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ORIGINAL PAPER

The effects of breathing and coughing exercises on respiratory parameters in COVID-19 patients

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ABSTRACT

Introduction and aim. COVID-19 primarily affects the respiratory system, often resulting in pneumonia and dyspnea that may persist after recovery. This study aimed to evaluate the effect of deep breathing and coughing exercises using a Triflow device on respiratory parameters in patients with COVID-19 pneumonia.

Material and methods. This single-blinded randomized controlled study was conducted with 326 patients diagnosed with COVID-19 pneumonia. Participants were randomly assigned to an experimental group (n=163) or a control group (n=163). The experimental group performed exercises for 10 consecutive days. The control group received routine hospital care, which included routine nurse-led monitoring of vital signs, peripheral oxygen saturation (SpO_2) assessment, medical treatment per clinical guidelines, and supportive care, but no structured breathing-exercise education. Data were analyzed using descriptive statistics, ANOVA, chi-square, and post hoc tests.

Results. After 10 days of intervention, Dyspnea-12 scores decreased more markedly in the experimental group than in the control group (mean change −15 vs. −8 points; $p<0.001$). Arterial oxygen and SpO_2 levels also improved significantly in the experimental group compared to controls ($p<0.001$), while respiratory rate decreased to a greater extent ($p<0.001$). No adverse effects were observed.

Conclusion. Deep breathing and coughing exercises with the Trilow device significantly reduced the severity of dyspnea and improved oxygenation in COVID-19 pneumonia patients. These findings suggest that incorporating structured respiratory exercises into standard care may enhance clinical outcomes and support recovery in this population.

Keywords. cough exercise, COVID-19, deep breathing, nursing care, pneumonia, Triflow

Introduction

The novel coronavirus (COVID-19) was first identified in December 2019 in China.[1] The World Health Organization (WHO) recognized the virus as a public health threat and declared it a pandemic on March 11, 2020, due to its rapid spread.[1] According to scientific research, the COVID-19 virus can spread through direct contact with respiratory droplets and fecal matter.[1] Early outbreak analyses estimated an incubation period of approximately 5.2 days and a basic reproduction number (R_0) of about 2.2.[1,2]

The most common symptoms of COVID-19 include high fever (98%), cough (76%), dyspnea (55%), myalgia or fatigue (44%), sputum production (28%), headache (8%), and other less typical symptoms. Additionally, pneumonia affects nearly all patients. Other frequently reported complications include acute respiratory distress syndrome (ARDS) (29%), acute heart injury (12%), and

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secondary infections (10%).[3,4] COVID-19 patients often exhibit rapid and shallow breathing, with increased rates of tachypnea.[5] A significant portion of COVID-19 patients have at least one underlying chronic condition, and these individuals often require hospitalization.[3,4] Researchers estimate that 20% of COVID-19 patients may require medical clinical care.[6] In patients with mild symptoms, the illness typically lasts about two weeks. However, in those with severe or critical diseases, symptoms can persist for anywhere between three and six weeks.[7]

The number of hospitalized COVID-19 patients exceeds the capacity of available hospital and healthcare facilities. To improve survival rates for patients with acute respiratory distress syndrome (ARDS), healthcare professionals employ various management techniques. Typically, patients with ARDS receive high-flow nasal oxygen therapy and corticosteroid treatment. Previous studies have demonstrated that active respiratory exercises are effective for a range of respiratory diseases, including cystic fibrosis, bronchiectasis, and chronic obstructive pulmonary disease (COPD).[8] Additionally, exercise training is a crucial component of pulmonary rehabilitation.[9,10] A recent study indicated that breathing exercises in COVID-19 patients serve not only to support physical recovery but also as a valuable non-pharmacological approach for managing psychological distress.[11] Another study reported that respiratory rehabilitation programs in COVID-19 patients alleviate dyspnea, anxiety, and depression, reduce related problems, enhance functionality, preserve pre-existing functions, and improve quality of life as much as possible.[12]

Aim

This study aimed to evaluate the effects of deep breathing and coughing exercises using Triflow on the respiratory parameters of COVID-19 patients with pneumonia. Based on this aim, the research hypotheses were formulated as follows:

H_0: Deep breathing and coughing exercises using Triflow have no statistically and clinically significant effect on the respiratory parameters of COVID-19 patients.

H_1: Deep breathing and coughing exercises using Triflow have a statistically and clinically significant effect on the respiratory parameters of COVID-19 patients.

