

Peculiarities of physical rehabilitation of patients with a severe COVID-19

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Abstract:

At present, physical rehabilitation of coronavirus patients is considered to be one of the most important tasks in the practice of maintaining and increasing the functional state and physical working capacity of the population. Meanwhile, the features of patients' recovery depending on the severity of the previous COVID-pneumonia have not been fully studied. *The objective of the study.* Improving individual approaches to physical rehabilitation of persons who have had COVID-19 with severe lung lesion (CT-3, CT-4). *Material and methods.* Two groups of male patients (n=34) who underwent outpatient rehabilitation after COVID-19 virus infection were examined at the Chita polyclinic (Russia). Nineteen patients in the first group (KT-3) were diagnosed with moderate severe lung lesion (50-75 per cent) and 15 patients in the second group (CT-4) with severe lung lesion (>75 per cent). There was a study of somatometric and functional indicators of patients, measuring an individual's effort and exertion, breathlessness and fatigue during physical work by The Borg Rating of Perceived Exertion (Borg RPE) scale and the 6-min walk distance test (6 MWD). Based on the monitoring results, a physical rehabilitation plan in the post-COVID period was drawn up. *Results.* After three months of physical rehabilitation, statistically significant differences in oxygen saturation (SpO₂) recovery rates compared to the initials values were found in the groups studied (p<0.05). After the completion of the rehabilitation course in both groups, the values of the Borg Rating of Perceived Exertion and the 6-min walk distance test, hand-held dynamometry significantly increased, the level of blood oxygen saturation increased. SpO₂ in the first group (CT-3) on average reached $97.7 \pm 0.7\%$ and were significantly higher than SpO₂ in the second CT-4 group ($96.4 \pm 0.7\%$). The breath-hold time increased in Stange and Genchi's tests results. *Conclusions.* The results of our outpatient research confirmed the effectiveness of using a three-month physical rehabilitation program for patients with severe lung lesion (CT-3-4) after COVID-19. Non-informative parameters (pulsometry in dynamics, Stange and Genchi's tests results) have been identified to assess the effectiveness of physical rehabilitation of a given contingent of patients.

Key Words: COVID-19, degree of lung lesion, recovery, physical rehabilitation

Introduction

For the second year, an increase in the number of patients with viral diseases caused by the SARS-CoV-2 coronavirus has been recorded in the world. It is still too early to predict the long-term effects of COVID-19 on the health of recovered citizens (Wu et al., 2020). However, there is already a well-founded opinion that SARS-CoV-2 pneumonia is often severe, with respiratory failure of the lungs, disruption of vital organs, as well as the oxygen transport function of the blood (Johansson & Sadari, 2020). A prolonged lesion of the pulmonary tissue results in a dysfunction of the gas transportation system of the COVID-19 patients, which causes changes and damage to various tissues and organs. Early physical rehabilitation leads to a more effective recovery of person's physical performance (Kjærgaard et al., 2020).

The basis of all rehabilitation programs for COVID-19 survivors are physical therapy exercises with an emphasis on breathing exercises. The effectiveness of physical rehabilitation depends entirely on the variety of methods, forms, intensity and time of physical therapy exercises, which are the key point (China Association of

Rehabilitation Medicine, 2020). COVID-19 is most dangerous for people over 65 and people with chronic diseases. In 13.8 per cent of such patients, severe form was observed with characteristic symptoms: respiratory failure, dyspnea, tachypnea, infiltration of lung fields is more than 50 per cent (according CT data).

A study in China indicates that pulmonary fibrosis may develop following discharge from hospital in many patients with moderate to severe coronavirus current, contributing to respiratory and physical insufficiency (Huang et al., 2020). It cannot be denied that the functional problems of patients with COVID-19 are mainly focused on ventilation respiratory failure. Prolonged artificial ventilation of the severely ill persons, who are not moving, and the lack of mobility of the patients with the average degree of illness, involves the provision of an individual rehabilitation program for them in the post-COVID period, taking into account existing respiratory disorders (Boldrini et al., 2020).

