Original Article

Impact Of Active Cycle Of Breathing Technique On Selected Pulmonary Outcomes In Post-COVID Syndrome Patients

Alshaimaa A. Ali [1*], Nesreen G. Elnahas [2], Samir A. Algazzar [3], Abdel Wahab M. Lotfy[4], Emad M. Taha [5]

1. *Department of cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, May University in Cairo, Egypt.*
2. *Department of Cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University, Egypt.*
3. *Dean of Faculty of Physical Therapy Heliopolis University for Sustainable Development, Egypt.*
4. *Department of internal medicine and vice director of allergy and immunology Centre, Faculty of medicine, Al-Azhar University, Egypt*
5. *Department of cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Hertfordshire University, Egypt.*

Corresponding author: Alshaimaa A. Ali

E-mail: *alshaimaa.alsayed@muc.edu.eg*

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Abstract

Background Worldwide, the 2019 coronavirus disease (COVID-19) pandemic has imposed a substantial burden. A large number of post-Covid-19 patients have long-lasting symptoms like fatigue and exercise intolerance. This condition been labelled 'post-acute sequelae of Covid-19' (PASC). Pulmonary rehabilitation is a comprehensive treatment that is based on a thorough assessment of the patient and is meant to improve the health of people with respiratory disease. **Purpose** To determine how active cycle breathing affects specific pulmonary outcomes in patients having post-COVID syndrome. **Materials and methods** 60 patients of both sexes (29 men and 31 women) took part. Their age was ranging from 40-50 years. Patients were randomized into 2 groups of the same size. Variables were assessed before and after training and statistically analyzed: Arterial blood gas analysis (ABG), the six-minute walk test (6MWT) and fatigue level **Results:** The mixed MANOVA statistical analysis results indicated no substantial change in any outcome measures between the two groups prior to treatment ($p > 0.05$). After treatment, comparisons across the groups showed that Group A had significantly increased (6MWT 11.09%, PaO_2 3.5%, SaO_2 2.7%) (Decrease fatigue 35.92% $PaCO_2$ 4.35%). Group B: (6MWT 21.61%, PaO_2 12.41%, SaO_2 6.43%) (Decrease fatigue 61.05%, $PaCO_2$ 10.75). **Conclusion** ABG parameters, fatigue level and six-minute walk test (6MWT) for post-COVID syndrome patients were all positively impacted by the active cycle of breathing technique, which is an efficient modality that may be incorporated into conventional physical therapy protocols.

Keywords: Post-COVID-19, arterial blood gases, pulmonary rehabilitation, and active cycle of breathing technique.

Introduction

The 2019 coronavirus disease (COVID-19) pandemic will likely have widespread consequences around the world. The clinical manifestations result from infection with the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), vary from asymptomatic infection to respiratory difficulties, multi-organ failure, as well as disastrous outcome [1]**.**

The cardiovascular, renal, gastrointestinal, endocrine, neurological, and musculoskeletal systems can all be negatively impacted by the COVID-19 coronavirus in addition to the respiratory system. Risk factors for more severe disease include advanced age and coexisting conditions like smoking, obesity, diabetes, heart disease, hypertension, and past respiratory infections [2].

Post-COVID syndrome, also recognized as long-COVID, was first thought to be a clinical entity in the spring of 2020, when COVID-19 patients still had symptoms weeks after their acute infection and soon after the first cases were found. The first complete patient survey of post-COVID syndrome gave a lot of useful information [3].

Additionally, patients with Post-COVID syndrome frequently need lengthy hospital stays and mechanical ventilation, which may have major side effects and lead to the emergence of Post-Intensive Care Syndrome. Physical, cognitive, and psychological limitations that are a feature of this disorder have an impact on patients' quality of life long after they leave the hospital [4].

Even though most COVID-19 patients fully recover without complications, many individuals may continue to experience COVID-19 symptoms after their infection has cleared up. Yet, other patients may even acquire new symptoms. This entire clinical range that follows an acute infection is known as post-COVID syndrome (PCS). According to some writers, PCS is a condition in which signs and symptoms persist for more than 4 weeks following an acute COVID-19 infection [5].

