy było przedstawienie autorskiego planu przeprowadzenia interwencji fizjoterapeutycznej dla chorych w fazie poszpitalnej COVID-19. W postępowaniu terapeutycznym wyróżniono terapię oddechową, trening aerobowy i oporowy oraz edukację pacjenta.

Opis przypadku. Badanie przeprowadzono na 62-letniej kobiecie, u której stwierdzono zakażenie wirusem SARS-CoV-2. Pacjentka przyjęta na OIT z ostrym ARDS, w stanie bardzo ciężkim. W wywiadzie stwierdzono otyłość, przewlekłą chorobę niedokrwienną serca, nadciśnienie tętnicze oraz stan po zawale mięśnia sercowego w 2011 roku. Pacjentka trafiła na oddział rehabilitacji w fazie poszpitalnej, korzystając z tlenoterapii biernej z przepływem tlenu na poziomie 4 l/min. Podczas kwalifikacji do terapii pacjentkę zbadano kwestionariuszem, w skład którego wchodziły wystandaryzowane testy, takie jak: 6-MWT, MRC, 30CST oraz skala FIM. Ponadto przeprowadzono ocenę czynnościową płuc za pomocą badania spirometrycznego. Identyczne pomiary dokonywano co 2 tygodnie terapii. Po 8 tygodniach postępowania terapeutycznego zaobserwowano istotną poprawę wyników 6-MWT, które zwiększyły się o 750%. Systematycznej poprawie ulegało również odczucie duszności i zmęczenia, które po zakończeniu terapii całkowicie ustąpiło. Stan funkcjonalny pacjentki znacznie się poprawił, co sugerują wyniki 30CST, które poprawiły się o 380%. Analiza wyników badania spirometrycznego wykazała poprawę FVC, FEV1 i wskaźnika pseudo-Tiffeneau odpowiednio o 40%, 53% oraz o 9,6%.

Podsumowanie. Ocena programu terapeutycznego, bazującego na terapii oddechowej, treningu aerobowym i oporowym oraz edukacji pacjenta, jest bardzo obiecująca. Zastosowany plan terapeutyczny przyczynił się do względnie szybkiego powrotu do zdrowia sprzed choroby pacjentki. U pacjentki zaobserwowano zwiększenie wydolności fizycznej oraz oddechowej, poprawę tolerancji wysiłkowej, ustąpienie odczucia duszności oraz zmęczenia, a także wzrost sprawności funkcjonalnej. Poprawiła się także czynność układu oddechowego, co wykazano za pomocą badania spirometrycznego.

Słowa kluczowe:

SARS-Cov-2, COVID-19, fizjoterapia, rehabilitacja

Introduction

COVID-19 is an acute infectious disease of the respiratory system caused by infection with the SARS-Cov-2 coronavirus, which is characterized by a varied clinical course. Severe course of the infection is reported in approximately 13.8% of patients, while 6.1% of patients require hospitalization in the Intensive Care Unit (ICU) due to multiple organ failure [1, 2]. The most common early complications in the severe course of COVID-19 are acute respiratory distress syndrome – ARDS (67%), acute kidney injury (29%), liver dysfunction (29%) and heart damage (23%) [3]. Due to the time criteria of persistent symptoms, three stages of the disease were distinguished: acute COVID-19 – symptoms of the infection lasting up to 4 weeks; prolonged symptomatic COVID-19 – post-acute stage (post-hospitalization stage), in which symptoms last from 4 to 12 weeks; post-COVID-19 syndrome – long COVID, where symptoms, consistent with the symptoms of COVID-19, developed during or after the infection and last longer than 12 weeks, and for which there is no alternative explanation [4, 5].

In patients hospitalized in the ICU due to ARDS who received invasive mechanical ventilation or high-flow oxygen therapy, a significant deterioration in general physical fitness and lung function is observed. These conditions last from several months to even several years, which significantly reduces the patients' quality of life [6]. In order to counteract the negative effects of COVID-19 and to minimize unwanted symptoms, rapid physiotherapeutic intervention is recommended. According to the position of the World Health Organization, some patients hospitalized at the ICU require implementation of physiotherapeutic interventions immediately after hospitalization [7]. Moreover, the National Institute for Health and Care Excellence indicates that the implementation of a progressive rehabilitation program in the first 30 days (post-acute stage) has the greatest impact on patient's recovery [8, 9]. It should be remembered that pulmonary physiotherapy is one of the key elements of multidisciplinary treatment of patients after COVID-19.

