Original Article

©2024 NRITLD, *National Research Institute of Tuberculosis and Lung Disease, Iran*

ISSN: 1735-0344 *Tanaffos 2024; 23(4): 392-402*

TANAFFOS

Effect of Chest Physiotherapy on the Clinical Outcomes of COVID-19 Patients

Reza Moradi-Azhgil [1], Neda Sayadi [1], Shayesteh Haghighi [1], Parya Moradi [2]

[1] Department of Nursing and Midwifery, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran,
[2] Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

Received: 29 November 2023
Accepted: 24 August 2024

Correspondence to: Sayadi N
Address: Department of Nursing and Midwifery, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
Email address: sayadi_neda@yahoo.com

Background: The novel coronavirus 2019 primarily affects the respiratory system and may lead to respiratory failure and the need for intubation. This study aimed to investigate the effect of chest physiotherapy on the clinical outcomes of patients with COVID-19.
Materials and Methods: This randomized clinical trial was performed in 2022-2023. The research population included 58 patients with COVID-19 who were hospitalized at Izeh Shohada Hospital, Khuzestan. Patients in the control group received routine care, which included the use of supportive drugs based on the doctor's opinion, oxygen therapy, and nutritional support. The intervention group received chest physiotherapy and breathing exercises for six days. At the end of the third and sixth days, the patients of both groups were evaluated in terms of lung function, respiratory gases, and the length of hospital stay. Moreover, the need for intubation was recorded during study time. Data analysis was done using SPSS version 23 software.
Results: In the intervention group, a significant improvement was observed in FVC (P<0.01), FEV_1(P<0.01), FEV_1/FVC ratio (P<0.01), PaO_2 (P<0.01), $PaCO_2$ (P<0.01), and SPO_2 (P<0.01) as well as the length of hospital stay (P<0.01) after the intervention. However, no significant difference was observed in the PaO2/FiO_2 ratio (P>0.05) and the need for intubation (P>0.05).
Conclusion: The results showed that in the new crisis resulting from COVID-19, chest physiotherapy and respiratory exercises could be used as a helpful method in improving lung function, respiratory gases, and reducing the hospital stay in COVID-19 patients.

Keywords: COVID-19; Respiratory system; Intubation; Hospital stay; Respiratory gases; Chest physiotherapy

INTRODUCTION

The COVID-19 pandemic triggered an outbreak of pneumonia in Wuhan, China, in late 2019. In recent years, this disease has spread rapidly and become the most significant global health challenge (1, 2). People with COVID-19 have symptoms of fever (89%), cough (68%), fatigue (38%), sputum production (34%), and shortness of breath (19%) (3). Many patients may experience acute respiratory problems threatening their lives (4). Those with COVID-19 suffer from oxygen deficiency before respiratory problems occur (5). Therefore, other factors before creating pro-inflammatory cytokines may play a role in hypoxia caused by COVID-19 (6). Liu et al. showed that interferon induction in COVID-19 infection leads to activating the aryl hydrocarbon receptor and increasing the transcription and expression of mucins. This hypothesis states that COVID-19 infection stimulates mucus production and exacerbates hypoxia by preventing oxygen diffusion in the alveolar areas (6). Therefore, excessive mucus secretion is directly related to the severity of COVID-19 (7, 8).

Pro-inflammatory cascades cause excessive mucus production with changed compositions, impaired mucociliary clearance in infected respiratory epithelium, further obstruction of airways, and respiratory distress (7, 9). Accumulated mucus during the COVID-19 disease may narrow or block the airways. Therefore, retention of secretions in the airways can lead to serious clinical issues, respiratory distress, and, if spread, atelectasis (10).

The significant decline in respiratory function in some COVID-19 patients necessitates aggressive interventions, including mechanical ventilation, which can lead to serious complications if prolonged. Hence, supportive and safe measures such as chest physiotherapy techniques and breathing exercises are necessary to improve respiratory function, prevent the accumulation of increased pulmonary secretions and intubation, and reduce the length of hospitalization (11, 12). Liu et al. used breathing exercises for the first time to reduce respiratory disorders in patients with COVID-19. In this study, breathing exercises significantly improved patients' shortness of breath and lack of oxygen (13). Attention was given to the drainage of airway secretions and improved respiratory function in patients with COVID-19 through chest physiotherapy and breathing exercises. Several studies, including Battaglini et al. and Gonzalez-Gerez et al., have confirmed the effectiveness of chest physiotherapy in improving the respiratory function of COVID-19 patients (14, 15). However, in these studies, the patients had a low level of consciousness, or the intervention period was limited to one remote session with one type of intervention. Hence, it seems impossible to discuss the results of these studies with certainty.

This study combined chest physiotherapy techniques and breathing exercises, including cupping chest physiotherapy, lip bud breathing intervention, diaphragmatic breathing, and stimulation spirometer intervention. A combination of different chest physiotherapy and breathing exercises techniques is one of the distinctions of the present study from the rest. Therefore, the present study evaluated the effect of chest physiotherapy on the clinical outcomes of the COVID-19 patients.

