

## ABSTRACT

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## THE ROLE OF PULMONARY REHABILITATION IN RECOVERY AFTER COVID-19

**Introduction.** The outbreak of coronavirus infection (COVID-19) continues to be one of the most serious problems of the mankind. Patients who develop pneumonia as a result of coronavirus infection require rehabilitation measures to restore the functional capacity of the body and to prevent the negative consequences of the disease. For patients with COVID-19, rehabilitation should be aimed at alleviating symptoms (shortness of breath), improving psychological condition, physical form and quality of life. This can be achieved by improving the organization and methodology of pulmonary rehabilitation of patients with COVID-19.

**Purpose** is to justify the use of pulmonary rehabilitation in patients with COVID-19.

**Materials and methods:** analysis and systematization of data from modern scientific and methodological literature and Internet sources.

**Results.** The emergence and spread of coronavirus (SARS-CoV-2) is a major public health issue. Post-COVID syndrome has already become a massive phenomenon and part of our lives. Recovery from coronavirus infection is necessary for all, regardless of the severity of the disease. Physical therapy can be used at various stages of treatment for COVID-19 patients. However, the decision to use it, the nature, scope and purpose of the interventions should be based on clinical evidence, the safety of patients and staff. Pulmonary rehabilitation, the main component of which is physical exercise (aerobic and/or resistance training), can play a vital role in the recovery of patients, improving physical fitness, muscle strength and quality of life of those infected with severe acute respiratory coronavirus syndrome. Moreover, under quarantine conditions, it was important for many patients to have access to home-based rehabilitation, which was provided by tele-rehabilitation facilities using telecommunications technology.

**Conclusions.** Thus, pulmonary rehabilitation is an important part of recovery from COVID-19. The development of complications and the increase in the number of pulmonological patients who have suffered a severe or moderate coronary infection are updating the issues of adaptation of traditional rehabilitation programs to new conditions.

**Key words:** COVID-19, pulmonary rehabilitation, post-COVID syndrome, telerehabilitation, physical therapy.

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**РЕЗЮМЕ****Валентина Л. Войтенко***кафедра фізичної терапії, ерго-терапії та спортивної медицини, Сумський державний університет, м. Суми, Україна***Валентина П. Шевець***кафедра фізичної терапії, ерго-терапії та спортивної медицини, Сумський державний університет, м. Суми, Україна***Ірина А. Бріжата***кафедра фізичної терапії, ерго-терапії та спортивної медицини, Сумський державний університет, м. Суми, Україна***РОЛЬ ЛЕГЕНЕВОЇ РЕАБІЛІТАЦІЇ У ВІДНОВЛЕННІ ПІСЛЯ COVID-19**

**Вступ.** Спалах коронавірусної інфекції (COVID-19), продовжує залишатися однією з найсерйозніших проблем людства. Пацієнтам, у яких через коронавірусну інфекцію розвивається пневмонія, необхідні заходи реабілітації, щоб відновити функціональні можливості організму та виключити негативні наслідки захворювання. Для хворих з COVID-19 реабілітація має бути спрямована на полегшення симптомів (задишки), поліпшення психологічного стану, поліпшення фізичної форми та якості життя. Цього можна досягти шляхом покращення та вдосконалення організації й методики проведення легеневої реабілітації пацієнтів із COVID-19.