Aim of the research work

The aim of this research work is to present a therapeutic procedure on the example of a patient in the post-hospitalization period (post-acute stage) after a severe course of COVID-19.

Case study

A 62-year-old woman with a history of obesity, chronic ischemic heart disease, arterial hypertension and cardiac arrest in 2011. The patient was admitted to the ICU due to acute respiratory failure as a result of infection with the SARS-CoV-2 virus. When the patient was admitted with limited logical contact, the peripheral blood saturation was 50%. At the ICU, high-flow oxygen therapy (60 l/min) was implemented. Due to extremely severe oxygenation disorders and increasing fatigue, intubation was performed and non-invasive ventilation (NIV) was commenced. In the course of the disease, a further deterioration of the respiratory parameters associated with the acute respiratory distress syndrome was observed, which led to the decision to perform

Griggs' percutaneous tracheostomy in the operating theatre and generate percutaneous endoscopic gastrostomy (PEG). The patient's condition was assessed as very serious. In the following days of hospitalization in the intensive care unit, due to periodic problems with ventilation, additional bronchoscopy examinations, modification of the position and replacement of the tracheostomy tube, and the implementation of antitussive treatment were required. As a result of the imaging examination, bilateral, diffuse parenchymal opacities in the lungs of a "matte glass" character were found. Over time, a slow, gradual improvement in respiratory function was observed, and sedation was reduced, obtaining simple, non-verbal contact until fully logical contact was achieved. A significant improvement in arterial blood gas parameters resulted in the removal of the tracheostomy tube, which was very poorly tolerated by the patient. Instead, passive oxygen therapy through nasal cannulas was introduced. The patient in the post-acute stage was admitted to the stationary rehabilitation ward at the Origin Centre in Kraków. On the day of admission, the patient was administered passive oxygen therapy with a flow set at 4 l/min, with full auto- and allopsychic orientation, verbally responsive.
Prior to the physiotherapeutic intervention, the patient was assessed using standardized and publicly available functional tests. Exercise tolerance (6-MWT), the occurrence of dyspnoea and its severity (MRC), strength and endurance of the muscles of the lower limbs (30CST) were assessed, and independence in daily activities (FIM) was tested. The results of the above tests are presented in the summary table 3. In addition, a functional assessment of the lungs was performed based on the performed spirometry (Table 4). The patient was subjected to an identical assessment questionnaire five times: before the initiation of therapeutic procedure, and then every 2 weeks of the procedure. The therapeutic intervention lasted 8 weeks.

Assumptions and description of the therapeutic procedure
Taking into account the patient's condition, on the day of admission to the Origin Centre in Kraków, a rehabilitation plan was established, in which three main components can be distinguished, i.e. pulmonary therapy, physical training and patient's education. Breathing exercises were adopted as pulmonary therapy, including active breathing exercises, active breathing exercises with resistance, learning to cough and expectorate, and manual techniques. Physical training was divided into three stages: passive and active verticalization, preparation for walking, including gait re-education using orthopaedic equipment, and proper physical training, involving aerobic and resistance exercises. Patient's education included instructions how to exercise, discussion of possible complications after the disease and ways of coping with them, and further recommendations for rehabilitation. As part of patient's education, an information brochure was used, in line with WHO guidelines, translated by the National Chamber of Physiotherapists, entitled "Support in self-rehabilitation after suffering from a COVID-19-related disease" [10].
Therapy was carried out 6 days a week. Each day, the patient underwent 3 hours of therapy; one day (Sunday) was devoted to the patient's regeneration and rest. During rehabilitation, the arterial oxygen saturation level was systematically measured. Training was discontinued when the saturation dropped by more than 4 percentage points from the baseline value [11].