MATERIALS AND METHODS

This clinical trial with registration number IRCT202208150557 03N1 was conducted from August to March 2022 on 58 patients hospitalized with COVID-19 at Shohada Izeh Specialized Hospital.

After obtaining informed consent and explaining the objectives of the research to the participants, they were categorized randomly into two groups: experimental and control. To avoid the two groups from having contact, the patients were selected from two wards: the internal ward and the ICU.

The inclusion criteria were: 1) willingness to participate in the study, 2) average severity of the disease based on the diagnosis of a pulmonologist, 3) being hospitalized at the time of diagnosis, 4) no simultaneous use of other chest physiotherapy programs, 5) lack of underlying diseases such as cancer, heart and vascular diseases and diabetes, 6) consciousness level of 10 or higher 7) able to perform chest physiotherapy activities 8) 18 years of age and above 9) arterial blood oxygen saturation above 80% 10) under oxygen therapy with a simple mask or venture mask 11) under ventilation with a non-invasive ventilator (CPAP, BiPAP). The exclusion criteria included: 1) change in disease severity from moderate to severe disease, 2) respiratory failure, and 3) death of the patient during the study. The sample size was determined based on the studies of Gonzalez-Gerez et al. (15) and Elrefaey and Zidan (16) using MedCalc statistical software by the following formula with 95% power and 1% error (15, 16). A total of 26 cases were in the control group, and 26 patients were in the intervention group (Figure 1). The final sample size was determined to be 58, considering a dropout rate of 10%. The sampling formula was as follows:

$$n = \frac{\left(Z_{1-\alpha/2} + Z_{\beta}\right)^2 \left(P_1(1-P_1) + P_2(1-P_2)\right)}{(P_1 - P_2)^2}$$

This research was approved with the ethical code of IR.AJUMS.REC.1401.178 in the Ethics Committee of the Vice-Chancellery for Research and Technology at Ahvaz Jundishapur University of Medical Sciences.

A purpose-based random sampling method was used to select the samples. Following the selection, the samples were randomly divided into intervention (N=29) and control (N=29) groups. The randomization method was done using the table of random numbers.

Even numbers for the control group and odd numbers for the intervention group were considered in the table of random numbers. The advantage of simple randomization is that if it is fully implemented, the allocation of people to each group becomes unpredictable. In addition, the possibility of the researcher's mental bias in the random allocation of people in each of the groups is minimized consciously and unconsciously. All patients were given a sufficient explanation about the intervention method of chest physiotherapy and follow-up after the researcher went to Shohada Izeh Hospital. Moreover, the research objective was explained to the study participants, and written informed consent was obtained from them. All patients were assured that their personal information would remain confidential and that they could withdraw from the study at any time.

Demographic information of the patients of both intervention and control groups was recorded by the researcher on the first day and before the intervention. The respiratory variables related to the study objectives were recorded in both groups before the start of the intervention. A physiotherapist trained the researcher for five sessions (45 minutes) before conducting the study. Patients in the intervention group were subjected to chest physiotherapy, breathing exercises, and routine care after registering demographic information. Chest physiotherapy intervention and breathing exercises were performed for six days, every morning and evening for 10 minutes in each session. During this period, the patients of the control group received only routine care, including supportive treatments and prescription drugs such as Kaletra tablets, ritonavir, interferon beta 1b, and interferon beta 1a. At the end of the third and sixth days, both groups were evaluated regarding parameters related to the study objectives. The patients' hospitalization duration and the need for intubation were recorded during the study.

The intervention of cupping chest physiotherapy was performed manually by the researcher in five different positions: sitting, palmar, arched, right lateral, and left. The chest physiotherapy was performed by cupping the palms and tapping slowly and regularly for 10 minutes after placing the patient in the desired positions.

The patient was asked to lie down or sit for the Pursed lip breathing intervention. The researcher taught the patient to breathe normally through the nose and during exhalation by closing the lips slowly and using the abdominal muscles. In this intervention, the researcher taught the patient that the exhalation time should be twice as long as the inhalation time for 10 minutes.

The participants were asked to lie on their backs on their beds and place a pillow under their heads and knees to perform diaphragmatic breathing intervention. They should place one hand on their chest and the other on their stomach. The studied patients were taught to move the hand on the abdomen upwards while inhaling and downward on the abdomen during exhalation. The abdomen moves upward due to the diaphragm flattening. In contrast, the other hand remained motionless on the chest during inhalation and exhalation. The patients had to take air into their lungs through the nose and exhale through the mouth to inhale. Patients were also asked to breathe slowly and with concentration. After learning to do diaphragmatic breathing, patients can do this type of breathing while sitting. This intervention was also done for 10 minutes.

A total of 10 deep breaths was performed in the morning and evening sessions (according to other interventions explained above). For stimulus spirometer intervention, ten deep breaths were performed in the morning and evening sessions.

Before the intervention, the researcher taught the patient to use the stimulation spirometer. The patient was placed in a sitting or semi-sitting position to perform this intervention. The Incentive Spirometer tube was placed in the patient's mouth to carry out inhalation inside the device. After the inhalation, the patient held his breath for three seconds and slowly exhaled through the mouth by removing the device. The patients were told to take a deeper breath each time by increasing the amount of raising the ball.