There is currently no reliable information on the assessment of the effects of coronavirus infection on moderate and severe pneumonia with concomitant chronic illnesses and recovery times. It has been suggested that remote respiratory complications associated with pulmonary fibrosis may occur (Bartolo et al., 2020). According to Chinese rehabilitation workers, rehabilitation programs should be started already in the acute period of the disease, which will affect the duration of treatment and improve the functional condition of the patient (Yang F. et al., 2020).

The Russian rehabilitation service, like similar services in other countries, is in the process of compiling and analyzing the data obtained during the pandemic. Currently, it is difficult to predict the number of people with severe COVID-19 pneumonia. However, according to preliminary calculations, in Russia alone there are more than 100,000 people in need of medical rehabilitation (Fesyun et al., 2020).

For the rapid recovery of persons after a disease, an effective way of eliminating complications is the individual selection of a set of physical rehabilitation methods which, taken together, may contribute to the elimination of oxygen deficient, restoration of the gas balance and physical activity of the human body. The primary goal of physical rehabilitation for COVID-19 survivors is to improve post-COVID respiratory symptoms and health status (Wang et al., 2020).

Already at the stationary stage, physical therapy exercises can start with a dosed physical load. In an intensive care unit or treatment department of a hospital, initial movement activity should be carried out carefully and under control (Yang et al., 2020). The SpO₂ minimum must be at least 90% at the physical therapy exercise starting. (Rodriguez-Morales et al., 2020). If the SpO₂ is lower than this value, a break in physical activity is required (Mayer et al., 2018). For discharged patients, full-time home rehabilitation in 14-82% of cases prevents re-hospitalization due to deteriorating health (Wang et al., 2019).

Prior to the coronavirus pandemic, a significant number of older Russians was physically inactive. In England, more than a third of the people before the pandemic suffered from hyperkinesia. During the rise of COVID-19, this figure increased significantly, especially among older people with chronic illnesses (Rogers et al., 2020). During the growth in the number of cases of COVID-19, this figure has increased significantly, especially among older people with chronic diseases (Rogers et al., 2020). Physical inactivity and bed rest in seriously ill COVID-19 persons leads to exhaustion and weakness of muscles; therefore, physical therapy exercise is indispensable and has a therapeutic and restorative effect (Qiu et al., 2020).

For every person, physical activity must be part of everyday life (Manolis Adamakis, 2021), which will allow long-term health. Awareness raising and education about physical activity daily volume should be expanded, using all available media to inform society, especially in the face of a pandemic.

Thus, high contagiousness, age-specific characteristics of the course of the infectious process, increase in the number of cases of coronavirus infection, limited information on primary, secondary prevention and medical rehabilitation of this disease confirm the relevance of our research project, the importance of research of the organization and evaluation of the effectiveness of rehabilitation measures for COVID-19 survivors.

The objective of the study. Improving individual approaches to physical rehabilitation of persons who have had COVID-19 with severe lung lesion (CT-3, CT-4).

Material & methods

The study was carried out from January to March 2021 based on the physiotherapy department of the Chita polyclinic (Russia). The project involved two groups of male patients (n = 34), COVID-19 survivors without contraindications for physical rehabilitation in ambulatory conditions. The criterion for exclusion was severe cognitive impairment and some others typical for rehabilitation contraindications.

The first group (KT-3) consisted of 19 patients (55.9 per cent), who were diagnosed as having an average severe lung lesion (50-75 per cent) according to CT scans. In the second group (CT-4), 15 persons (44.1 per cent) with severe lung disease (> 75 per cent) were participated.

During the period of rehabilitation, we carried out a stage monitoring of the participants functional status, based on a survey on their level of daily physical activity, presence of post-COVID symptoms, well-being, etc.