Pulmonary physiotherapy means as a complete intervention on the basis of a detailed patient assessment, accompanied by individual treatment plans, including exercise training, education, and behavior change, consistent with the American Thoracic Society/European Respiratory society, all of which are intended with the hope of enhancing the health of those suffering from respiratory disease. In COVID-19 patients, pulmonary rehabilitation aims to lessen dyspnea symptoms, calm anxiety, lessen complications, limit disability, maintain function, and enhance the quality of life [6].

Individuals with COVID-19 benefit from the Active Cycle of Breathing Technique, a chest physiotherapy technique that reduces dyspnea, anxiety, and depression. It has been asserted that when administered early, it enhances gas exchange, delays the onset of pathology, and lessens or completely eliminates the need for mechanical ventilation. Over time, it also recovers physical capabilities that enhance the quality of life and facilitate reintegration into society [7].

Respiratory exercises can help those with the post-COVID syndrome. Teaching the patient to rely mainly on their diaphragm to lessen the load on accessory muscles is a key component of diaphragmatic breathing. For the diaphragm to be recruited and for better humidification, nasal inspiration should be encouraged. Active abdominal muscle contraction at the end of expiration can increase abdominal pressure and raise the diaphragm to a more optimal length of tension [6].

Exercise has been known to have psychedelic effects. Regular exercise is an effective method for enhancing the quality of life, managing mood and related disorders (such as depression and anxiety), lowering psychological stress, and modifying how pain is perceived. The structure and function of the brain are altered by exercise to promote a better neurological phenotype. Parallel training (endurance and strength) is the recommended course of action for lung diseases to improve increase oxygen intake through the lungs, systemic oxidative stress, muscle strength, muscle size, functional capacity, also quality of life [8].

Material and Methods

A prospective, single-blinded, before and post-test, randomized controlled trial was used in the investigation design.

Participants

Sixty patients were selected as convenient studies of both sexes (31 women and 29 men) recruited from Ain-shams General Hospital in Cairo. Their ages ranged from 40 to 50. Participants in the current study must be oriented, medically stable, and suffering from clinical symptoms of post-COVID as difficulty in breathing during the activity of daily living, excessive dyspnea, excessive cough and sputum production, altered sputum color and/or viscosity. The participants excluded from the study, Smoker patients, Heart failure, neurological diseases affecting respiratory muscles or any muscular dystrophy and Hemodynamic instability (heart rate >150 beat/pm, or blood pressure < 90/60 mmHg or >140/90 mmHg) is present.

Ethical considerations

1. The faculty ethical committee approval no: **P.T.REC/012/003309.**
2. Before participation, aims of the study, nature, also procedure was explained to all subjects enrolled in the study, and confidentiality was assured.

3. Each participant signed an informed consent form before the trial began.

Randomization

All statistical analyses were executed using SPSS version 25 for Windows, the statistical package for social studies. Each participant was assigned a unique identification number. These numbers were divided into two equal groups (n=30).