One of the devices used in this study was a spirometer. The spirometer used in this research was the Spirolab New model of MIR, Italy, with a 7-inch color screen. Forced expiratory volume in the first second (FEV1) and forced vital capacity (FVC) were measured using a spirometer. To measure these two parameters, the patient breathed in a spirometer that was calibrated every day using a calibration syringe and according to the instructions. After measuring and recording FEV1 and FVC separately, the ratio FEV1/FVC, which represents the vital capacity that can be expelled from the lungs in the first second during exhalation, was calculated.

Also, an arterial blood test was performed to measure arterial blood gases, including partial pressure of oxygen (PaO2), partial pressure of carbon dioxide (PaCO2), oxygen saturation (SaO2), and ratio of partial pressure of oxygen and inspiratory oxygen fraction (PaO2/FiO2). The patient's blood sample was taken from the radial artery in the inner part of the wrist under the thumb, where the pulse is felt. All measurements were performed by an independent evaluator who did not know the group assignment and used the Castat-601-techno device. It should be noted that all patients were tested by the same device and in the same center.

A questionnaire was used to evaluate the demographic information of the patients, along with a clinical status form and an information registration form related to the number of days of hospitalization and the need for intubation.

The questionnaire for collecting demographic information included gender, age, marital status, education level, duration of hospitalization, weight, height, and body mass index (BMI).

The patient's clinical status form was related to recording the results of measurements related to the patient's respiratory parameters. These parameters included FEV_1, FVC, FEV1/FVC, SPO_2, PaO_2, SaO_2, PaO_2/FiO_2, and $PaCO_2$, evaluated at the beginning and after the chest physiotherapy intervention.

An information registration form was used to check the prevention of intubation and the number of hospitalization days. Question one was about the patient's need for intubation for the control and intervention groups. The answer to this question has two options: "Yes, the patient needed to be converted," and "No, the patient did not need to be converted." The second question was related to the number of days of hospitalization. The answer to this question was numerical.

Data analysis

Quantitative variables were reported as mean and standard deviation, and qualitative variables were expressed as numbers (percentage). The Kolmogorov-Smirnov test was used for the normality of data distribution. Independent t-test or its non-parametric equivalent (Man-Whitney test) was used to check the relationship between qualitative variables using the chi-square test (or Fisher's exact test) and to compare quantitative variables between two groups. Repeated measurement analysis was used to investigate the parameter changes during the experiment (before the intervention, on the third day, and after the sixth day). The significance level was smaller than 0.05, and the data were analyzed by SPSS software version 23.

RESULTS

A total of six patients with COVID-19 were excluded from the study. Most patients in the control group (15 people, 57.7%) were men. However, in the intervention group, the female gender (14 people, 53.8%) was more than the male. The chi-score statistical test showed no significant difference between the control and test groups in terms of gender (P=0.405), marital status (P=0.960), and education level (P=0.674). The average age of all participants in the study was 59.23 ± 9.52 years. The t-test showed no significant difference between age (P=0.323), weight (P=0.871), height (P=0.952), and body mass index (P=0.071) of participants in the control and intervention groups (Table 1).

Table 2 shows a significant difference at the level of 1% between the average of these parameters six days after the intervention in the two groups (control and intervention) (P<0.01). In addition, the changes in these parameters during the measurement stages of arterial blood gas (ABG) (before the intervention, three days, and six days after the intervention) in the intervention group were significant (P<0.01) based on RM statistical test.

There was a significant difference between the control and intervention groups three days after the intervention for SPO2 at 1% (P=0.007) and for PaCO2 at 5% (P=0.024). Intra-group comparison of mean SPO2 and PaCO2 based on RM test showed that intra-group changes during ABG times in the intervention group were significant at 1% level (P<0.01).

Table 3 shows that the control group patients were hospitalized for 15.23 ± 4.36 days. In contrast, patients in the intervention group were hospitalized for 10.15 ± 4.36 days. The t-test analysis showed that the difference between the average number of hospitalization days in the control and intervention group patients was significant at 1% (P=0.000). The results showed that 4 (15.4) patients in the control group were intubated, while only one (3.8) in the intervention group was intubated. However, based on Mann-Whitney statistical analysis, this difference was not significant (P=0.162).