Weeks 0–2

After admitting the patient, one of the main therapeutic tasks was to minimize the patient's dyspnoea, evacuate copious secretions from the respiratory tract, improve respiratory parameters and independence from oxygen therapy. For this purpose, starting from the first day of hospitalization, pulmonary therapy was implemented, which consisted of manual techniques (rib springing, manually assisted cough - MAC, vibration techniques), modified poses, and the use of grips that stimulate breathing in accordance with the PNF method (Figure 1). The above-mentioned interventions contributed to increasing chest elasticity, blood supply and elasticity of the lungs, and made it possible to remove the residual secretions. This resulted in a significant improvement in respiratory parameters, so the use of passive oxygen therapy during the day was discontinued (day 7). Due to the accompanying significant orthostatic disturbances, passive verticalization (Figure 2) with the use of a verticalization table (day 1-5) and active verticalization in a sitting position (days 5-10) were included in the procedure. A key aspect of early physiotherapy was the achievement of basic self-care skills, such as: changing the basic body position in bed, moving from a side-lying position to a sitting position, and stable torso control in this position, and assisted transfer to a wheelchair. The above skills were acquired by the patient during the first two weeks of her hospitalization.

Fig. 1. Breathing stimulation with the use of an upper costal grip (left) and a one-sided lower costal grip (right)

Weeks 3–4

The next step in the process of regaining the patient's independence was the implementation of resistance exercises with the use of light weights. Thera-band tapes, 0.5–3 kg weights and rubber balls were used for this purpose. These exercises were

Fig. 2. Passive verticalization using a verticalization table, position 30 degrees (left) and 70 degrees (right)

Fig. 3. Active verticalization with the use of a therapeutic table and ladders

mainly performed in the supine position. Due to the decreasing orthostatic disorders and the complete discontinuation of passive oxygen therapy, also at night (day 14), active verticalization was implemented with the use of ladders, therapeutic tables (Figure 3) and a walking frame, to which the patient responded very well. The patient gradually started to perform resistance exercises in higher positions (day 18), i.e. rhythmic and continuous stabilization of the torso in a sitting position, exercises with a therapeutic column (Figure 4), strengthening the muscles of the upper and lower limbs using the HUR system. After obtaining satisfactory circulatory and respiratory parameters during active verticalization (day 21), gait training and re-education was started with the use of a high and then a low walking frame (Figure 5), which also constituted introduction to aerobic exercises. At the end of the 4th week, the patient acquired the ability to independently move short distances using Nordic walking poles in the presence of a therapist.

Fig. 4. Sample resistance exercise with the use of a therapeutic column, starting and ending position

Weeks 5–6

Therapy was supplemented with aerobic training (day 28), which was carried out in two procedures - intermittent and continuous. The bicycle ergometer (Figure 6) and walking training were the core of intermittent training, while continuous training took place on an anti-gravity treadmill (Figure 7). Aerobic exer-

Fig. 5. Gait training and re-education with the use of a low walking frame

Fig. 6. Aerobic exercises with the use of a bicycle ergometer

Fig. 7. Aerobic exercises with the use of an anti-gravity treadmill

cises were conducted in accordance with the guidelines presented in Table 1. The patient was moving across the flat area by herself, without the use of orthopaedic equipment (day 30), while climbing and descending stairs required the use of a handrail and one pole. As the patient's health gradually improved, more demanding resistance exercises were performed (day 32), focusing on strength and endurance training. The exercises were selected in such a way as to improve postural control, increase the strength of the muscles in the limbs and improve static and dynamic stabilization. The following exercises were performed: squats with weights from a rehabilitation table, progressing the weight of the dumbbells and lowering the table (Figure 8), torso rotation and exercises to strengthen the muscles of the upper limbs at a therapeutic column, straightening the lower limbs with weights or rowing (Figure 9). The volume of resistance training was selected on the basis of the RM unit, the remaining parameters are presented in Table 2. During resistance exercises, particular attention was paid to the correct breathing pattern and to avoiding the Valsalva manoeuvre. The exercises were carried out with the use of the HUR system and basic therapeutic accessories. On the 41st day of therapy, the patient acquired the ability to independently climb and descend stairs without any help.