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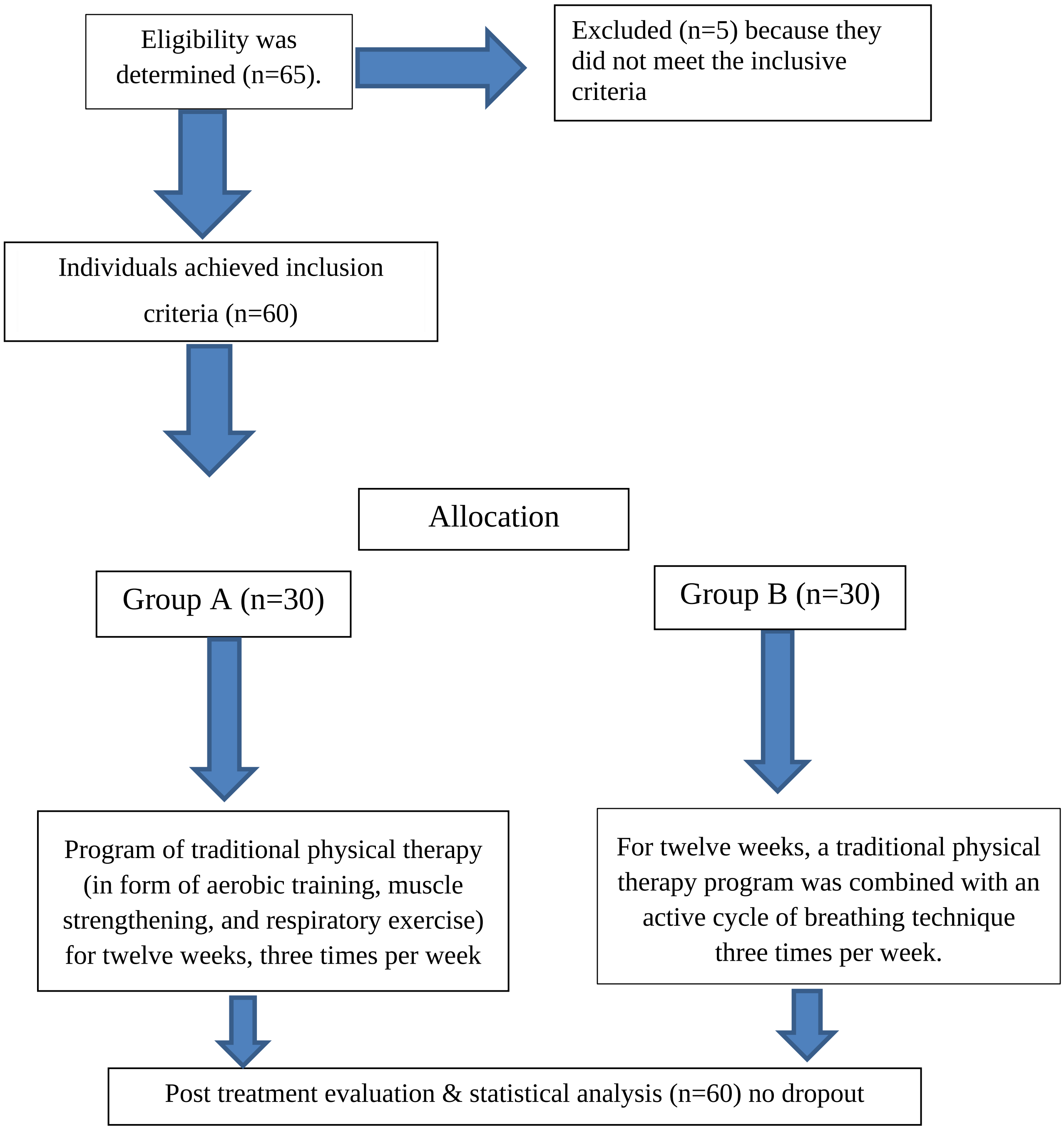

Figure 1: Flow chart of the study

Intervention

Group A obtained a traditional physiotherapy program for the chest that included aerobic exercise, muscle strengthening, and respiratory exercise. In contrast, Group B received an active cycle of breathing technique in addition to the traditional physiotherapy program. For the next 12 weeks, both groups received three sessions per week.

Active Cycle of Breathing Technique (ACBT)

It points to a breathing control cycle that includes Thoracic expansion exercises TEEs and forced expiration technique FET. It's useful with or without assistance in post-COVID-19 patients to clear excess bronchial secretions. The patient should begin by controlling their breathing for 20-30 seconds. TEE is then practiced 3-4 times by the patient. TEEs, as well as increasing lung volume, help to clear excess bronchial secretions. After this, the patient can breathe normally again for 20–30 seconds or 6 breaths. The patient will complete the FET. This can be done by taking a medium-sized breath and huffing for a long time or a big breath and huffing for a short time, based on whether the secretions are located at the distal or proximal ends of the airway. It is recommended that the cycle be performed 2 to 3 times [9]

Aerobic exercise

All participants were required to complete twenty minutes of aerobic exercise on a treadmill three times per week under the supervision of a physiotherapist. Heart rate, oxygen saturation, also perceived level of exertion (Borg scale of 6-20) have been measured for each exercise session. Patients with post-COVID-19 should feel "fairly light" during warming-up and cooling-down periods and "somewhat hard" during the main time of the exercise session. Participants received a total of 36 aerobic training sessions. The participants' maximum heart rate is calculated by subtracting their age from 220, served as a measurement of the intensity of the exercises **(ALAWNA et al., 2021).**
On the 1st day, we did 20 minutes of aerobic training (5-minute warming-up, 10-min training, as well as 5 min of cooling-down session). The duration of the aerobic exercises was gradually increased each day based on participants' tolerability [10]**.**