Table 1. Demographic characteristics of the participants

Group		**Control**		**Intervention**		**Total**		**P-value[1]**
Demographic variables and their dimensions		**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**	
Gender	Man	15	7.57	12	2.46	27	9.51	405.0
	Woman	11	3.42	14	8.53	25	1.48	
Marital status	Single	1	8.3	1	8.3	2	8.3	960.0
	Married	14	8.53	15	7.57	29	8.55	
	Other	11	3.42	10	5.38	21	4.40	
Level of Education	Illiterate	9	6.34	8	8.30	17	7.32	674.0
	Elementary	7	9.26	5	2.19	12	1.23	
	High school	4	4.15	5	2.19	9	3.17	
	Diploma	1	8.3	3	5.11	4	7.7	
	Associate Degree	2	7.7	4	4.15	6	5.11	
	Bachelor's degree	3	5.11	1	8.3	4	7.7	
Demographic variables and their dimensions		**Mean**		**SD**	**Mean**	**SD**		**P value[2]**
Age		88.58		85.8	57.59	45.10		323.0
Weight		69.73		10.10	11.76	76.10		871.0
height		92.170		67.7	15.166	94.7		952.0
BMI		15.25		37.2	62.27	96.3		071.0

[1] Chi-square, [2] t-test

Table 2. Intergroup and intragroup comparison of respiratory parameters of patients with COVID-19

Variable	Time	Control		Intervention		P-value[1]
		Mean	SD	SD	Mean	
FEV1	Before intervention	1.78	0.45	0.35	1.70	463.0
	Three days after the intervention	1.83	0.39	0.37	2.03	065.0
	Six days after the intervention	1.93	0.46	0.46	2.52	000.0
	Repeated measurement (RM) analysis	054.0		000.0		RM-ANOVA[2]
FVC	Before intervention	2.80	0.69	0.54	2.77	853.0
	Three days after the intervention	2.89	0.74	0.61	3.15	170.0
	Six days after the intervention	2.97	0.68	0.60	3.51	004.0
	Repeated measurement (RM) analysis	299.0		000.0		RM-ANOVA[2]
FEV1.FVC	Before intervention	63.71	4.71	5.81	61.54	145.0
	Three days after the intervention	64.66	8.34	5.57	64.81	941.0
	Six days after the intervention	64.99	3.92	6.62	71.98	000.0
	Repeated measurement (RM) analysis	668.0		000.0		RM-ANOVA[2]
SPO_2	Before intervention	89.11	2.10	2.24	89.30	751.0
	Three days after the intervention	90.76	2.99	3.38	93.26	007.0
	Six days after the intervention	91.69	3.70	5.21	97.34	000.0
	Repeated measurement (RM) analysis	000.0		000.0		RM-ANOVA[2]
SaO_2	Before intervention	90.84	1.97	1.79	91.03	715.0
	Three days after the intervention	91.88	2.65	1.94	92.03	813.0
	Six days after the intervention	92.34	2.43	2.42	92.96	365.0
	Repeated measurement (RM) analysis	691.0		102.0		RM-ANOVA[2]
$PaCO_2$	Before intervention	40.42	3.45	2.97	39.73	442.0
	Three days after the intervention	38.88	3.99	3.72	36.38	024.0
	Six days after the intervention	37.65	4.59	3.37	31.53	000.0
	Repeated measurement (RM) analysis	054.0		000.0		RM-ANOVA[2]
PaO_2	Before intervention	72.92	10.54	10.55	71.87	720.0
	Three days after the intervention	73.85	7.22	8.03	76.69	187.0
	Six days after the intervention	74.64	7.48	7.74	81.98	001.0
	Repeated measurement (RM) analysis	483.0		000.0		RM-ANOVA[2]
$PaO_2.FiO_2$	Before intervention	242.57	17.94	18.77	253.53	096.0
	Three days after the intervention	274.96	30.48	37.51	291.77	082.0
	Six days after the intervention	290.76	41.40	37.59	310.50	078.0
	Repeated measurement (RM) analysis	000.0		000.0		RM-ANOVA[2]

[1]t-test

[2]Repeated-measures analysis of variance

Table 3. Comparison of the number of hospitalization days and the need for intubation in control and intervention group patients

Value		Control		Intervention		P value[1]
		Mean	SD	SD	Mean	
Number of hospitalization days		23.15	36.4	9.2	15.10	000.0
		Frequency	**Percentage**	**Percentage**	**Frequency**	**P value[2]**
Intubation	Yes	4	4.15	8.3	1	162.0
	No	22	6.84	2.96	25	