Fig. 8. Sample resistance exercise - squats from a rehabilitation table with dumbbells, starting and ending position

Fig. 9. Sample resistance exercise - rowing with HUR equipment, starting and ending position

Table 1. Aerobic training parameters

Type of training	Intermittent aerobic training	Continuous aerobic training
Work	At the beginning: • 30 sec activity, 30 sec break Target: • 3 min activity, 30 sec break;	Continuous work
Equipment used	Walking training Bicycle ergometer	Antigravity treadmill
Intensity	At the beginning: • Low – 40-50% HRmax Target: • Moderate – 60-70% HRmax	
Duration	At the beginning: • 12-15 min Target: • 40 min (including breaks)	At the beginning: • 10-12 min Target: • 30 min
Progression	Increase in the intensity of the training unit according to the patient's needs	

HRmax: maximum heart rate

Table 2. Resistance training parameters

Type of training	Resistance and endurance training
Load	30-80% 1-RM
Volume	0-30 repetitions of the exercise in 1-3 series
Breaks	1 min. between individual series
Duration	At the beginning: • 10-15 min; Target: • 30 min;

1-RM: the maximum load at which the patient is able to do one repetition

Weeks 7–8

During the last two weeks of hospitalization (day 43–56), aerobic and resistance training was continued, constantly increasing the training volume by increasing the number of series and load, which significantly improved the patient's overall fitness. In addition, efforts were made to gradually reduce breaks between individual series and exercises so that the patient had less time to rest. The progression of individual exercises also involved performing several tasks simultaneously in order to improve hand-eye coordination and the patient's concentration. Particular attention was paid to improving the automation of gait, e.g. by using obstacle courses (Figure 10), introducing specific mental and physical tasks during walking or deliberately distracting the patient.