**Матеріали і методи** – аналіз і систематизація даних сучасної науково-методичної літератури та інтернет джерел.

**Результати.** Виникнення та поширення коронавірусу (SARS-CoV-2) є основним питанням до якого прикута увага сфери охорони здоров'я. Постковідний синдром уже став масовим явищем і частиною нашого життя. Відновлення після перенесеної коронавірусної інфекції потрібно усім, незалежно від ступеня важкості захворювання. Фізична терапія може застосовуватися на різних етапах лікування пацієнтів з COVID-19. Однак, рішення про її застосування, особливості, об'єм та мету втручань повинні прийматися із врахуванням клінічних показів, безпеки пацієнтів та персоналу. Легенева реабілітація, основним компонентом якої є фізичні вправи (аеробні та/або тренування на опір), може відігравати життєво важливу роль у одужанні пацієнтів, підвищенні фізичної працездатності, м'язової сили та якості життя інфікованих важким гострим респіраторним синдромом коронавірусу. Крім того, в умовах карантину для багатьох пацієнтів важливо мати доступ до реабілітації в домашніх умовах, що забезпечується засобами телереабілітації з використанням телекомунікаційних технологій.

**Висновки.** Таким чином, легенева реабілітація є важливою частиною відновлення здоров'я після COVID-19. Розвиток ускладнень і збільшення числа пульмонологічних хворих, які перенесли коронавірусну інфекцію у важкій або середньоважкій формі, актуалізують питання адаптації традиційних реабілітаційних програм до нових умов.

**Ключові слова:** COVID-19, легенева реабілітація, постковідний синдром, телереабілітація, фізична терапія.

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**INTRODUCTION/ВСТУП**

The emergence and spread of the coronavirus (SARS-CoV-2) and the disease caused by it (COVID-19) in China at the end of 2019 has caused

a global pandemic and at this time is the main issue to which the attention in the health sector [1]. The COVID-19 pandemic has created a complex global health scenario with different types of

complications and levels of functional disorders in millions of people who have been recovering from the disease. Severe disease causes lung damage and can lead to respiratory insufficiency [2].

At present, there are no reports that allow to assume that patients from COVID-19 have severed secretion production that requires intensive respiratory physical therapy and airway clearance. Physical therapists will play a major role in the rehabilitation of patients with COVID-19, who will have a reduction in their functional level relative to the initial level after the acute period and in the long periods [3]. Rehabilitation interventions for patients with severe COVID-19 transits are especially necessary in the acute period. The needs of patients with COVID-19 for rehabilitation differ depending on the period of rehabilitation, peculiarities of disease course, comorbid pathology.

Pulmonary rehabilitation is the main aspect of medical rehabilitation, the main tools and interventions of which are traditional interventions, which play an important new role and application in the treatment of COVID-19.

Therefore, the issue of improvement and improvement of organization and methodology of carrying out of the legal rehabilitation of patients with COVID-19 is rather topical for scientific research.

**Materials and methods of research** – analysis and systematization of data of modern scientific-methodical literature and Internet sources.

**Results of the survey.** Coronavirus disease (COVID-19), caused by the infection of severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2), leads to unknown and unusual health conditions, which are difficult to cope with. Lung damage due to direct damage of coronavirus and cytokines endothelium of vessels and alveolar complex (alveolocytes and interalveolar partitions; thus developing X-ray symptom of "frosted glass") causes development of interflow pneumonias, activation of process of fibrosis, as well as reduction of function of lungs.

Post-COVID-19 syndrome is one of such problems that is becoming more common with the development of the pandemic. According to the latest estimates, from 10 to 20% of patients with SARS-CoV-2 who have suffered a severe symptomatic phase will suffer the consequences of the disease within 12 weeks after diagnosis [4].

Post-COVID syndrome has already become a mass phenomenon and part of our lives. The respiratory system suffers from coronavirus almost

the most. Even those who have experienced severe lung damage and saturation problems respond to cough and shortness of breath. According to the criteria for the involvement of patients with COVID-19 in respiratory physical therapy [4], referral to physical therapy for airway cleansing is recommended for patients with mild symptoms and/or pneumonia and the presence of exudate with difficulty clearing or inability to clear secretions and whooping cough, auscultatory wet wheezing, etc.).

Recovery after a previous coronavirus infection is necessary for all, regardless of the severity of the disease. However, to a greater extent, recovery requires patients with moderate or severe transits. The volume of recovery and rehabilitation programs will vary for each patient category. In case of mild or asymptomatic coronavirus infection it is necessary to follow the recommendations of the doctor concerning prevention of complications. In case of changes in lung parenchyma by type of "frosted glass" is necessary respiratory rehabilitation under supervision of the specialist [5].