Strengthening exercises

Active limb exercises have been done, followed by progressive muscle strengthening. It will target large muscle groups and was done with weight machines, free weights, also elastic bands. Low-intensity (30-40% of 1RM) to high-intensity (80% of 1RM) exercises were indicated on the Borg scale 11-13. 1RM refers to the maximum amount of weight anyone can lift in one repetition. The duration of the strengthening exercise was 3 sets of 8–12→15 repetitions with one minute of resting among sets 10→45 min for each session 1-3 times/ week. The main group muscles include: Shoulder flexors and extensors, Shoulder abductors, Elbow flexors and extensors, Hip flexors, Knee flexors and knee extensors [11]

Diaphragmatic breathing exercise

The patient was lying supine on a flat surface (or in bed) with their knees bent and a pillow under his head and knees for support if that was more comfortable. One hand was placed on the patient's upper chest while the other on his abdomen, just beneath the rib cage. The patient is directed to take slow, deep breaths through his nose towards his lower belly. His chest hand should remain still, while his abdomen hand should rise. The patient is therefore instructed to exhale slowly via his nose. Ten times repetition for each exercise was done and 20 seconds of relaxation in between (3 times/week for 12 weeks) [12]**.**

Pursed-lip abdominal breathing exercise

The patient was sitting against an armchair's back, with his arms resting on the chair's armrests or his thighs. The patient closed his mouth and breathed in through his nose for a few seconds before gently exhaling through tightly pursed lips for 4-6 seconds. The patient formed a large, thin slit with his lips, which delayed his expiration and increased the pressure inside his mouth. In general, the duration of an exhale was double or triple that of an inhale. Breathing from the diaphragm instead of the chest might slow your heart rate and help your blood oxygen levels. You should perform the exercises 3 to 4 times daily for no more than three minutes each time **(Besnier et al., 2022).**

Outcome measurements

Evaluating arterial blood gases

Hyperventilation, which causes a loss of carbon dioxide, is a common response to hypoxic stimulation in pulmonary diseases. Some patients may not have had severe hypoxemia to begin with, however, if respiratory alkalosis sets in, they may experience hyperventilation as a form of compensation, leading to a rapid decline in health. Even though hypoxemia has not been proven in COVID-19 patients who have respiratory alkalosis, they definitely need to be closely monitored [14]

Six-minute walk test

Every individual was closely monitored and evaluated on an individual basis. The 6MWT was run on a 121-meter indoor circular track with a hardened, level surface. Individuals were asked to cover as much ground as feasible in six minutes without jogging. In addition to being provided with comfortable footwear and clothing, they were also given the freedom to stop whenever they felt the need to [15].

Fatigue level assessment (FAS)

The Fatigue Assessment Scale (FAS) has been utilized for the evaluation of fatigue in a wide range of chronic medical conditions including sarcoidosis, systemic lupus erythematosus (SLE), end-stage renal disease (ESRD), as well as post-COVID. This fatigue evaluation scale is a standardized tool. It has ten questions, and each one is scored out of 5. The scale of 1 (never) to 5 (always) Likert-type questions. A total score of 10 on the FAS indicates minimal fatigue, while a score of 50 indicates extreme fatigue [16].

Statistical analysis

An unpaired t-test was conducted to compare the ages of the groups. The chi-squared test was utilized to examine differences in the ratio of males to females across sample sizes. In order to make sure the data have a normal distribution, the Shapiro-Wilk test was performed. Levene's test for variance homogeneity was utilized to analyze the degree of similarity between groups. The effects of the intervention on measures of fatigue level, 6MWT, SaO2, PaO2, as were investigated using a mixed (MANOVA). Additional pairwise testing was performed using post hoc tests with the Bonferroni correction. The Mann-Whitney U test was utilized to compare the modified dyspnea scale among groups, and the Wilcoxon Signed Ranks Test was utilized to compare before and after treatment in each group. All statistical tests were conducted with a p-value of 0.05 as the threshold for significance. All statistical analyses were performed utilizing SPSS for Windows version 25 (*IBM SPSS, Chicago, IL, USA*).