Material and methods

Study design and setting

This study was conducted as a single-blinded randomized controlled trial in the pandemic clinic of a state hospital in the Black Sea Region of Turkey. The clinical trials were obtained from ClinicalTrials.gov for our experimental design research (ID: NCT05218200). The study was designed according to the Consolidated Standards of Reporting Trials (CONSORT) 2010 statement. The CONSORT diagram of the study is presented in Figure 1.

Participants

The study population includes COVID-19 pneumonia patients admitted to the hospital's pandemic clinic over the past year, totalling 2,161 patients. The study sample size is 326 COVID-19 patients, determined using the known population sample size formula ($n = Nt^2\ pq/d^2\ (N-1) + t^2pq$).[13] In the study, 355 patients were assessed. Three hundred and forty-six patients were included in the study. The inclusion criteria were as follows: COVID-19 patients who were over 18 years old, conscious, without cognitive issues, and had no sensory or perceptual impairments, who were not admitted to intensive care units and were not connected to any respiratory support devices. The nine patients under 18 years old, those who were unconscious, could not speak or understand Turkish, had sensory or perceptual disabilities, or required CPAP (Continuous Positive Airway Pressure) or BiPAP (Bilevel Positive Airway Pressure), were excluded from the study. Patients (n=346) were randomly assigned to the experimental and control groups. During the intervention phase, 10 patients from the experimental group and 10 patients from the control group were excluded due to discharge before 10 days, referral to the intensive care unit, or withdrawal from the study. Ultimately, data from a total of 326 patients were analysed, with 163 patients in the experimental group and 163 in the control group (Fig. 1).

Healthcare personnel and professional qualifications

The study was conducted by four researchers with doctoral degrees and one with a master's degree in surgical nursing, all with clinical experience in intensive and palliative care. The doctoral-level researchers developed the exercise training protocol and instructional video based on current literature and expertise. The COVID-19 clinic team included bachelor-level nurses and a pulmonology specialist who provided routine medical care and monitoring. Collaboration among the research team, clinic nurses, and the pulmonologist ensured continuous patient observation, enhanced compliance, and supported the safety and effectiveness of the interventions.

Randomization

The patients (n=346) who met the inclusion criteria were divided into two groups – experimental (173 patients) and control (173 patients) – using a computer-generated block randomization with a 1:1 ratio (randomizer.org). Patients were assigned to groups according to the sequence number determined independently by the program. The patients are unaware of their group allocation. Blinding was not possible for measurements obtained after the intervention. To reduce the risk of bias, objective measurements (device-based parameters such as SpO_2 and PO_2) and valid and reliable scales were used.

Outcomes

The primary outcome of the study was the change in dyspnea severity, measured using the Dyspnea-12 scale, from baseline to day 10. Secondary outcomes included SpO_2 levels, respiratory rate, and sputum quantity. All outcomes were pre-specified in the study protocol to ensure consistency and transparency in intervention and analysis.

Instruments

We collected data using an information form, the Dyspnea-12 scale, and Triflo.

Information form

The first part of the form includes information on age, gender, anthropometric measurements, comorbidities, blood values, clinical picture, and hemodynamic parameters. The second part consists of each individual's measurement results recorded on the 5th and 10th days.

Dyspnea-12 scale

A scale with a total of 12 items and four Likert-type response options was used in this study to assess the severity of dyspnea. The maximum scores on the scale are 21 for the physical dimension and 15 for the emotional dimension, with a total range from 0 to 36. A higher score on the scale indicates greater severity of dyspnea.[14] An internal consistency score of 0.90 was reported by Yorke et al. in the initial study of the scale. In a validity and reliability study conducted in our country by Gök Metin and Helvacı, the Cronbach's alpha value was found to be 0.97.[15] We determined the Cronbach's alpha value for the current study to be 0.93, indicating that the scale has strong internal consistency. The minimal clinically important difference (MCID) for Dyspnea-12(D-12) was set at 2.8 points.[17]

Triflow

Triflow consists of a main body and a blowpipe (Berger A10066, Made in Türkiye). The main body features three columns, each with a corresponding ball. The first column in the main body measures 600 cc, the second measures 900 cc, and the third measures 1200 cc. These measurements represent different levels of lung vital capacity.