Prior to the beginning of the training and three months after the end of the course of the physical therapy exercises from the moment of discharge from hospital, the indicators of the pulesmetry, the levels of

systolic and diastolic arterial pressure and the hand-held dynamometry results were evaluated. SpO2 data, the Borg Rating of Perceived Exertion (Borg RPE) scale results and the 6-min walk distance test (6 MWD), Stange and Genchi's tests, Kettle II Body mass index (BMI=body mass/body length² (kg/m²)) were monitored.

In accordance with the New guide to respiratory rehabilitation for pneumonia due to coronavirus (second edition), the volume of activities at the third phase corresponded to the peculiarities of providing covid patients care with pneumonia and exercise tolerance aimed priority recovery of respiratory system indicators.

During the rehabilitation course, 14 therapeutic physical therapy exercises sessions, 30 minutes each, were held in an individual format. Special static and dynamic breathing exercises were used to train the respiratory muscles of the thorax and diaphragm, which created the basis for optimization of respiratory control by the patient. Physiotherapeutic procedures have been followed, depending on the symptoms severity degree.

The research did not violate the rights of the participants in the project, the consent was obtained. A database was formed and a statistical analysis of the obtained results was carried out, which are represented by absolute numbers, relative values in percent (%), average values $M \pm SD$, Me (Q25; Q75). Null hypothesis was tested using Shapiro-Wilk's W test. If it did not differ from normal ($p > 0.05$), a parametric version of the analysis was used. Otherwise, the data have been analyzed by means of non-parametric statistics depending on the objectives.

To compare the two independent (1 and 2 groups) abnormally distributed samples was used the Mann-Whitney U-test, for dependent (analyzing indicators in dynamics within one group) was used the Wilcoxon matched test pair. 95% of the faultless prognosis was considered to be the minimum sufficient ($p > 0.05$). In the case of a non-parametric type of distribution, the correlation between the attributes was estimated by computing the Spearman rank correlation coefficient, taking into account the statistical significance ($p > 0.05$). Licensed versions of programs (STATISTICA 10.0, MS Excel, 2010) were used to process and analyze empirical data. Table 1 provides some data on the participants in the research project.

Table 1. Morphological and functional characteristics of the research participants (M±SD)

Indicators	Group 1 (n=19)	Group 2 (n=15)
	$M_1 \pm SD$	$M_2 \pm SD$
Age, years	45,7±13,5	61,7±11,3
Body length, cm	173,1±8,8	176,7±7,8
Body weight, kg	76,0±10,1	89,6±12,6
BMI, kg / m ²	26,8±3,5	28,6±3,0
Respiratory volume before rehabilitation, dm ³	489,5±59,1	448,0±55,8

According to the analysis of outpatient patient records, SARS CoV-2 RNA was confirmed in 61.8% of cases. The virus was not identified in 38.2% of cases with a typical COVID-19 clinical picture. It is important to note that 39.5 per cent of the participants had a history of chronic illness. Before COVID-19, only 14.7% of those examined had systematically engaged in physical culture. A high level of physical fitness is observed in 23.5 per cent of patients. According to a survey of project participants, 32.4 per cent of patients reported addictions (smoking).

Results

In accordance with the study design, the main control points for participant's functional status monitoring (before the beginning and after the end of the physical rehabilitation course, 3 months after the end of the course) are determined.

Based on the research results, it was found that the rehabilitation started immediately after the patient's discharge from hospital or later. Rehabilitation began in 32.4% of the participants immediately after being discharged from the hospital, after one week -14.7%, after two weeks - 17.6%, after three weeks- 5.9%, after one month- 11.8% and 8.8% participants began rehabilitation course after three months. The rehabilitation peculiarities were related to individual manifestations of the disease, the severity of the condition and the presence of a chronic pathology. 17.7 per cent of patients had a cardiovascular disease, 8.8 per cent had a respiratory system disease, 11.7% of the participants suffered from a combination of these illnesses and diabetes mellitus. 61.8% of the study participants did not have a chronic pathology, at the same time they were seriously ill with COVID-19.