Results

Subject characteristics

In **Table 1** we compared the characteristics of the subjects in groups A and B. There was no statistically substantial difference between groups concerning the distribution of ages and sex ($p > 0.05$).

Table (1) Comparison of subject characteristics between groups A and B

	Group A	Group B	p-value
	Mean ±SD	Mean ±SD	
Age (years)	45.63 ± 2.47	45.7 ± 2.33	0.91
Sex, N (%)			
Females	18 (60%)	17 (57%)	0.19
Males	12 (40%)	13 (43%)	

SD, Standard deviation; p-value, the Probability value

Effect of treatment on 6MWT, SaO2, PaO2, PaCO2 and fatigue level

A significant interaction between treatment and time was statistically substantial (F = 78.04, p 0.001). The main effect of treatment was statistically substantial (F = 25.41, p = 0.001). The main effect time was statistically substantial (F = 500.18, p = 0.001).

Within group comparison

Both groups reported significantly lower fatigue after treatment than before treatment (p 0.001). Group A demonstrated a 34.92% decline, whereas group B demonstrated a 61.05% decline in fatigue **(Table 2).**

In both groups, after treatment values for 6MWT were significantly higher than before treatment values (p > 0.001). Group A demonstrated an improvement of 11.09 % in 6MWT, whereas Group B demonstrated an increase of 21.61% **(Table 3).**

After treatment SaO2 and PaO2 were significantly higher in both groups compared to before treatment values, while PaCO2 were significantly lower in both groups (p > 0.001). Group A demonstrated a 2.75 increase in SaO2, 3.5 percent increase in PaO2, 4.35 percent decrease in PaCO2 while Group B demonstrated a 6.43 percent increase in SaO2, 12.41 percent increase in PaO2, 10.75 percent decrease in PaCO2 **(Table 3).**

Between groups' comparison

Before treatment, there was no significant difference between groups (p > 0.05). After-treatment comparison of groups revealed that group B had a significantly lower fatigue level, PaCO2 than group A (p < 0.001). There was a substantial rise in 6MWT, SaO2 and PaO2 of group B as compared to that of group after-treatment (p < 0.001) **(Tables 2-3).**

Table (2) Mean fatigue level and 6MWT before and after-treatment of groups A and B:

	Pre-treatment	Post-treatment	MD	% of change	p-value
	Mean ±SD	Mean ±SD			
Fatigue level					
Group A	39.06 ± 3.11	25.03 ± 2.39	14.03	35.92	0.001
Group B	38.66 ± 2.46	15.06 ± 2.34	23.6	61.05	0.001
MD	0.4	9.97			
p-value	***p = 0.58***	***p = 0.001***			
6MWT (m)					
Group A	478 ± 22.76	531.03 ± 24.89	-53.03	11.09	0.001
Group B	487.03 ± 21.02	592.3 ± 29.92	-105.27	21.61	0.001
MD	-9.03	-61.27			
p-value	***p = 0.11***	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; p-value, the Probability value

Table (3) Mean SaO2, PaO2 and PaCO2 before and after-treatment of groups A and B

	Pre-treatment	Post-treatment	MD	% of change	p-value
	Mean ±SD	Mean ±SD			
SaO2 (%)					
Group A	88.86 ± 1.85	91.26 ± 1.43	-2.4	2.70	0.001
Group B	88.6 ± 1.75	94.3 ± 1.64	-5.7	6.43	0.001
MD	0.26	-3.04			
p-value	***p = 0.56***	***p = 0.001***			
PaO2 (mmHg)					
Group A	74.82 ± 6.3	77.44 ± 6.17	-2.62	3.50	0.001
Group B	74.52 ± 6.05	83.77 ± 5.91	-9.25	12.41	0.001
MD	0.3	-6.33			
p-value	***p = 0.85***	***p = 0.001***			
PaCO2 (mmHg)					
Group A	37.66 ± 2.58	36.02 ± 2.21	1.64	4.35	0.001
Group B	36.76 ± 2.04	32.81 ± 2.26	3.95	10.75	0.001
MD	0.9	3.21			