Procedure

The study was conducted between December 2021 and September 2022 at one of the State hospitals in Black Sea Region of Turkey. Initially, demographic and clinical information, Dyspnea-12 scale, hemodynamic and respiratory parameters for both groups were evaluated and recorded on the first day. The amount of sputum, hemodynamic parameters, biochemical tests, blood gas analyses, and Dyspnea-12 scale scores were recorded on the 5th and 10th days. This measurement schedule was chosen because the inpatient treatment and observation period is at least 10 days, according to the current treatment algorithm of the Ministry of Health (TC Ministry of Health, 2021).[16] All blood samples were collected at 7:00 AM, following hospital routine procedures. Measurements of hemodynamic and respiratory parameters and sputum volume were scheduled for 8:30 AM on the 1st, 5th, and 10th days. All measurements and records were performed by the same experienced researcher with a master's degree in surgical nursing who has worked in the COVID-19 clinic. This approach was intended to minimize interobserver variability. Because there is no established MCID for sputum quantity in the literature, the operational MCID in our study was predefined as at least one category of improvement (2–5 ml → <2 ml or <2 ml → none).

Control group

Patients in the control group received the same routine of care as other COVID-19 patients in the clinic, which included daily arterial blood gas monitoring, hourly assessment of respiratory parameters, frequent position changes, and support in a semi-upright position. In addition, breathing and coughing exercises were taught to the patients without using assistive devices. All blood samples were collected according to hospital routine practice. The vital parameters and Dyspnea-12 scale scores were measured at 8:30 AM after the patient had rested for at least 30 minutes.

Experimental group

Patients in the experimental group, in addition to receiving routine care, were taught deep breathing and coughing exercises using Triflow. The exercise training content and video were prepared by researchers based on the literature.[17,18] One of the researchers who prepared the exercise video provided face-to-face exercise training to the patients before they independently performed the exercise. After the same researcher who provided the training confirmed that the exercises were performed with correct technique, the patients performed the exercises themselves throughout the study. Previous studies suggest that short-term implementation of deep breathing and coughing exercises, such as 5 times every hour, may have positive effects on respiratory parameters in patients with COVID-19 and pneumonia patients.[8,11] In line with this literature, patients in the experimental group were instructed to regularly perform 5 times of breathing and coughing exercises five times every hour between 09:00 and 22:00. Compliance with the exercises was carefully monitored by an experienced researcher who has worked in the COVID-19 clinic using a checklist. The researchers ensured that the prepared training video, along with reminder messages, was sent to the patients' smartphones twice daily, at 9:00 AM and 3:00 PM. The amount of sputum, hemodynam-

ic and respiratory parameters, biochemical tests, blood gas analyses, and Dyspnea-12 scale scores were recorded before exercises on the 1st, 5th, and 10th days. Only patients who completed the exercises with 100% adherence were included in the study. There were no missing data; therefore, no imputation or handling was required.

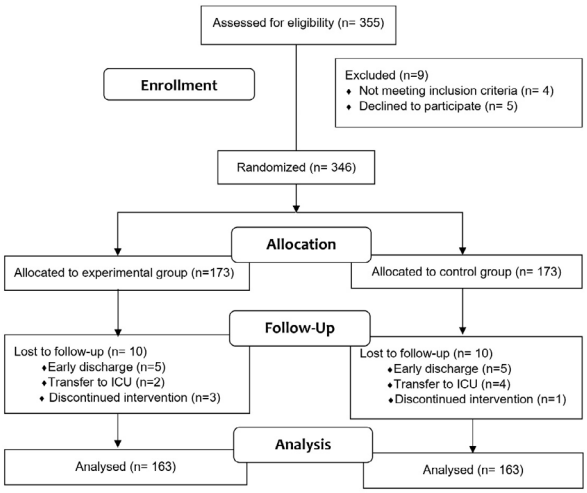

Fig. 1. Consort flow diagram of the study

Ethical consideration

The study obtained ethical approval from the state University Ethical Committee in Turkey on September 14, 2021, with the reference number 2021-SBB-0329, T.R. Ministry of Health (dated 24.11.2021 and numbered 2021-11-22T11), Provincial Health Directorate and hospital (dated 03.12.2021 and E-26080346-799) permissions were obtained. Informed verbal consent was obtained from the service physician and nurses. Before participating in the study, each patient gave written informed consent. They were told they could leave the study whenever they wanted without facing any consequences. Additionally, the patients were guaranteed that their data would be kept private and only used for legitimate scientific purposes. All materials used in the research were provided by Bartin University Scientific Research Projects Unit (Project No: 2021-FEN-A-016).