Physical therapy can be applied at different stages of treatment of patients with COVID-19. However, decisions on its application, peculiarities, volume and purpose of intervention should take into account clinical indications, safety of patients and personnel, expediency, needs of the patient, availability of material and human resources, etc. [6]. The decision on the necessity of the use of respiratory physical therapy and/or other rehabilitation interventions for each specific patient is made individually, in coordination with the doctor and team of specialists. Physical therapy should be provided only with clinical indications from patients, weighing the risk of infection of employees [7]. At the early stages COVID-19 should carefully plan the program of physical therapy at the respiratory distress-syndromes. Intervention should not cause additional strain on respiratory work, which may increase the risk of respiratory distress [8].

Coronavirus infection breaks gas exchange in lungs. The process of their restoration is long, takes a lot of effort. Everything depends on the initial state of health of the patient, degree of severity of the disease [9]. Compensation of lost functions occurs continuously from the first days of the disease under the control of laboratory, instrumental methods of research. With mild or asymptomatic infection, recovery takes up to 2–3 months, and with a more severe process takes more than a year. At timely correction and regular

observation, the disease can be taken under control, avoid adverse course [10].

Pulmonary rehabilitation (PR) is effective for reducing symptoms and improving health, as well as for tolerance to physical stress [7]. PR can play a vital role in recovery of patients infected with severe acute respiratory syndrome (SARS-CoV-2) [9]. The most common complications in patients with severe course are bilateral pneumonia, respiratory insufficiency, acute respiratory distress syndrome [11]; also changes in the interstitial tissue of lungs, parenchyma, respiratory tract, pleural and vascular lungs.

The aim of pulmonary rehabilitation of patients with COVID-19 is to improve the symptoms of the scoring, relieve anxiety, reduce complications, minimize disability, preserve function, and improve quality of life. Pulmonary rehabilitation should be selected individually for each patient [12]. In mild disease, pulmonary rehabilitation may be considered, including training, airway cleansing techniques, exercise, breathing exercises, activity recommendations, and anxiety management.

At this stage you can use breathing exercises. Diaphragm breathing includes patient training mainly to use diaphragm at minimizing the activity of auxiliary muscles. Nasal breathing should be encouraged to facilitate diaphragm recruitment and increase hydration. Active reduction of abdominal muscles should be used at the end of the breath to increase internal pressure and push the diaphragm to a more favorable elongation [13].

Optimally, PR sessions should include endurance training, interval training and strength training of the upper and lower extremities in addition to walking exercises. Other key components of PR include self-monitoring training. Self-monitoring interventions are structured, often multicomponent, and ideally personalized to achieve patient motivation and engagement goals that allow you to adopt positive health behaviors and develop self-monitoring skills and control your illness [14]. Randomized controlled trials (RCTs) showed that self-help interventions in the right way improve the health of patients and reduce the risk of hospitalization and visiting the emergency care department [15, 16].

The benefits of pulmonary rehabilitation are well-known and existing programs can be used as one of the ways of referral for rehabilitation for those who have survived COVID-19 who have symptoms or physical function violation [7]. The main component of lightweight rehabilitation

programs is physical exercises, which include aerobic and/or resistance training, and it has been shown that these exercises reduce the negative impact of prolonged sitting position and inactivity during hospitalization on the physical functions of patients. Also, pulmonary rehabilitation increases physical efficiency, muscle strength and quality of life in people with respiratory diseases [17].

The duration of physical therapy is not less than 6 weeks (optimal 8–12), individually, under the supervision of the physical therapist up to 5 lessons per week, duration from 20 to 90 min. The minimal number of physical therapy classes – 3 per week, of which once can be done independently, without supervision of the physical therapist.