[1]t-test was

[2] Mann–Whitney

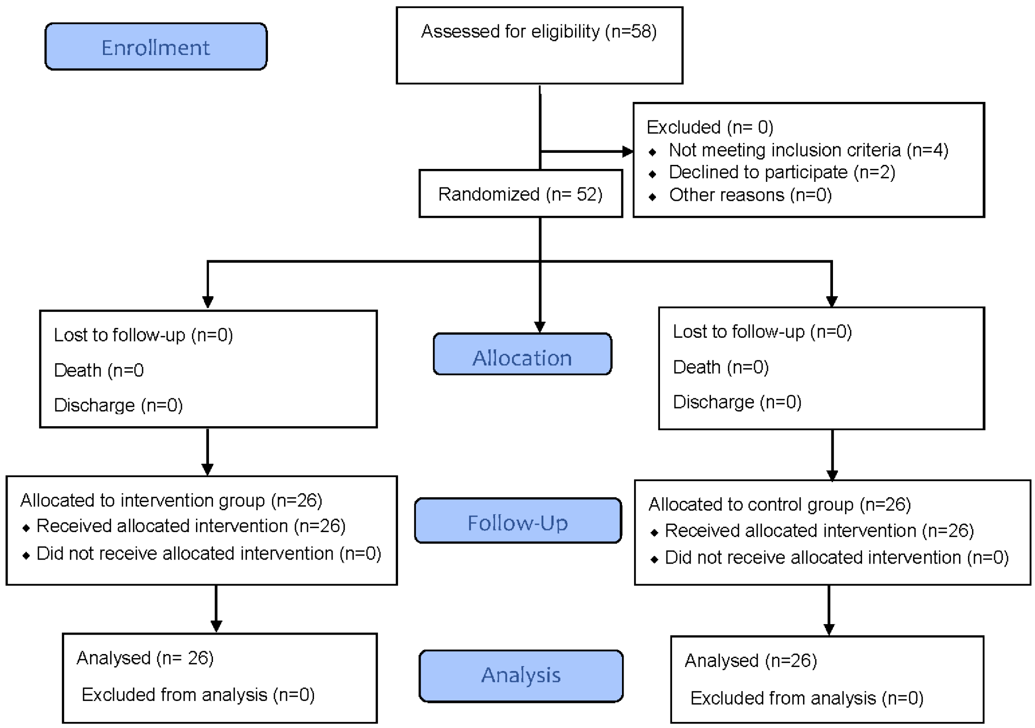

Figure 1. The CONSORT chart of selection, evaluation, and follow-up process of the participants

DISCUSSION

This study evaluated the effect of chest physiotherapy on the clinical outcomes of patients with COVID-19 referred to Shohada Izeh Specialized Hospital, Iran.

The results showed a significant improvement in FVC, FEV_1, FEV_1/FVC ratio, PaO_2, $PaCO_2$, and SPO_2, as well as a reduction in the duration of the patient's hospitalization after chest physiotherapy intervention. FEV_1 and FVC potentially reflect an obstructive or restrictive pattern as indicators of pulmonary function evaluation, which is reduced in patients with respiratory diseases, including COVID-19 and fibrosis (17-19). Chest physiotherapy significantly affected FEV1 and FVC in patients with COVID-19.

Consistent with the results of the current study, Liu et al. found that chest physiotherapy significantly increases FEV1 and FVC in patients with COVID-19 (13). In addition, Srinivasan et al. and Rathi et al. also showed that Pursed lip breathing intervention leads to a significant improvement in these parameters (20, 21). In another study, Ponce-Campos et al. evaluated the intervention of chest physiotherapy in reducing the respiratory consequences of patients after COVID-19 infection. The physiotherapy treatment program (12 sessions) significantly improved FEV1 and FVC in these patients (22). Gloeckl et al., Al Chikhanie et al., and Zhu et al. confirmed the results of the present study, which indicated the positive and significant effect of chest intervention on FEV1 and FVC in patients with COVID-19 (23-25). The results were also confirmed in the present study. The chest physiotherapy increased the FEV1 and FVC six days after the intervention by draining secretions from small airways in patients with COVID-19.

Chest physiotherapy intervention for six days significantly improved the FEV_1/FVC ratio. In line with the results of the current study, Liu et al. also showed that chest physiotherapy significantly increases the FEV_1/FVC ratio in patients with COVID-19 (13). The results of a study in Iran, contrary to the results of the present study, showed that exercise intervention for six weeks does not affect the

FEV1/FVC ratio (26). The difference in the intervention and community research type was a reason for the conflict. Nevertheless, the improvement of this index is expected after breathing exercises and chest physiotherapy in all people. Therefore, more diverse studies are still needed to find out the best training package and the best duration of the program to achieve the desired result.

The results showed the positive effect of chest physiotherapy intervention on SPO_2 in intervention group patients compared to control group patients. Consistent with the present study, the results of various studies have shown that chest physiotherapy and pulmonary rehabilitation interventions improve SPO_2 in COVID-19 patients (23, 27-30). Physiotherapy intervention of the chest easily opens the areas that have undergone atelectasis in the lung, which allows the movement of secretions and subsequently leads to the improvement of gas transfer and ventilation-perfusion in the lung (31). PaO_2 levels often change with respiratory disorders. Chest physiotherapy intervention positively and significantly increases PaO_2 in patients with COVID-19. The results of the present study are supported by Akram et al., Elsherbeni et al., and Malik and Tassadaq, who showed that respiratory physiotherapy and respiratory rehabilitation lead to a significant increase in PaO_2 in patients with COVID-19 (32-34). Chest physiotherapy helps empty the pulmonary bronchi by increasing the volume of the upper lung, and thereby increasing gas exchange and ventilation (16).

The results showed that chest physiotherapy increased SaO2, but this increase was not statistically significant. In line with the results of the present study, Copotoiu et al. showed in a prospective interventional study that SaO_2 changes were not significant (35). Patman et al., similar to the present study's results, showed no difference in SaO_2 between the two groups (36). Contrary to the results of the present study, Elrefaey and Zidan showed that SaO_2 increases significantly in patients under mechanical ventilation (16). The difference between the patients and the difference in the type of chest physiotherapy intervention can be the reason for the contrast.