Data analysis

Data were analysed using IBM SPSS 25 (Armonk, NY, USA). The skewness and kurtosis coefficients of the scores were assessed, revealing that these coefficients fell within the ±2 range. This indicates that the distribution of the scores can be considered approximately normal, as values within this range suggest a relatively symmetrical distribution with moderate peakiness. Based on these findings, descriptive statistical analysis was conducted for the demographic data, and repeated measures ANOVA was used to analyze the repeated measurements, provided the data met the normal distribution criteria. The chi-square test was also employed to compare categorical data. A post hoc power analysis was performed using the G*Power 3.1 program after the research.

Table 1. Demographic and clinical characteristics of the participants (n=326)[a]

	Experimental group (n=163)		Control group (n=163)		t	p
	Mean±SD	Min–Max	Mean±SD	Min–Max		
Age	75.71±9.29	61–93	75.66±9.32	60–94	0.048	0.962
Height (cm)	170.67±8.56	150–180	170.59±8.50	150–185	0.084	0.933
Weight (kg)	72.21±10.96	50–95	72.44±11.36	49–110	-0.184	0.855
Blood values						
Hemoglobin (g/dL)	11.69±1.73	7.6–14.1	11.67±1.73	7.6–14.1	0.108	0.994
Platelets ($\times 10^9$/L)	255.85±79.27	80–491	258.87±82.78	82–490	-0.336	0.681
Blood glucose (mg/dL)	154.87±86.86	84–413	154.20±86.30	89–410	0.070	0.921
Urea (mg/dL)	53.80±24.46	23–114	54.20±24.59	23–116	-0.147	0.860
Uric acid (mg/dL)	3.71±1.51	1.49–6.40	3.64±1.47	1.51–6.39	0.400	0.682
INR	1.02±0.05	0.92–1.14	1.02±0.05	0.92–1.14	-0.214	0.803
PO_2 (mmHg)	71.15±17.43	34.2–104.2	70.05±17.89	36.1–100.0	0.559	0.576
PCO_2 (mmHg)	39.66±6.13	32.2–66.5	38.91±5.14	32.2–53.9	1.202	0.230
HCO_3 (mmol/L)	24.19±3.88	18.6–32.3	24.22±3.94	18.2–29.0	-0.071	0.807
pH	7.40±0.04	7.24–7.68	7.39±0.03	7.27–7.57	0.324	0.746
Respiration rate (breaths/min)	19.53±0.90	18–22	19.52±0.85	18–20	0.126	0.900
Peripheral capillary oxygen saturation (%)	93.70±2.39	87–98	93.72±2.36	90–98	-0.093	0.926
Body temperature (°)	36.32±0.39	34.5–36.8	36.41±0.41	34.5–37.0	0.302	0.702
Heart rate (beats/min)	88.95±13.40	57–115	89.21±13.43	61–111	-0.173	0.895
	n	%	n	%	X^2	p
Gender						
Female	116	71.2	106	65	1.412	0.235
Male	47	28.8	57	35		
Smoking						
Yes	16	9.8	9	5.5	3.829	0.147
No	147	90.2	154	94.5		
Steroid use						
Yes	96	58.9	100	61.3	0.205	0.651
No	67	41.1	63	38.7		
Mobilization						
Dependent	6	3.7	7	4.3	0.080	0.777
Independent	157	96.3	156	95.7		
Chronic diseases*						
Hypertension	90	55.2	93	57.1	0.112	0.738
Obesity	19	11.7	17	10.4	0.125	0.724
Allergy	6	3.7	7	4.3	0.080	0.777
Diabetes	20	12.3	19	11.7	0.029	0.864
CRF**	6	3.7	7	4.3	0.080	0.777
Hypercholesterolemia	13	8.0	13	8.0	0.000	1.000
COPD***	19	11.7	20	12.3	0.029	0.864

[a] T – independent sample t test, X^2 – Chi square test, * – multiple response, **CRF – chronic renal failure, ***COPD: – chronic obstructive pulmonary disease

Results

The measurement results of patients in the experimental (n=163) and control (n=163) groups were presented in tables and figures. Each of the total 326 COVID-19 participants received ten days of follow-up care. There were

no material or moral losses incurred by the patients participating in the study. No adverse effects or harm were observed by any of the researchers.