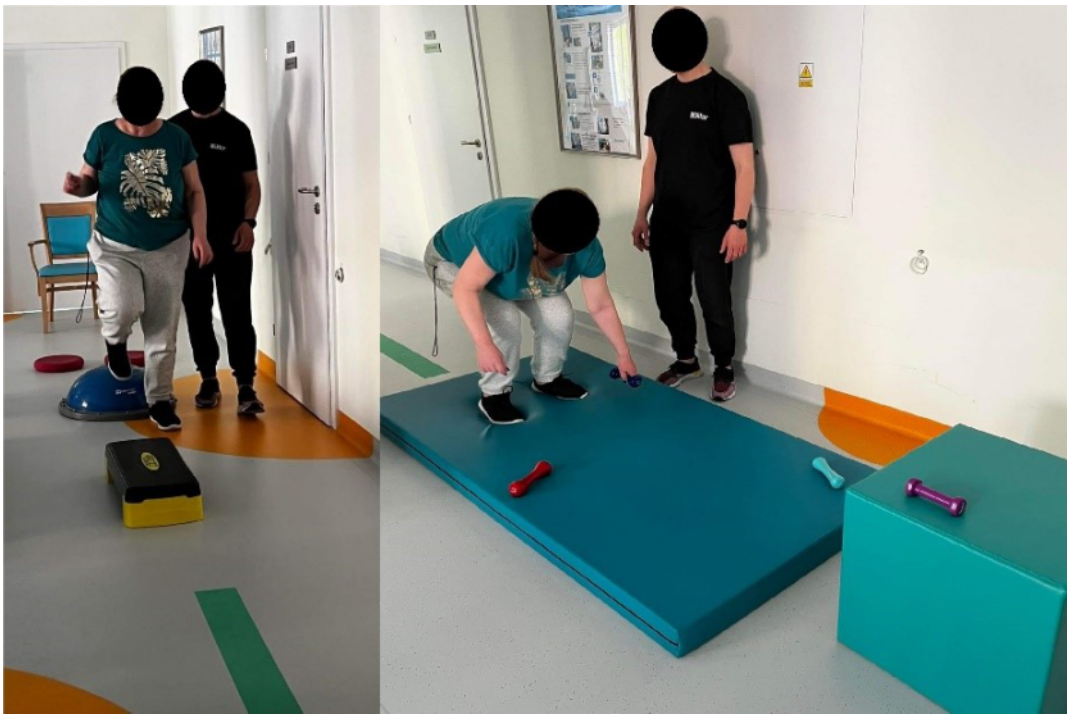

Fig. 10. Obstacle course

Results

The results of functional tests of the 8-week rehabilitation procedure are presented in Table 3. A significant, systematic improvement of all the parameters tested was observed. This indicates a significant improvement in the functioning of the respiratory and cardiovascular systems as well as an increase in muscle strength and endurance. Before starting the therapeutic procedure, the patient was not able to independently change position in bed, stand up or stand. This excluded her from carrying out the 6-MWT and 30CST tests, which means that the appropriate result of 0 meters and 0 repetitions was assumed. Due to the above, for the calculation of the percent improvement values in the given tests, the initial parameters were measured after 2 weeks of therapy.

The 6-minute walk test score increased by 420 meters during the final evaluation. This means that the patient increased the distance covered by as much as 750% in relation to the baseline measurement. Moreover, from the 6th week inclusive, the number of breaks needed to complete the test dropped to 0. This indicates a significant improvement in respiratory efficiency and exercise tolerance. Improvement was also seen on the Borg scale which was performed before and after 6-MWT. The final measurement of subjective fatigue (after 8 weeks of rehabilitation) was lower by 4 and 2 points, respectively, before and after the test, compared to the baseline test. It is the reduction of fatigue determined by the patient from “moderate” to “no fatigue” before the test and from “very significant fatigue” to “significant” after the test. Importantly, the level of fatigue and dyspnoea after the end of the therapeutic cycle reached the normative levels, i.e. it dropped to 6 points. Similar conclusions can be drawn by analysing the patient’s MRC dyspnoea severity grades. Dyspnoea decreased from 4 points (dyspnoea at rest) upon admission to 1 point (dyspnoea occurs with intensive training) from the 4th week of therapy, while after the rehabilitation stay, it completely disappeared. Functional assessment was performed using 30CST and the FIM scale. In the 30-second sit to stand test, an increase from 5 to 19 repetitions was noted, i.e. an improvement of 380%. It is worth noting that the normative values for women aged 60–64 are 12–17 repetitions [12]. This indicates that the patient achieved the test values for healthy people in a given age group after the 4th week of therapy. Then, after 8 weeks of rehabilitation, she achieved an above-average result. On the FIM scale, the following were assessed: self-care, sphincter control, mobility, locomotion, communication and social awareness. The minimum number of points that could be obtained was 18, the maximum was 126. Upon admission, the patient was rated at 42 points, gradually increasing her independence, scoring respectively 90, 121, 123 and 126 points after the 8th week of therapy. This proves that the patient has regained full functional efficiency, without any defects.

Table 3. Results from functional tests performed before, during and after therapeutic intervention

	Before rehabilitation	After 2 weeks of rehabilitation	After 4 weeks of rehabilitation	After 6 weeks of rehabilitation	After 8 weeks – the end of rehabilitation
6MWT	0 (test impossible to perform)	60 m	340 m	420 m	450 m
Breaks:	–	2	2	0	0
Borg scale (before/after the test):	–	10/16	7/11	8/15	6/14
Orthopaedic equipment:	–	High walking frame	Nordic walking poles	–	–
MRC	4	3	1	1	0
30CST	0 (test impossible to perform)	5	12	17	19
FIM	42 pkt./ 42 pts	90 pkt. / 90 pts	121 pkt. / 121 pts	123 pkt. / 123 pts	126 pkt. / 126 pts

6-MWT: 6 Minute Walk Test; MRC: Medical Research Council; 30CST: 30 Seconds Sit To Stand Test; FIM: Functional Independence Measure

Spirometry was performed 4 times, starting from the 2nd week of rehabilitation, ending with the 8th week. After admission to the hospital, the patient was unable to follow the instructions necessary to obtain reliable results in the lung function test due to the significant retention of secretions in the respiratory tract. Therefore, the parameters obtained after the second week of rehabilitation were adopted as the baseline results. After analysing the results of spirometry, an improvement was found: forced vital capacity by 40.4%, increased forced expiratory volume in the first second by 53%, Tiffeneau-Pinelli FEV1/FVC index by 9.6%. Table 4 presents the exact values of spirometry before, every 2 weeks and after the end of the therapeutic intervention.

