Effect of Aerobic Exercises versus Incentive Spirometer Device on post-covid Pulmonary Fibrosis Patients.

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ABSTRACT

Background: *The COVID-19 virus outbreak severely harmed the survivors' quality of life and their cardiopulmonary system.* ***Purpose:*** *Evaluate Aerobic Exercises Versus Incentive-Spirometery in treating post-COVID pulmonary fibrosis.* ***Subjects and Methods:*** *45 patients had post-COVID respiratory complications aged between 40-80 years old and were randomly divided into 3 groups, study groups (A,B) and control group (C). Each group had 15 patients all received traditional chest physiotherapy (Breathing Exercises, Postural Drainage, Percussion, Coughing, and Vibration) 5 times/week for 2 months. Group (A) received aerobic exercises, Group (B) received incentive spirometer training, and Group (C) received only traditional chest physiotherapy. Results: showed high significant increases in six-minute walk and lung function tests while significant decreases in heart rates of the group (A) compared with that of (B) and (C) (p <0.05). There were significant increases in forced vital capacity and forced expiratory volume in the first second and six-minute walk distance tests and a significant decrease in the maximum heart rate of group (B) compared with that of (C) (p <0.05) while no significant difference in peak expiratory flow and resting heart rate between group (B) and (C) post-treatment (p >0.05).* ***Conclusion:*** *The application of both aerobic exercises and incentive-spirometer therapy with traditional chest physiotherapy had a valuable effect in the treatment of post-COVID pulmonary fibrosis. However aerobic exercises had the greatest positive effect.*

Keywords: *Aerobic exercises; Incentive spirometer device; Post-COVID pulmonary fibrosis; Lung function tests).*

INTRODUCTION

The severe acute respiratory syndrome-coronavirus-2, or SARS-CoV-2, has caused a global health crisis that has tested the ability of governments' public health policies and healthcare systems. Despite this, the COVID-19 pandemic has claimed over 12 million lives and resulted in over 550,000 confirmed cases of infection, even though wearing masks and implementing social distancing measures has slowed the virus's spread in many regions of the world. [1] Nevertheless, a large number of individuals who survive the acute phase of the illness experience what is known as post-COVID-19 syndrome (PCS), which is characterized by the persistence of symptoms and indications following an acute COVID-19 infection for more than four weeks.[2]

The number of patients who are recovering is growing, therefore it's important to learn about respiratory complications that may appear four weeks or more after the initial recovery. Since the pulmonary effects of COVID-19 are still poorly known, information in this area can assist us in identifying the risk categories that require careful monitoring. Since pulmonary fibrosis is linked to architectural distortion of the lung parenchyma and general degradation of lung function, which lowers quality of life, it is regarded as one of the major issues surrounding COVID-19 pulmonary sequelae. [3] As a result, exercise training is recognized as the cornerstone of a comprehensive pulmonary rehabilitation program, and pulmonary rehabilitation (PR) is thought to be essential for the recovery of patients with viral pneumonia from COVID-19 in both the acute and rehabilitative stages.[4]

Enhancing one's aerobic capacity has the potential to both prevent and treat respiratory infections and illnesses. It can be used to prevent or treat COVID-19-related common illnesses that cause respiratory system failure, such as pneumonia [3] and acute respiratory distress syndrome (ARDS) [3]. Four mechanisms can be used to characterize the impact of raising aerobic capacity on enhancing lung functioning and reducing lung damage. Increasing aerobic capacity plays a role in improving lung and body immunity, as does prophylactic use of antibiotics and antimycotics.[5]

The second process involves the restoration of normal lung tissue elasticity through an increase in aerobic capacity, as well as the strengthening and endurance of respiratory muscles. These factors contribute to improved ventilation, improved lung mechanics, and a reduction in lung damage. [7]The third pathway involves enhancing aerobic capacity as an antioxidant to reduce the generation of free radicals and oxidative damage. [8]

By enhancing lung immunity and causing autonomic modulation, the fourth mechanism involves raising the aerobic capacity to lessen coughing and clear respiratory airways. [9] Enhancing one's aerobic capacity has a greater impact on immunity and pulmonary functions than breathing exercises, and it can also improve the cough mechanism. [7]

Wu et al., 2020 proved that age, hypertension, diabetes, and heart issues are risk factors associated with the occurrence of COVID-19 and its progression to mortality. Increased aerobic capacity has been demonstrated to benefit all of these risk factors either immediately or quickly in the past. [10]

Additionally, both targets can analyze their performance and practice deep, prolonged breaths by utilizing an incentive spirometer (IS), a tool that provides visual and/or aural feedback to encourage the achievement of maximum sustained inspirations. In situations where lung ventilation is compromised or at risk, it is frequently utilized in clinical practice to improve alveolar ventilation and functional residual capacity. [11] Thus, the goal of this study was to evaluate the efficacy of incentive-spirometer therapy and aerobic exercise in the treatment of post-COVID pulmonary fibrosis.