Table 1 shows that both the experimental and control groups were homogeneous in terms of demographic and clinical characteristics, as indicated by p-values greater than 0.05 (Table 1).

The results from the initial observation of patients and Dyspnea-12 scale scores are presented in Table 2. The results indicate that the groups are homogeneous, with no statistically significant difference in the mean Dyspnea-12 scale scores ($p>0.05$). On day 10, both groups experienced a statistically significant decline in their Dyspnea-12 scores, but the decline in the experimental group was more pronounced than in the control group ($p<0.001$). Dyspnea-12 scale score decreased by an average of 15 points in the experimental group, while it decreased by 8 points in the control group (Table 2). A change in ΔD-12 of ≥ 2.8 between Day 1 and Day 10 was considered clinically significant.

Table 2. Comparison of variables according to the measurement times of the experimental and control groups (n=326)[a]

Dispne-12 scale		Experimental (n=163)	Control (n=163)	t	p[1]	
		Mean±SD	Mean±SD			
First day		22.64±7.16	20.44±7.30	2.748	0.412	
5th day		12.84±5.42	16.31±6.81	-5.080	0.004*	
10th day		7.01±4.66	12.99±6.66	-9.388	0.001*	
F		376.987	193.616			
p[2]		0.000*	0.000*			
Bonferonni		1>2 , 2>3	1>2 , 2>3			
Expectoration amounts		n(%)	n (%)	X^2	p[1]	OR (95% CI)
First day	None	125 (50.6)	122 (49.4)	0.338	0.845	
	Less than 2ml	32 (4.2)	33(50.8)			
	2–5 ml	6 (42.9)	8 (57.1)			
5th day	None	143 (52.0)	132 (48.0)	3.440	0.179	
	Less than 2ml	20 (40.0)	30 (60.0)			
	2–5 ml	–	1 (100.0)			
10th day	None	162 (51.8)	151 (48.2)	9.694	0.001*	0.780 (0.010-0.605)
	Less than 2ml	1 (7.7)	12 (92.3)			
	2–5 ml	–	–			

[a] p[1] – independent sample t test significant value, p[2] – F test significant value, F – ANOVA, SD – standard deviation, X^2 – Chi square test, * – p<0.05, OR – odds ratio, CI – confidence interval

The quantity of sputum in patients on the fifth and tenth days is shown in Table 2. The findings indicate that there was no statistically significant difference between the experimental and control groups at admission and on day five ($p>0.05$). However, on the 10th day, sputum production significantly decreased in the experimental group ($p<0.001$, OR=0.780). This suggests that Triflow-assisted coughing exercises and deep breathing significantly reduced sputum production in COVID-19 patients (OR=0.780) (Table 2).

Table 3. Comparison of arterial blood gas and respiratory parameters according to the measurement times of the experimental and control groups[a]

Parameters	Experimental (n=163)	Control (n=163)	t	p[1]
	Mean±SD	Mean±SD		
PO_2 (mmHg)				
First day	71.15±17.43	70.05±17.89	0.559	0.576
5th day	76.21±14.57	71.39±15.85	2.853	0.005*
10th day	80.67±14.54	73.98±15.79	3.981	0.001*
F	64.460	22.110		
p[2]	0.001*	0.001*		
Bonferonni	1<3, 2<3	1<3, 2<3		
PCO_2 (mmHg)				
First day	39.66±6.13	38.91±5.14	1.202	0.230
5th day	39.26±5.20	39.15±4.92	0.211	0.833
10th day	38.44±3.94	38.98±4.01	-1.222	0.233
F	7.079	7.226		
P[2]	0.003*	0.027*		
Bonferonni	2<3	1<2, 3<2		
SPO_2 (%)				
First day	93.70 ±2.39	93.72±2.36	-0.093	0.926
5th day	94.47±2.14	94.15±2.39	1.266	0.206
10th day	96.02±1.80	94.82±2.00	5.690	0.001*
F	144.313	80.433		
P[2]	0.001*	0.001*		
Bonferonni	1<2<3	1<2<3		
Respiratory rate (rate/minute)				
First day	19.53 ±0.90	19.52±0.85	0.126	0.900
5th day	17.31±2.17	19.83±1.14	-13.116	0.001*
10th day	15.06±3.30	18.60±0.13	-12.158	0.001*
F	167.585	66.681		
P[2]	0.001*	0.001*		
Bonferonni	1>2>3	1>3, 2>3		