Table 4. Results from lung function tests performed before, during and after therapeutic intervention

	Before rehabilitation	After 2 weeks of rehabilitation	After 4 weeks of rehabilitation	After 6 weeks of rehabilitation	After 8 weeks – the end of rehabilitation
FVC	–	2.25 l	2.49 l	2.72 l	3.16 l
FEV1	–	1.81 l	2.11 l	2.24 l	2.77 l
FEV1/FVC	–	80.0%	84.7%	83.0%	87.7%

FVC: forced vital capacity, FEV1: forced expiratory volume in the first second, FEV1/FVC: Tiffeneau-Pinelli index

Discussion

Since the appearance of the SARS-CoV-2 virus, many reports and research papers have been published on the recommendations and comments concerning the multidisciplinary post-COVID-19 therapeutic procedure. Unfortunately, most of the available studies still mainly constitute consensus of specialists or recommendations of experts, which are difficult to directly translate into the work of physiotherapists with the patient. According to the authors, there are no scientific reports that would present comprehensive physiotherapy with a specific description of the techniques used, selected parameters and exercises performed in the post-hospitalization stage. Reports dedicated to physiotherapists, focusing primarily on the practical part of working with the patient, may contribute to the improvement of health services and maximization of therapeutic effects due to the possibility of implementing previously unused medical procedures in the therapeutic process. As presented in the above research work, the 8-week comprehensive rehabilitation stay can restore full pre-COVID-19 functional fitness. Similar conclusions were obtained in the study conducted by Liu K. et al., which presented pulmonary rehabilitation of adults after COVID-19. Patients participating in the 6-week therapeutic procedure were subjected to pulmonary therapy techniques similar to those used in the presented research work; the following were implemented: effective coughing exercises, breathing muscles exercises, diaphragm training and muscle stretching. After completion of the procedure, significant statistical changes were noted in the results of the pulmonary function test, the 6-minute walk test and the ADL scale. These tests indicate that pulmonary therapy can significantly improve the function of the respiratory system and increase the overall physical efficiency [13]. Similar conclusions were reached in the study conducted by Giansanti et al., who achieved a clear improvement in the results of 6-MWT over the course of 6–9 weeks of pulmonary therapy [14]. Respiratory training, which was performed with the patient during her 8-week therapeutic stay, was an integral part of therapy and significantly supported the patient's progress. The study published by Maki et al. confirms the above statement, paying attention to the fact that the implementation of persistently used breathing exercises in the rehabilitation procedure contributes to the achievement of better effects in the area of the respiratory system function compared to the identical procedure without the use of the above-mentioned exercises [15]. According to the authors, pulmonary rehabilitation should be supplemented with aerobic and resistance training in order to optimally improve the efficiency of the patient's body. This type of intervention was necessary to reduce the negative effects of long-term immobilization of the patient, which is indicated as the main factor that reduces efficiency in the acute stage of COVID-19 [16]. The case study conducted by Shan et al. presents a case of a patient who improved the 6-MWT result by 645% over 10 days of therapy aimed at improving exercise tolerance and endurance. This result is extremely impressive considering the time it took to achieve it. However, it should be noted that the initial functional state of the patient differed significantly from that of the patient described in the above research work [17].

Conclusions

The evaluation of the therapeutic program based on pulmonary therapy, aerobic and resistance training, and patient's education is very promising. The use of targeted therapy, aimed to eliminate the patient's deficits after COVID-19, along with the selection of the above-mentioned parameters of physical training, contributed to a relatively quick recovery. Moreover, some functional tests have shown that the patient has a higher exercise tolerance than the corresponding control group of the healthy population. The patient experienced an increase in physical and respiratory capacity, a gradual reduction until the symptoms of dyspnoea and fatigue completely disappeared, improvement in functional efficiency and in lung function.

The therapeutic program is used to treat patients in the post-acute stage of COVID-19, which enables further data completion and the creation of necessary analyses. In the next article, the authors plan to include a larger group of patients in the study and to conduct a statistical analysis to confirm the static significance of the procedure.

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