88.2% of the persons was dyspnea during physical exertion before the physical therapy exercises beginning and only 11.8% of patients had not dyspnea. Before the rehabilitation course, clinically there was a difference in the indicators of well-being, physical activity and the state of the main life-supporting systems of the body in both groups (tabl. 2).

Table 2. Indicators of the functional state of the research participants before the start of the rehabilitation course (Me (Q₂₅; Q₇₅))

Indicators	Group 1 (n=19)			Group 2 (n=15)			p	p*
	Me ₁	Q ₂₅	Q ₇₅	Me ₂	Q ₂₅	Q ₇₅		
Estimation according Borg RPE scale, points	1,0	0,0	2,0	3,0	3,0	4,0	0,0004	p<0,05
Hand-held dynamometry (on the left), kg	44,5	42,6	49,0	33,5	31,5	46,2	0,0029	p<0,05
Hand-held dynamometry (on the right), kg	50,9	47,7	52,9	38,1	35,6	49,8	0,0017	p<0,05
Pulse at the beginning of physical therapy exercises session, beats / min	72,0	68,0	76,0	76,0	68,0	86,0	0,5098	p>0,05
Pulse at the end of physical therapy exercises session, beats / min	72,0	64,0	78,0	74,0	68,0	78,0	0,5210	p>0,05
Genchi test, s	38,0	30,0	40,0	30,0	29,0	31,0	0,0098	p<0,05
Stange test, s	44,0	35,0	49,0	35,0	34,0	37,0	0,0125	p<0,05
6 MWD test, m	512,0	401,0	527,0	420,0	376,0	460,0	0,0072	p<0,05

* p - value when comparing Groups 1 and 2 (independent samples) using the Mann-Whitney test. p < 0.05 - the difference between the compared samples was considered statistically significant at the level of the faultless prognosis of 95%.

The Rating of Perceived Exertion was evaluated on the modified (simplified) Borg scale (Borg CR10 (Category Ratio) scale). The physical activity of the category «moderately heavy and heavy» corresponds to 13-16 points on the Borg RPE scale and is associated with 70-90% of peak heart rate and 60-80% of VO₂ max. This is approximately 3-6 on the Borg CR10 scale. The prognostic value is the level of physical activity from mild to moderate degree, corresponding to 11-14 points. The Borg scale was used as one of the criteria for the dosing of physical activity at the session, as well as for the formation of an adequate self-assessment of physical activity intensity. Prior to the recovery, the Borg scale (table.2) in the first group (CT-3) was statistically lower than in the second group (CT-4), p=0.0004. The hand-held dynamometry of patients in the first group (CT-3) is reliably higher than in the second group (CT-4), p < 0.05. It is important to note that at the beginning of the rehabilitation, despite differences in the functional state of patients, the pulsometry rates in both groups were similar. Significant differences were revealed in the values of the Stange and Genchi functional tests before the start of the rehabilitation course, confirming the relationship of the respiratory system and the severity of its injury in COVID-19. According to the results of the 6 MWD test, different values of patient tolerance to physical activity have been established in the observed groups, which confirms the relationship between the damaged leading vital systems of the patients under investigation and the severity of lung lesion (tabl.2).

Based on the results of monitoring the functional indicators of all project participants, after physical rehabilitation, the features of the recovery processes of the body of patients with varying degrees of severity of lung damage were revealed (tabl. 3).