[a] p[1] – independent sample t test significant value, p[2] – F test significant value, F – ANOVA, SD – standard deviation, *p<0.05

Figure 2B compares arterial PO_2 values for the experimental and control groups at various measurement times. On day 10, PO_2 levels increased in both groups ($p<0.001$), but the increase in the experimental group was statistically significant (Fig. 2B, Table 3). Throughout the study, no statistically significant difference was found between the arterial PCO_2 levels of the experimental and control groups ($p>0.05$). However, arterial PCO_2 levels decreased continuously in the experimental group ($p=0.003$), while in the control group, they increased on day 5 but decreased again on day 10 ($p=0.027$) (Fig. 2A, Table 3). Post hoc analysis revealed that the significant change observed in the experimental group occurred between days 5 and 10 ($p=0.003$) (Fig. 2A, Table 3).

A statistically significant difference in SpO_2 levels was found between the groups on day 10 ($p<0.001$) (Ta-

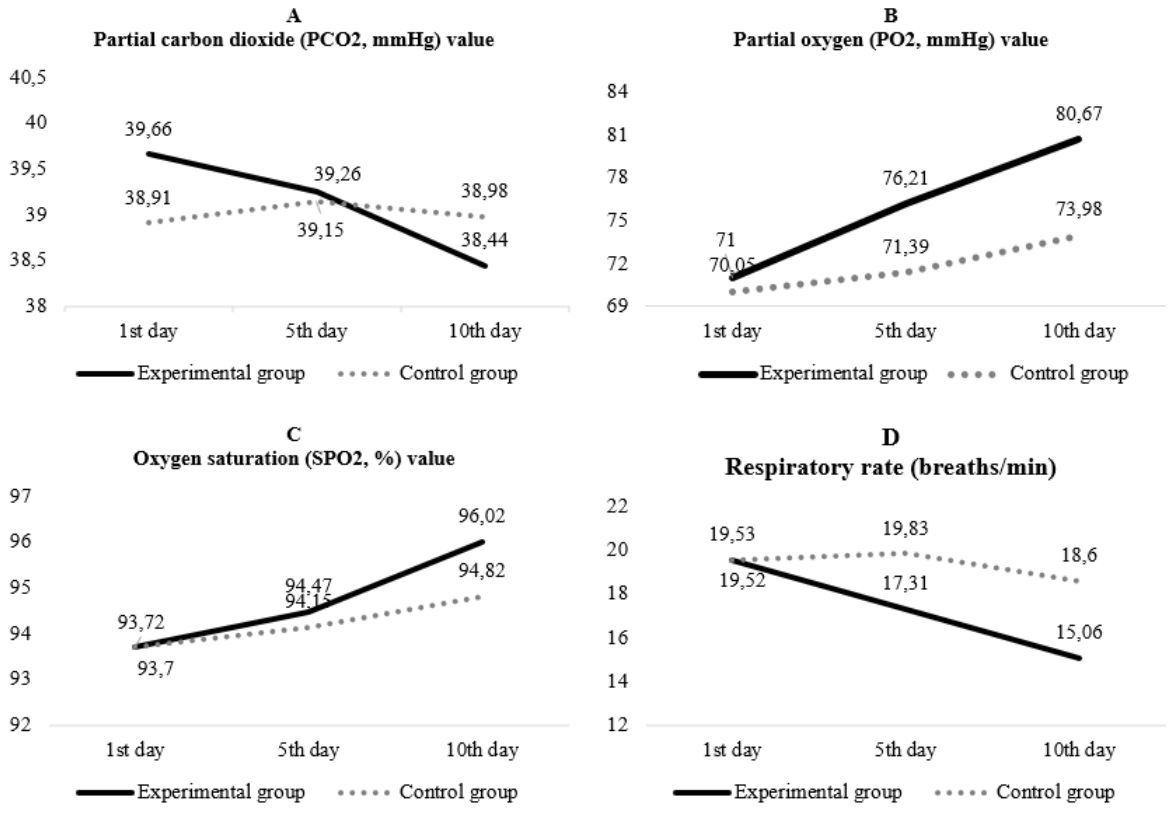

Fig. 2. Comparison of arterial blood gases and respiratory rate values according to measurement time and groups, A: Change in PCO_2 (mmHg) value over time, B: Change in PO_2 (mmHg) value over time; C: Change in SpO_2 (%) over time, D: Change in respiratory rate (breaths/min) over time

ble 3). SpO_2 levels increased on day 10 in both groups compared to the duration of hospital stay ($p<0.001$) (Fig. 2C, Table 3).