In the present study, chest physiotherapy significantly reduced $PaCO_2$ in intervention group patients. Elsherbeni et al. evaluated the effect of physiotherapy on COVID-19 patients. Patients in the intervention group received the protocol of physiotherapy exercises in the form of respiratory physiotherapy, limb exercises, and peripheral muscle training for three sessions a week for two weeks (33). The results were in line with the results of the present study, showing a significant decrease in $PaCO_2$ in the patients of the intervention group. The results of the present study are consistent with the results of Malik and Tassadaq. Deep breathing exercises are essential in reducing $PaCO_2$ in patients with respiratory problems (34). The results of the present study are supported by Berney et al., Dennis et al., and Savian et al. (37-39). Based on these studies, chest physiotherapy leads to better patient ventilation by helping to open the areas with atelectasis and subsequently improving oxygen supply, better drainage of secretions, and stimulating the transfer of fluids or secretions from the lung and bronchial parenchyma. As a result, the arterial carbon dioxide gas pressure decreases.

Although the difference in the prevention of intubation in the two intervention and control groups was insignificant, chest physiotherapy positively reduced the intubation rate in intervention group patients. The sources show that the lungs can be cleared using chest physiotherapy techniques and breathing exercises. Other studies showed that chest physiotherapy and breathing exercises, as non-invasive techniques, could help improve respiratory functions, gas exchange, increase lung function, and remove residual mucus (24, 40, 41).

The intervention of physical therapy and breathing exercises in the present study led to a significant reduction in the number of days of hospitalization for patients in the intervention group. Johnson et al. showed that chest physiotherapy interventions reduce the length of the patient's hospitalization and early discharge of the patient (42). The results were confirmed by reducing the hospitalization of patients in the intervention group. Peiris et al. showed that physical therapy intervention improved the ability to perform daily activities and self-care tasks and reduced the length of the patient's hospitalization. In addition, physiotherapy in the hospital increased the discharge probability of patients with total hip arthroplasty. Following an acute stroke, frequent chest physiotherapy treatments reduce the patient's hospitalization and its risks (43). The duration of hospitalization in intervention group patients significantly decreased compared to control group patients.

The current study has several strengths: the first is that all parts of the study, including the intervention, were conducted by one researcher. Therefore, the results are less subject to bias. The second: Unlike other studies in which interventions are performed as home programs, breathing exercises, and chest physiotherapy interventions were performed by a trained researcher. Therefore, the safety of the participants and the accuracy of their adherence to the intervention were guaranteed. The third: Using a combination of breathing exercises and chest physiotherapy interventions. In most studies, only one type of intervention has been used. Finally, the use of conscious patients with moderate levels of COVID-19 disease made it possible to correctly perform the respiratory interventions and chest physiotherapy.

However, the present study has several limitations: The most important limitation of the current study was the small sample size of patients with COVID-19, which may cause the generalizability of the results to larger samples with problems. It is suggested to use larger sample sizes in future studies. The second limitation of the present study was the limited number of intervention sessions of chest physiotherapy and breathing exercises for six days. The limited number of intervention sessions can directly affect the effectiveness of the researcher's work. Therefore, future studies should increase the number of intervention sessions and follow-ups for two months. The third is that specific inclusion criteria were considered to select patients. Therefore, future studies should increase the number of two-month intervention sessions and follow-ups. Finally, the participants were only patients referred to an academic tertiary care center, and the results may not be generalizable to other centers.

CONCLUSION

Based on the results, chest physiotherapy and breathing exercises positively affected the improvement of respiratory gases, reducing hospital stay and the patient's need for intubation.

Acknowledgement

This article is an excerpt from a master’s thesis by Reza Moradi-Azhgil (first author) that received financial support from the Office of the Deputy Vice-Chancellor for Research at Ahvaz Jundishapur University of Medical Sciences. We sincerely appreciate the financial support of the project and all patients who honestly collaborated with this research.

Funding

This research received a grant from the Office of Deputy Vice-Chancellor for Research at Ahvaz Jundishapur University of Medical Sciences (IR.AJUMS.REC.1401.178).

Conflict of interest

The authors declare no conflict of interests.

REFERENCES

1. McFadyen JD, Stevens H, Peter K. The Emerging Threat of (Micro)Thrombosis in COVID-19 and Its Therapeutic Implications. ***Circ Res*** 2020;127(4):571-87.
2. Motaqi M, Ghanjal A. Respiratory physiotherapy in COVID-19 based on available evidence-narrative review. ***Journal of Marine Medicine*** 2020;2(1):26-32.
3. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. N Engl J Med. 2020 Apr 30;382(18):1708-1720.
4. Abbasi F, Eslami R, Bassami M. The effect of eight weeks respiratory rehabilitation training on pulmonary and functional indices in patient with COVID-19 referred to

Beheshti Hospital Kashan. ***Feyz Medical Sciences Journal*** 2022;26(5):530-8.