MATERIALS AND METHODS

Study design:

A randomized controlled clinical trial with a pre-test-post-test approach was used for the study.

Participants:

Forty-five patients (23 males and 22 females) who had post-COVID syndrome and complained of respiratory complications at age ranging from 40-80 years old participated in this study. They were recruited from the pulmonary out-clinic and internal wards and departments of the Police Academy Hospital. Three equal groups were created by random selection: two study groups (A and B) and a control group (C).

Group A: Patients received aerobic exercise techniques and traditional chest physiotherapy. Group B: Patients received incentive spirometer training techniques and traditional chest physiotherapy. Group C: Patients received traditional chest physiotherapy only. Measurements were taken as a preliminary record before the start of the therapy and as an outcome record after it was completed.

Measurement Procedures:

the use of a pulse oximeter to evaluate blood oxygen saturation (SPO2), measurement of resting and maximum heart rates, measurement of lung function tests (PFTS) e.g.: forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), peak expiratory flow (PEF) by using Spirometer and 6-minute walk distance test (6 MWDT).

Treatment Procedures:

The Aerobic exercises for the study group (A):

Patients were asked to follow instructions. Measurement procedures were applied for each patient as they were mentioned. Place the patient in a suitable position for every exercise. Each session includes using several exercises assigned for the subject according to his\her level of endurance from 3 levels. Exercises were applied once daily, five times per week for 2 consecutive months.

Level 1 Exercises: Ankle pumps, Heel slides, side lying leg raises, prone lying, Arm raises, shoulder blade squeeze and sit to stand.

Level 2 Exercises: Ankle Pumps, Long Arc Quad, Seated Marching, Arm Raises, Trunk Rotation, Sit to Stand and Standing Marching.

Level 3 Exercises: Standing Marching, Shoulder Blade Squeezes, Heel Raises, Arm Raises, Wall Push-up, Side leg Kick-Out, Sit to Stand and Walking.

The Incentive spirometer training for the study group (B):

Good explanation about the physical therapy assessment and treatment program and what would be done, and the spirometer will be cleaned with alcohol then the Patient’s position would be comfortable supine, half supine, sitting position with head support, or stand. The patient is encouraged to take slow, deliberate breaths through the mouthpiece. The patient is encouraged to achieve a certain volume, which can vary depending on the patient's height and age. The individual gets visual feedback from the piston's movement rising to the preset marker. The patient is directed to hold his breath for at least two or three seconds at a minimum at full inspiration. The patient should stand comfortably, maintain good posture, and support the incentive spirometer in the correct, upright position. After ten inhalations, slowly and quietly exhale while opening your lips to let go of the mouthpiece. Coughing should be encouraged to help further cleanse the lungs of mucus. This technique was repeated five times per week for two consecutive months. [12]

Traditional chest physical therapy:

Application of the old physiotherapy techniques of chest rehabilitation such as Breathing Exercises, Postural Drainage, Percussion, Coughing, and Vibration.

Data Analysis:

The MANOVA test was used to evaluate subject characteristics between groups. The chi-squared test was used to compare the distribution of genders among the groups. The data was tested for normal distribution utilizing the Shapiro-Wilk test. To evaluate the homogeneity between groups, Levene's test evaluating homogenization of variances was used. The effects of the groups on FVC, FEV1, PEF, resting heart rate (RHR), maximal heart rate (MHR), and 6MWT were compared within and across groups using mixed MANOVA. The Bonferroni correction was used in post-hoc tests for the ensuing multiple comparisons. All statistical tests were conducted with a significance level of $p < 0.05$. The statistical package for social studies (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA) was used for all statistical analysis.

Ethical Approval

The study was submitted to registration on clinical trials with ID (NCT06191367) and authorized by the Research Ethics Board of the Faculty of Physiotherapy at Cairo University (approval no.: P.T.REC/012/004811).