Figure 2D shows a statistically significant change in respiratory rates across various measurement periods in both the experimental and control groups ($p<0.001$) (Table 3). Furthermore, changes in respiratory rates were significantly different between the two groups. Patients in the experimental group had lower respiratory rates compared to those in the control group at measurements on days 5 and 10, but these rates remained within clinically acceptable ranges ($p<0.001$) (Fig. 2D, Table 3).

Discussion

The definitive treatment for COVID-19 has not yet been fully established, and the effects of deep breathing exercises as part of care and treatment strategies have not been fully clarified. In the literature, there is a limited number of randomized controlled clinical trials that assess the effectiveness of deep breathing exercises in COVID-19 patients.[17,18]

COVID-19 directly affects respiratory function, often causing dyspnea of varying severity.[19] In this study, dyspnea severity was measured using the Dyspnea-12 scale. The experimental group showed a significantly faster decrease in dyspnea scores on days 5 and 10 compared to baseline ($p<0.05$), suggesting that deep breathing and coughing exercises with Triflow effectively reduce dyspnea in COVID-19 patients. Although overall differences between experimental and control groups were not always statistically significant, the exercises demonstrated symptom relief. Similarly, Öner Cengiz et al. observed beneficial effects of deep breathing exercises on dyspnea severity, though differences between groups were not significant.[18] Zha et al. reported that respiratory rehabilitation, including deep breathing exercises, can effectively manage dyspnea in COVID-19 patients,[19] supporting the overall benefit of these interventions.[20] Abdullahi also reported in a critical review that breathing exercises could be used to reduce dyspnea in COVID-19 patients.[21]

In addition to typical COVID-19 symptoms, about 40% of patients show increased sputum, and autopsies have revealed severe mucoid tracheitis in roughly one-third of non-survivors.[22,23] This highlights the role of respiratory inflammation and mucus in disease severity and outcomes. Effective management of mucus is therefore critical. In our study, only one patient in the experimental group performing Triflow deep breathing exercises produced sputum on day 10, compared to 12

patients in the control group ($p<0.05$; OR=0.780), suggesting that Triflow exercises may reduce sputum production. Similarly, Mollerup applied positive expiratory pressure (PEP-flute) therapy in 378 COVID-19 patients, with 255 reporting sputum symptoms.[24] These findings support the literature, indicating that respiratory exercises can help manage sputum in COVID-19 patients. However, studies on this specific effect remain limited, and further research is needed to confirm these results.

In our study, respiratory rate decreased in both groups, but the reduction was faster in the experimental group performing deep breathing and cough exercises with Triflow. SpO_2 levels also improved more rapidly in this group, suggesting that these exercises enhanced lung capacity and airway clearance, facilitating oxygenation. The respiration rate of COVID-19 patients was found to be 20 breaths per minute in the study by Li et al.[25,26] In another study, it was determined that the respiratory rate in COVID-19 patients exceeded 24 breaths per minute 25. According to research conducted by Cengiz et al., the respiratory rate in the deep breathing exercise group significantly decreased compared to the control group.[18] These findings indicate that deep breathing exercises can effectively improve respiratory parameters in COVID-19 patients, likely by supporting relaxation and accelerating recovery in conjunction with standard treatment. Similarly, in quasi-experimental studies by Kader et al., it was reported that the respiratory rate decreased significantly in the deep breathing exercise group and returned to normal faster than in the control group.[17] In this study, we believe that the decrease in respiratory rate observed in both groups is attributable to reduced virulence and symptom relief due to the treatment process. Additionally, we think that breathing exercises contribute effectively to patient relaxation, as evidenced by the respiratory rate in the experimental group returning to normal limits more quickly than in the control group.

In our study, the baseline SpO_2 levels of patients in both groups were an average 93%. This current study involved a larger sample (n=326) of COVID-19 patients compared to previous studies. The literature reports that the SARS-CoV-2 virus induces inflammatory responses and widespread alveolar damage in the human body. Consequently, changes in O_2, CO_2, SpO_2, and blood pH levels occur.[27] In a study, the SpO_2 levels of patients hospitalized due to COVID-19 were found to be ≤89%.[28] The study by Öner Cengiz et al. examined the effect of breathing exercises on respiratory parameters in 44 COVID-19 patients. They found that SpO_2 levels increased following deep breathing exercises in these patients.[18] In the quasi-experimental study by Kader et al., it was reported that SpO_2 levels in the deep breathing exercise group were significantly higher.[17] These findings are consistent with the existing literature, indicating that our research aligns with previous studies.