5. Tobin MJ, Laghi F, Jubran A. Why COVID-19 Silent Hypoxemia Is Baffling to Physicians. ***Am J Respir Crit Care Med*** 2020;202(3):356-360.
6. Liu Y, Lv J, Liu J, Li M, Xie J, Lv Q, et al. Mucus production stimulated by IFN-AhR signaling triggers hypoxia of COVID-19. ***Cell Res*** 2020;30(12):1078-87.
7. Kumar SS, Binu A, Devan AR, Nath LR. Mucus targeting as a plausible approach to improve lung function in COVID-19 patients. ***Med Hypotheses*** 2021;156:110680.
8. Mohammadi M, Khafaee Pour Khamseh A, Varpaei HA. Invasive Airway "Intubation" in COVID-19 Patients; Statistics, Causes, and Recommendations: A Review Article. ***Anesth Pain Med*** 2021;11(3):e115868.
9. He J, Cai S, Feng H, Cai B, Lin L, Mai Y, et al. Single-cell analysis reveals bronchoalveolar epithelial dysfunction in COVID-19 patients. ***Protein Cell*** 2020;11(9):680-7.
10. Volpe MS, Adams AB, Amato MB, Marini JJ. Ventilation patterns influence airway secretion movement. ***Respir Care*** 2008;53(10):1287-94.
11. Hallifax RJ, Porter BM, Elder PJ, Evans SB, Turnbull CD, Hynes G, et al. Successful awake proning is associated with improved clinical outcomes in patients with COVID-19: single-centre high-dependency unit experience. ***BMJ Open Respir Res*** 2020;7(1):e000678.
12. Soleimanifar M. Pulmonary rehabilitation and physiotherapy management of respiratory conditions in patient with COVID-19: narrative review. ***Military Caring Sciences*** 2020;7(1):63-72.
13. Liu K, Zhang W, Yang Y, Zhang J, Li Y, Chen Y. Respiratory rehabilitation in elderly patients with COVID-19: A randomized controlled study. ***Complement Ther Clin Pract*** 2020;39:101166.
14. Battaglini D, Robba C, Caiffa S, Ball L, Brunetti I, Loconte M, et al. Chest physiotherapy: An important adjuvant in critically ill mechanically ventilated patients with COVID-19. ***Respir Physiol Neurobiol*** 2020;282:103529.
15. Gonzalez-Gerez JJ, Saavedra-Hernandez M, Anarte-Lazo E, Bernal-Utrera C, Perez-Ale M, Rodriguez-Blanco C. Short-Term Effects of a Respiratory Telerehabilitation Program in Confined COVID-19 Patients in the Acute Phase: A Pilot Study. ***Int J Environ Res Public Health*** 2021;18(14):7511.
16. Elrefaey BH, Zidan MS. Efficacy of manual hyperinflation on arterial blood gases in patients with ventilator-associated pneumonia. ***Bulletin of Faculty of Physical Therapy*** 2020;25:1-7.
17. Yavary M, Mousavi SAJ, Janani L, Feizi Z, Vafa M. Effect of supplementation of vitamin D, C and E on the lung spirometry and plethysmography in idiopathic pulmonary fibrosis patients. ***Razi Journal of Medical Sciences*** 2018;25(170):65-72.
18. Jastrzębski D, Maksymiak M, Kostorz S, Bezubka B, Osmanska I, Młynczak T, et al. Pulmonary Rehabilitation in Advanced Lung Cancer Patients During Chemotherapy. ***Adv Exp Med Biol*** 2015;861:57-64.
19. Ambrosino P, Molino A, Calcaterra I, Formisano R, Stufano S, Spedicato GA, et al. Clinical Assessment of Endothelial Function in Convalescent COVID-19 Patients Undergoing Multidisciplinary Pulmonary Rehabilitation. ***Biomedicines*** 2021;9(6):614.
20. Srinivasan V, Kandakurti PK, Alagesan J, Suganthirababu P, Kishore JT, Jenifer AS, et al. Efficacy of pursed lip breathing with bhastrika pranayama vs incentive spirometry in rehabilitating post Covid 19 follow up-a randomized control study. ***Turkish Journal of Physiotherapy and Rehabilitation*** 2021;32(3):402-7.
21. Rathi DR, Maid RA, Gadgerao S. Effectiveness of Pursed Lip Breathing Exercise in Covid Patients. ***Indian Journal of Physiotherapy & Occupational Therapy*** 2022;16(2):64-8.
22. Ponce-Campos SD, Díaz JM, Moreno-Agundis D, González-Delgado AL, Andrade-Lozano P, Avelar-González FJ, et al. A Physiotherapy Treatment Plan for Post-COVID-19 Patients That Improves the FEV1, FVC, and 6-Min Walk Values, and Reduces the Sequelae in 12 Sessions. ***Front Rehabil Sci*** 2022;3:907603.
23. Gloeckl R, Leitl D, Jarosch I, Schneeberger T, Nell C, Stenzel N, et al. Benefits of pulmonary rehabilitation in COVID-19: a prospective observational cohort study. ***ERJ Open Res*** 2021;7(2):00108-2021.
24. Al Chikhanie Y, Veale D, Schoeffler M, Pépin JL, Verges S, Hérengt F. Effectiveness of pulmonary rehabilitation in COVID-19 respiratory failure patients post-ICU. ***Respir Physiol Neurobiol*** 2021;287:103639.