*Physical therapy tasks:*

1. Improve your overall physical condition.
2. Improve bronchial patency and pulmonary ventilation.
3. Stimulate gas exchange in the lungs.
4. Reduce shortness of breath.
5. Strengthen the respiratory muscles.
6. Improve psycho-emotional state.

*Expected results of rehabilitation:*

1. Restoration the functional state of the respiratory system.
2. Strengthening the immune system.
3. Increase of activity and tone.
4. Return to the usual way of life.

Physical exercise is an important condition of recovery after a serious case of Covid-19. Respiratory exercises (Table 1) (static, dynamic, drainage) are leading in carrying out any form of physical therapy. They positively influence the function of the respiratory system, stimulate metabolism [18]. Static breathing exercises are performed in different initial positions in a state of calm, that is without movements of legs, hands, torso, dynamic – in combination with movements of limbs, torso. To drainage exercises include respiratory exercises, specially directed on outflow of exudate from pleural cavity and removal of sputum.

When performing breathing exercises, it is necessary to teach the patient to breathe properly through the nose – deeply, rhythmically, evenly. Under the condition of proper breathing, the rhythmicity of respiratory movements (inhalation–exhalation) is produced, their frequency decreases, exhalations are prolonged and intensified. With the help of a physical therapist, the patient tries to take as deep a breath as possible and exhale for a long time through the lips folded into a tube (2–3 times).

Next, the physical therapist puts his hand on the upper quadrants of the patient's abdomen (diaphragm) and asks him to take in the abdomen as much as possible during a deep breath. After mastering these exercises, the patient performs

them independently 5–6 times a day. They help to improve pulmonary ventilation, increase the depth of respiration and reduce its frequency, increase the mobility of the diaphragm [19].

**Table 1 – Approximate set of breathing exercises**

1. P.s.p. lying on his back, arms along the torso. To increase lung volume, place a roller under the neck and shoulder level. P.s.r. – standing on the side of the couch, holds the lower third of the forearm with one hand, and the hand of the other puts on the patient's shoulder joint. We ask the patient to lift his hands up – breath, p.s. exhale.
<i>Complications:</i> the patient's hands crossed on his chest, diagonal withdrawal.
2. P.s.p. same. P.s.r. – standing on the side of the couch. The rehabilitation specialist fixes the hands on the intercostal muscles. We ask the patient to take a deep breath, pressing on the chest – exhale. We control the patient's breathing, combine his breathing with our efforts.
3. P.s.p. same. P.s.r. – standing behind the patient, hands on his chest, without embossing perform displacement – inhale and exhale. We control the movements, do not press, take into account the patient's breathing.
4. P.s.p. lying on his side under the chest roller. Legs half bent. P.s.r. – standing on the side of the couch. The rehabilitator puts his hands on his ribs, asking the patient to inhale and exhale. We adjust to breathing.
5. P.s.p. same. P.s.r. – standing on the side of the couch. With one hand the rehabilitator fixes the pelvis, with the other he takes his hand back while the patient inhale, exhale – v.p. We control the patient's well-being, the exercise should not cause pain, we do not stretch the muscles. The movements are performed synchronously with the patient's breathing.
6. P.s.p. lying on his stomach with emphasis on the forearms, the roller under the ankle joint. P.s.r. – standing on the side of the couch, holds the lower third of the forearm with one hand, and the hand of the other puts on the patient's shoulder joint. We ask the patient to extend and withdraw the right hand – breath, back to p.s.p. exhale. Do the same with your left hand.
7. P.s.p.– sitting, back straight, head tilted forward, arms crossed on the knees. P.s.r. – stands behind, with one hand holding the radial wrist joint of the patient's hand, the other grasps the shoulder. The patient alternately withdraws the right (left) hand back and up (eyes follow the movement of the hand) – breath, p.s. exhale.
8. P.s.p. – sitting (on the couch, on a chair), arms crossed on his knees. Simultaneous raising of hands up and sideways – breath, p.s. exhale.
9. P.s.p. – sitting right (left) hand on his stomach, left (right) on the opposite knee, bent into a fist. Take a deep breath, withdraw your hand up and to the side
10. P.s.p. – standing arms along the torso. Take a deep breath, tilt the torso to the left (right) hand up.
11. P.s. sitting, hands cover his mouth. Take a deep breath through your nose, exhale through your mouth, trying to push your hand away.
12. P.s.p. – sitting. Inflating a balloon. Inhale through the nose, exhale into the balloon. Number of repetitions 4–5 times. It should be performed with caution, without additional effort.
13. P.s.p. same. Take a slow breath through the nose for 4 counts, exhale through a straw for 6 counts. Exhale should be 1.5 times longer than inhale.