Alveolar ventilation and $PaCO_2$ are interconnected. $PaCO_2$ reflects the balance between CO_2 production and its removal. Elevated $PaCO_2$ levels indicate increased pulmonary dead space and a reduced ability of the lungs to expel CO_2.[29] On the 10th day of the trial, it was discovered that the experimental group's PCO_2 levels were noticeably lower than those of the control group. This indicates that the experimental group's arterial PCO_2 levels decreased as a result of engaging in deep breathing exercises. In contrast, the control group exhibited an increase in arterial PCO_2 levels.

It's worth noting that previous studies did not specifically investigate blood gas parameters in relation to deep breathing exercises. Therefore, the findings from your research offer valuable insights into the effect of deep breathing exercises on these blood gas parameters in COVID-19 patients.[17,18] Close monitoring of blood gases is crucial for COVID-19 patients as it guides healthcare professionals in planning treatment and care. The use of Triflow enhances pulmonary function by actively engaging the diaphragm and other inspiratory muscles during breathing exercises. Additionally, these positive findings suggest that patients adapted well to the breathing and cough exercises with Triflow.

Study limitations

The study was conducted exclusively with COVID-19 patients in pandemic clinics, which means its findings may not be generalizable to all COVID-19 patients. However, the results provide a valuable reference for future research on COVID-19 patients with severe pneumonia or those requiring intensive care. The observed impact of deep breathing exercises on respiratory parameters, such as PCO_2 levels, in the experimental group suggests that incorporating these exercises into therapy and care protocols for critically ill COVID-19 patients could be beneficial. Further research is needed to explore the effects of deep breathing exercises on specific subgroups, particularly those with severe pneumonia or in intensive care settings. Such studies could offer targeted insights into how these exercises can improve respiratory function, reduce complications, and enhance overall patient outcomes. This research could ultimately contribute to the development of evidence-based guidelines and interventions to optimize the care of critically ill COVID-19 patients. All patients reported 100% compliance with the exercise program. This should be considered as a potential source of bias since it is based on patient self-reporting.

In this study, all measurements and recordings were carried out by the same researcher, who worked as a clinic nurse. This reduced the risk of interobserver variability and can be considered a strength of the study. However, conducting all assessments by a single observer does not fully eliminate the potential for observer bias. Therefore, future studies could benefit from valida-

tion of the measurements by multiple independent observers. Although patient adherence to the intervention was monitored by the researchers, individual differences in adherence and motivation may have influenced the outcomes. Therefore, variability in treatment adherence should be considered as a potential limitation.

Conclusion

This study demonstrates that deep breathing and coughing exercises with Triflow reduce the severity of dyspnea, improve respiratory parameters, and decrease sputum production in COVID-19 patients. These findings support the idea that such respiratory exercises can help optimize pulmonary function in patients and that incorporating them into routine treatment and care protocols in hospital settings may be beneficial. Furthermore, the study can raise awareness among healthcare professionals and patients about the importance of breathing and coughing exercises and contribute to the development of proactive nursing care strategies aimed at alleviating respiratory distress in COVID-19 patients. In the future, more comprehensive studies with multidisciplinary approaches involving professionals from different disciplines such as physiotherapists and pulmonologists as well as nurses are recommended.

Declarations

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Author contributions

Conceptualization, Ö.U. and S.Ç.; Methodology, Ö.U.; Validation, Ö.U., S.Ç.. and S.U.; Formal Analysis, Ö.U., S.Ç., and E.K.; Investigation, Ö.U., S.U., and S.A.; Resources, Ö.U. and S.Ç.; Data Curation, Ö.U..; Writing – Original Draft Preparation, Ö.U., S.U., and S.A.; Writing – Review & Editing, Ö.U., S.Ç., and E.K.; Visualization, Ö.U.; Supervision, S.Ç.; Project Administration, S.Ç.; Funding Acquisition, S.Ç.

Conflicts of interest

The authors declare no competing interests.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Bartın University Ethical Committee (2021-SBB-0329).

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