p-value	*p = 0.14*	*p = 0.001*	

SD, Standard deviation; MD, Mean difference; p-value, the Probability value

Discussion

Symptoms of post-acute COVID-19 syndrome range from those of post-ICU syndrome to those of pulmonary fibrosis due to severe COVID-19 pneumonia. Among the most concerning forms of PASC, however, is PACS (also recognized as extended COVID). Symptoms often begin 4 weeks following infection and continue for months. Respiratory rehabilitation seeks to help people with respiratory conditions reclaim as much independence as possible in their everyday lives. Exercise training can enhance exercise tolerance, functional ability, and quality of life while reducing dyspnea. This study aimed to evaluate the impact of the active cycle of breathing technique on specific pulmonary outcomes in patients with post- COVID 19 syndrome.

This study's findings showed no substantial difference in all parameters among the two groups prior to treatment ($p > 0.05$).

Additionally, a cross-sectional investigation found similar outcomes in which patients underwent a physical therapy treatment plan consisting of 12 sessions carried out over four weeks. Patients' post-COVID health was evaluated using medical exams, in-depth interviews, the Depression, Anxiety, also Stress Scale - 21 Items (DASS-21), spirometry, a 6-minute walk test, and hand dynamometry before as well as after the sessions. In the end, 42 people were a part of the program. The results of this investigation demonstrated that patients' psycho-emotional state and the severity of their symptoms improved after treatment for COVID-19. They also found that FEV1 and FVC had improved by 7.16 and 7.56 percent, respectively. The maximal oxygen uptake (SpO2) increased by 1.40 percentage points, the 6-minute walk test score increased by 13.0 percentage points, and the maximal functional capacity increased by 0.577 METs.[17]

The results of a previous study **(Zhu et al., 2021)** that split 123 patients with COVID-19 in half based on whether or not they had had pulmonary rehabilitation are consistent with the current study (PR group or Control group). Discharge measurements included six-minute walk distance (6MW), heart rate (HR), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), diffusing capacity of the lung for carbon monoxide (DLCO), as well as computed tomography (CT) scan. Follow-up measurements were taken at 1, 4, 12, and 24 weeks. Pulmonary function not significantly different between the PR and Control groups after the first week. Both groups showed substantial improvement in 6MW, HR, FVC, FEV1, and DLCO after 4 and 12 weeks. But the PR group has gotten better than the Control group.[18]

These findings corroborate those of **Giansanti**, who found that after 6-9 weeks of pulmonary rehabilitation, there was a substantial improvement in 6MWD, showing an improvement in exercise capacity. While pulmonary rehabilitation has many aspects, exercise training is essential; the success of pulmonary rehabilitation influenced by the type, level, frequency, also setting of exercise training; moderate exercise training improves physical and mental health and quality of life, of patients with COVID-19 [19]

Maki et al. shown a 78% increase in muscle strength, endurance by 92%, as well as muscle mass improved by 88% among 2504 individuals with COPD who received an exercise intervention. Improvements in the respiratory capacity, gas exchange, cardiovascular health, and limb muscle function are at the heart of exercise training's beneficial effects on COPD rehabilitation. Our results suggest that exercise training can substantially increase exercise capacity in individuals with COVID-19. [20]

According to a recent study, one hundred patients suffering from post-discharge symptoms due to COVID-19 will be randomized evenly between a group getting regular care (control group) another group that did a multi-component exercise program twice weekly for six weeks. The primary hypothesis is that COVID-19 patients' immunological, inflammatory profile, physical state, as well as persisting reported symptoms (fatigue/tiredness, musculoskeletal pain, and dyspnea) will all improve after taking part in a 6-week multicomponent exercise program [21]

Limitations

Despite areas of strength, the current study's weakness is that little research has been done on the active cycle of breathing techniques, particularly on different age levels.

Recommendations

1. More research is required to decide how effective it is in cases post-COVID.
2. Awareness campaigns to raise awareness of the importance of exercise training as the main part of pulmonary rehabilitation.

Conclusion

Subjects of both groups showed improvement in all measured variables (functional aerobic capacity by six-minute walk test, ABG test, and fatigue level) in favor of group B.

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