Exercises are performed 30 minutes before the meal or an hour after in a ventilated room. The air temperature in the room should be comfortable in the range 20–24°. It is desirable to moisten the air, with the help of a special device or other way.

Clothes should be comfortable, do not compressed movements. It is desirable to wear pants, shirt with long sleeves, and socks. If you are engaged on the floor – prepare a mat. You can also do on a bed with a semi-firm mattress and on a table with a back.

Breathing should be comfortable; the exhalation should not be forced and loud. Inhale through the nose and exhale through the lips folded into a tube. With this technique you control the duration and smoothness of exhalation.

You can start exercising if your condition is satisfactory, there are no new complaints of shortness of breath, weakness, heart pain, headache, no rise in temperature during the day above 37.5 degrees, if the heart rate does not exceed 100 beats per minute, arterial pressure not higher than 160/100 and not lower than 90/60.

Load control: Before performing exercises, it is necessary to count the pulse, measure blood pressure, determine oxygen saturation with a pulse oximeter.

*Criteria for stopping exercise:*

- saturation less than 95% or fall during exercise by more than 4 marks;
- increased shortness of breath, increased weakness;
- feeling of heaviness in the chest, chest pain, difficulty breathing;
- dizziness, headache, blurred vision;
- palpitations, sweating, malaise;
- Blood pressure less than 90/60.

At the beginning of the class each exercise is repeated 4–6 times controlling your own feelings. Gradually, the number of repetitions of each exercise can be increased to 6–10–12 times or the rate of exercise can be accelerated. The main goal is to gradually perform deeper breathing with full exhalation.

In the case of respiratory disease, which causes respiratory dysfunction, involuntary compensations are formed for the body's adaptation, which can be fixed and automated. One of the most common compensatory reactions in respiratory failure is shortness of breath with frequent and shallow breathing. Loss of strength and physical shape during the disease, as well as

the disease itself, can lead to the rapid emergence of this pathological condition. This can lead to feelings of anxiety, which can further worsen your well-being. The situation with shortness of breath will improve as you slowly increase physical activity and exercise, while this happens, you can try the following body positions and techniques that will help alleviate this condition [20].

Shortness of breath during exercise is normal, safe and not harmful. Gradually coming to the appropriate physical form, it will decrease. If shortness of breath is too severe to speak, you should slow down or stop until breathing becomes more controlled.

There are several body positions you can take to relieve shortness of breath:

1. P.s. lying on your side, legs slightly bent at the knees, put a pillow under the head and neck.
2. P.s. sitting at the table, lean forward, putting his head on the pillow, forearms on the table. This position can also be tried without a pillow.
3. P.s. sitting on a chair, forearms on his knees, tilt his torso forward.
4. P.s. standing near a window sill or other stable surface, tilt the torso forward.
5. P.s. standing with his back to the wall, arms along the torso, feet at a distance of 30 cm from the wall and slightly spaced.

Thus, proper and adapted exercise is a promising and effective therapy to alleviate the symptoms of post-COVID-19 and help people recover faster and increase their autonomy, functionality and quality of life [20, 21].