25. Zhu F, Zhang M, Gao M, Zeng C, Wang D, Hong Q, et al. Effects of respiratory rehabilitation on patients with novel coronavirus (COVID-19) pneumonia in the rehabilitation phase: protocol for a systematic review and meta-analysis. ***BMJ Open*** 2020;10(7):e039771.
26. Mashhadi M, Sahebozamani M, Daneshjoo A, Adeli SH. the effect of respiratory and core stability tele-exercises on pulmonary and functional status in COVID-19 survivors: a randomized clinical trial. ***Physical Treatments-Specific Physical Therapy Journal*** 2022;12(2):85-92.
27. Nopp S, Moik F, Klok FA, Gattinger D, Petrovic M, Vonbank K, et al. Outpatient Pulmonary Rehabilitation in Patients with Long COVID Improves Exercise Capacity, Functional Status, Dyspnea, Fatigue, and Quality of Life. ***Respiration*** 2022;101(6):593-601.
28. Rayegani SM, Bozorgmehr R, Oshnari LA, Mahdi Kaghazi AH. The Effect of Exercise-Based Pulmonary Rehabilitation on Quality of Life in Recovered COVID-19 Patients; a Quasi-Experimental Study. ***Arch Acad Emerg Med*** 2022;10(1):e45.
29. Sun J, Liu J, Li H, Shang C, Li T, Ji W, et al. Pulmonary rehabilitation focusing on the regulation of respiratory movement can improve prognosis of severe patients with COVID-19. ***Ann Palliat Med*** 2021;10(4):4262-72.
30. Zhou K, Dong S, Fu G, Cui S, Guo S. Massage Therapy for Pulmonary Function in Patients Recovering From Covid-19: A Protocol for Systematic Review and Meta-analysis. ***Research Square*** 2020.
31. Raafat A, Elbasiouny HS. Arterial oxygenation response to manual hyperinflation as an added procedure to chest physiotherapy in critically ill mechanically ventilated patients. ***Bull Fac Ph Th Cairo Univ*** 2008;13(2): 55-62.
32. Akram A, Faisal S, Misdaq Batool HA, Younas M, Iqbal A. Effects of Chest Physiotherapy in Hospitalized Elderly Patients with COVID-19. ***Journal of Xi'an Shiyou University, Natural Science Edition*** 2022; 18(12): 1642-7.
33. Elsherbeni ME, Flefil SE, Badr ME, Elsherbeny ME. Impact of Physiotherapy on Vital Signs and Blood Gases in COVID-19 Patients. ***The Egyptian Journal of Hospital Medicine*** 2023;90(1):901-3.
34. Malik SS, Tassadaq N. Effectiveness of Deep Breathing Exercises and Incentive Spirometry on Arterial Blood Gases in Second Degree Inhalation Burn Patients. ***J Coll Physicians Surg Pak*** 2019;29(10):954-7.
35. Copotoiu M, Chis OL, Copotoiu R. The Benefits of the Respiratory Physiotherapy Program of the Intensive Care Unit's Mechanical Ventilated Patients. ***Chest*** 2014;145(3):191A.
36. Patman S, Jenkins S, Stiller K. Manual hyperinflation--effects on respiratory parameters. ***Physiother Res Int*** 2000;5(3):157-71.
37. Berney S, Denehy L, Pretto J. Head-down tilt and manual hyperinflation enhance sputum clearance in patients who are intubated and ventilated. ***Aust J Physiother*** 2004;50(1):9-14.
38. Dennis DM, Jacob WJ, Samuel FD. A survey of the use of ventilator hyperinflation in Australian tertiary intensive care units. ***Crit Care Resusc*** 2010;12(4):262-8.
39. Savian C, Paratz J, Davies A. Comparison of the effectiveness of manual and ventilator hyperinflation at different levels of positive end-expiratory pressure in artificially ventilated and intubated intensive care patients. ***Heart Lung*** 2006;35(5):334-41.
40. Mahmood T, Naqvi R, Waseem I, Afzal W, Khawar S. Viral infections in COVID-19 and Role of chest physical therapy with self-protections strategies for physical therapists-A Mini Review. ***Journal Riphah College of Rehabilitation Sciences*** 2022;10(02): 124-9.
41. Miyanda PM. Role of Physiotherapy in Respiratory Rehabilitation and Managing COVID-19 Patients in All Stages of the Disease. ***Journal of Preventive and Rehabilitative Medicine*** 2022;4(1):21-6.
42. Johnson JK, Lapin B, Green K, Stilphen M. Frequency of Physical Therapist Intervention Is Associated With Mobility Status and Disposition at Hospital Discharge for Patients With COVID-19. ***Phys Ther*** 2021;101(1):pzaa181.
43. Peiris CL, Shields N, Brusco NK, Watts JJ, Taylor NF. Additional Physical Therapy Services Reduce Length of Stay and Improve Health Outcomes in People With Acute and Subacute Conditions: An Updated Systematic Review and Meta-Analysis. ***Arch Phys Med Rehabil*** 2018;99(11):2299-312.