Table 3. - Indicators of the functional state of the research participants after the end of the rehabilitation course (Me (Q₂₅; Q₇₅))

Indicators	Group 1 (n=19)			Group 2 (n=15)			p	p*
	Me ₁	Q ₂₅	Q ₇₅	Me ₂	Q ₂₅	Q ₇₅		
Estimation according Borg RPE scale, points	0,0	0,0	1,0	2,0	1,0	3,0	0,0018	p < 0,05
Hand-held dynamometry (on the left), kg	48,3	43,6	51,2	37,1	31,9	47,9	0,0015	p < 0,05
Hand-held dynamometry (on the right), kg	52,3	49,2	55,6	39,9	37,1	52,4	0,0047	p < 0,05
Pulse at the beginning of physical therapy exercises session, beats / min	80,0	72,0	84,0	80,0	70,0	88,0	0,7418	p>0,05
Pulse at the end of physical therapy exercises session, beats / min	74,0	68,0	78,0	76,0	68,0	80,0	0,4771	p>0,05
Genchi test, s	44,0	39,0	49,0	40,0	38,0	41,0	0,0925	p>0,05
Stange test, s	52,0	48,0	57,0	48,0	46,0	49,0	0,0741	p>0,05
6 MWD test, m	529,0	434,0	551,0	439,0	394,0	482,0	0,0032	p < 0,05

* p - value when comparing Groups 1 and 2 (independent samples) using the Mann-Whitney test. p < 0.05 - the difference between the compared samples was considered statistically significant at the level of the faultless prognosis of 95%.

It is important to note that functional parameters have been identified that are non-informative in the case of assessing the dynamics and effectiveness of physical rehabilitation in persons who have undergone severe COVID-19. As can be seen from table 3, there were no statistically significant differences between Groups 1 and 2 in terms of pulse and hypoxic tests at the beginning and end of physical therapy exercises. At the same time, there was a positive trend in the restoration of the functional status of all patients after rehabilitation, which confirms the effectiveness of the concept of continuous rehabilitation treatment of patients who have undergone COVID-19 at all stages, starting from the hospital.

A statistically significant difference in the recovery of SpO₂ was found 3 months after the physical rehabilitation was carried out in outpatient conditions in the studied groups ($p=0.0002$). For example, the average SpO₂ in the first group was $97,7\pm 0,7\%$ and was higher than SpO₂ in the second group ($96,4\pm 0,7\%$). In both groups, there is no statistically significant trend in systolic pressure.

The study confirmed a positive correlation between recovery and SpO₂ levels prior to rehabilitation and after 3 months ($\rho = 0,6\pm 0,02$, $p < 0,05$), dyspnea at the physical activity ($\rho = 0,5\pm 0,02$, $p < 0,05$), respiratory volume ($\rho = 0,8\pm 0,01$, $p < 0,05$), Borg RPE scale indicators and the 6 MWD test before the start of rehabilitation course ($\rho = 0,6\pm 0,02$ и $\rho = 0,7\pm 0,02$ respectively, $p < 0,05$), hand-held dynamometry indicators ($\rho = 0,7\pm 0,02$, $p < 0,05$). The negative correlation in persons of different ages ($\rho = -0,6\pm 0,02$, $p < 0,05$), weights ($\rho = -0,4\pm 0,03$, $p < 0,05$), BMI ($\rho = -0,5\pm 0,02$, $p < 0,05$), and the presence of shortness of breath ($\rho = -0,5\pm 0,02$, $p < 0,05$) upon completion of the rehabilitation course was found.

Dicussion

The process of recovery from COVID-19 is long and variable, despite the positive results of in-patient treatment of the acute phase of the disease. According to the literature, the fact of complications of coronavirus infection from the cardiovascular and respiratory systems, psychoemotional and other disorders has been practically proven (Puntmann, 2020).

It is well known that the negative consequences are associated with hypodynamia are the main risk factor for non-communicable diseases (Galan et al., 2019; Andrieva et al., 2021). In such cases, informing and popularizing regular motor activity in conditions of self-isolation of the population is the only correct solution to preserve physical health, prevent physical inactivity (Kolokoltsev et al., 2021) and restore the functionality of those who have had COVID-19 (Gaetano Raiola, Felice Di Domenico, 2021; Drozdovska et al., 2020).