**Discussion.** The pandemic of coronavirus infection presents new challenges to all social spheres of society and individual for every person. The area of rehabilitation should also be working under new conditions, on the one hand taking into account the limitations of the implemented security measures, and on the other – the needs of people who need physical therapy and rehabilitation assistance. In quarantine, it is important for many patients to have access to rehabilitation, since some countries require temporary but urgent physical therapy, others – systematic, without long breaks [20]. Given the shortage of personal protective equipment and the high risk of nosocomial transmission, rehabilitation should take place through telemedicine with minimal contact.

The coronavirus disease pandemic (COVID-19) has had a major impact on public relations programs and their delivery to patients. Because of concerns about virus transmission and associated outbreaks COVID-19 public relations programs in the institutions were forced to significantly reduce the number of people, and in some cases completely shut down during the pandemic. Since most elderly patients have multiple associated diseases, including cardiovascular diseases and diabetes, they are particularly susceptible to severe complications of COVID-19. Thus, patients were advised to stay at home and avoid social contacts as much as possible. This increased the vulnerability of patients to physical deterioration, depression and social isolation. To eliminate this serious gap in the care, some traditional public-relations programs in hospitals or clinics have transformed part or all of their learning content into television at home during a pandemic.

The main recommendation in such conditions for patients with non-critical conditions is the continuation of physical therapy at home. Rehabilitation at home can be provided by means of telerehabilitation (including the Internet, telephone), which is provided by article 19 of the Law of Ukraine "On Rehabilitation in the field of health care". In particular, a number of studies and systematic reviews have shown high effectiveness of television-based examinations, sometimes even in the context of conventional eye therapy [22].

Telerehabilitation is a form of telemedicine that uses telecommunications technology to

synchronously or asynchronously provide rehabilitation services to remote patients to minimize barriers to distance, time, and cost [23]. Telerehabilitation covers all aspects of patient care and should include: assessment of the patient (by means of telerehabilitation) using telephone questionnaires or physical assessment by videoconference; assignment of an exercise program for each patient, for self-implementation and/or under control using real-time video conferencing; making entries in medical records with information about exercise tolerance (restrictions and symptoms during exercise) to ensure safety; checking the space and safety of the place where the exercises will be performed; therapeutic aerobic exercises for the lower extremities (eg walking); therapeutic exercises to strengthen the upper extremities (for example, with light weights, elastic bands, etc.); therapeutic exercises to strengthen the lower extremities (eg, squats); frequency: alternate outpatient sessions at least twice a week, in addition to the unsupervised home exercise program for at least two days a week (telemonitoring) [3]. Video conferences, e-mail, mobile applications, web communication, etc. are used for telerehabilitation [3, 21].

Unlike the typical rehabilitation regime for patients with COVID-19 [24], telemedicine can play a role in our local conditions not only in the long-term phase of care, but also in the acute and subacute phase, in which point rehabilitation is expensive, risky and impractical [3].

who have suffered coronavirus infection in severe or moderate form, raise the issue of adaptation of traditional rehabilitation programs to new conditions.

## CONCLUSIONS/ВИСНОВКИ

Thus, pulmonary rehabilitation is an important part of restoring health after COVID-19. The development of complications with COVID-19 and the increase in the number of pulmonary patients,

## PROSPECTS FOR FUTURE RESEARCH/ПЕРСПЕКТИВИ ПОДАЛЬШИХ ДОСЛІДЖЕНЬ

New proposals are needed for research in the protracted phase of the disease and to make every effort to ensure full functional recovery and return to normal life.

## CONFLICT OF INTEREST/КОНФЛІКТ ІНТЕРЕСІВ

The authors declare no conflict of interest.

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None.

## AUTHOR CONTRIBUTIONS/ВКЛАД АВТОРІВ

All authors substantively contributed to the drafting of the initial and revised versions of this paper. They take full responsibility for the integrity of all aspects of the work.

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