The results of our research project point to the effectiveness of outpatient physical rehabilitation as an element of continuous and long-term restorative technology in the medical rehabilitation stages after COVID-19. The use of compulsory physical therapeutic exercises has led to an improvement in SpO₂ parameters and the health status of the participants of this project. The use by us of dosed physical activity, individual approach to rehabilitation, constant monitoring of functional indicators has led to a decrease of shortness of breath and an increase of tolerance to physical activity in COVID-19 patients with severe lung lesions, which is consistent with the results of other studies (Cheng, 2021). The long period of development and the current of COVID-19 disease allow to use the entire range of physical factors for recovery and prevention of pulmonary pathology progression. Correction of early manifestations of coronavirus pneumonia and existing chronic complications, treatment of infection hotspots and increasing the resistance of the mucous respiratory tract by physiotherapy methods as part of physical rehabilitation contributes to the reduction of fibrous disorders and the development of secondary complications. The joint use of «apparatus physiotherapy» and physical therapeutic exercises proved to be effective in increasing the functional reserve of the organism, improving gas exchange and regulation of perfusion-ventilation ratio, restoring bronchial drainage, as well as stabilizing the psychophysical status of the convalescent (Fesyun et al., 2020). The training of abdominal breathing and other elements of respiratory gymnastics makes it possible to effectively use the ability of rehabilitatants to improve lung function and increase SpO₂. At the same time, the refusal to actively work in the physical therapeutic hall reduces the resource potential and chances of early integration into the society of COVID-19 patients.

Despite the various recommendations of ministries, federations, associations and societies to prevent post-covid complications and the gradual recovery of a person's physical abilities, to date there are no «correct guidelines» and common approaches for all patients without regard to their individual post-covid complications and chronic illnesses. Our study proves that it is necessary to take into account the differentiated approach to the restoration of functional status, taking into account the severity of the infection.

The stages of rehabilitation, with contraindications and the timely use of a complex impact at each time of the reconstruction process, cannot be ignored. Of particular importance is the availability of rehabilitation resources, which can best be implemented in outpatient clinic. This makes it possible to save not only financial resources but also human resources, to correctly place emphasis in approaches to individual development and selection of valid rehabilitation programmers. The development of the epidemic situation in the modern «post-covid period» does not give any hope of a rapid victory of the person over the virus. Consequently, in order to adapt effectively and ensure the survival of humankind, there remains an urgent need for a comprehensive examination not only of therapeutic approaches, but also of the physical rehabilitation process following the covid pathology, taking into account all factors.

Conclusions

The results of the analysis of the rehabilitation process of functional condition of COVID-19 survivors with severe lung injury (CT-3-4) made it possible to confirm the effectiveness of physical rehabilitation programs at outpatient stage. There has been an improvement in the functional indicators of patients for each group separately and together for the entire sample, $p < 0.05$. Statistically significant differences in recovery SpO₂ values were found in the observed groups 3 months after physical rehabilitation in outpatient conditions compared to the baseline data ($p=0.0002$). After physical rehabilitation course, the average SpO₂ values for CT-3 patients reached $97.7 \pm 0.7\%$ and was higher than for CT-4 patients ($96.4 \pm 0.7\%$).

The results of the research revealed parameters that are non-informative in the evaluation of the dynamics and effectiveness of physical rehabilitation in persons who have suffered COVID-19 in severe form with KT-3 and KT-4 (pulsometry data at the beginning and end of the therapeutic physical culture, Genchi and Stange tests). Timely and long-term follow-up of patients (at least 3 months) after discharge from hospital can be crucial in maintaining health, physical fitness and reducing the disability rate of COVID-19 COVID-19 survivors. Prevention and promotion of effective physical intervention after severe COVID-19, increased motivation of older persons to engage in physical culture and sports during the rehabilitation stages (outpatient-polyclinic, sanatorium-resort and home) will help to strengthen and preserve the physical and somatic health of those who need it.

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