Additionally, before any of these procedures started, the patients received information regarding the stages involved in the exercises as well as the protocols for measurement and treatment. Before being involved in this study, all subjects gave their informed consent.

RESULTS

(Table 1) provides an explanation of the general features of each group's members following their respective groups.

Table 1: Basic characteristics of participants

	Group A	Group B	Group C	p-value	Sig
	Mean ± SD	Mean ± SD	Mean ± SD		
Age (years)	56.60 ± 7.47	58.13 ± 9.53	58.46 ± 9.42	0.18	NS
Weight (kg)	77.06 ± 9.36	80.06 ± 10.82	80.20 ± 9.40	0.48	NS
Height (cm)	165.53 ± 6.65	163.73 ± 5.40	162.66 ± 8.85	0.62	NS
BMI (kg/m²)	28.12 ± 2.92	29.88 ± 3.99	30.51 ± 4.65	0.48	NS
Sex, n (%)					
Females	7 (47%)	8 (53%)	7 (47%)	0.91	
Males	8 (53%)	7 (47%)	8 (53%)		NS

(SD) standard deviation, (p-value) level of significance

<u>Effect of treatment on FVC, FEV1, PEF, RHR, MHR and 6MWT:</u>

A substantial connection between treatment and time was found using mixed MANOVA (F = 29.32, p = 0.001, Partial Eta Squared = 0.82). The main effect of time was significant (F = 272.45, p = 0.001, Partial Eta Squared = 0.97). The main effect of the treatment was significant (F = 3.63, p = 0.04, Partial Eta Squared = 0.23). In comparison to pre-treatment, there was a substantial increase ($p < 0.05$) in FVC, FEV1, and PEF in all three groups after therapy. (Refer to Table 2)

Table 2 : the groups A, B, and C's mean FVC, FEV1, and PEF before and after treatment:

	Group A	Group B	Group C	p-value		
	mean ± SD	mean ± SD	mean ± SD	A vs B	A vs C	B vs C
FVC (L)						
Pre-treatment	2.22 ± 0.31	2.24 ± 0.38	2.27 ± 0.35	0.97	0.91	0.97
Post-treatment	3.24 ± 0.35	2.84 ± 0.42	2.45 ± 0.39	0.02	0.001	0.02
MD (% of change)	-1.02 (45.95%)	-0.6 (26.79%)	-0.18 (7.93%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
FEV1 (L)						

Pre-treatment	1.93 ± 0.26	1.97 ± 0.33	1.98 ± 0.28	0.93	0.90	0.99
Post-treatment	2.77 ± 0.30	2.46 ± 0.31	2.13 ± 0.35	0.02	0.001	0.02
MD (% of change)	-0.84 (43.52%)	-0.49 (24.87%)	-0.15 (7.58%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
PEF (L/s)						
Pre-treatment	5.21± 0.39	5.15 ± 0.72	5.12 ± 0.67	0.96	0.90	0.98
Post-treatment	6.57 ± 1.05	5.63 ± 0.89	5.45 ± 0.72	0.01	0.004	0.86
MD (% of change)	-1.36 (26.1%)	-0.48 (9.32%)	-0.33 (6.45%)			
	p = 0.001	***p = 0.002***	***p = 0.02***			

(SD) Standard deviation, (MD) Mean difference, (p-value) Level of significance

There was a significant decrease in RHR and MHR and a significant increase in 6MWD in the three groups post-treatment compared with pre-treatment ($p < 0.05$). (Table 3)

Prior to therapy, there was no discernible difference between the groups ($p > 0.05$). When comparing group A's RHR and MHR to those of groups B and C, there was a substantial drop ($p < 0.05$) and a significant rise ($p < 0.05$) in FVC, FEV1, PEF, and 6MWD. After therapy, there was no statistically significant distinction in PEF and RHR between groups B and C ($p > 0.05$), but there was a substantial rise in FVC, FEV1, and 6MWD as well as a significant drop in MHR ($p < 0.05$) between the two groups.

Table 3: the groups A, B, and C's mean RHR, MHR, and 6MWD before and after therapy:

	Group A	Group B	Group C	p-value		
	mean ± SD	mean ± SD	mean ± SD	A vs B	A vs C	B vs C
RHR (beats/min)						
Pre-treatment	74.93 ± 6.13	74.27 ± 3.88	75.53 ± 4.15	0.92	0.93	0.75
Post-treatment	68.87 ± 4.95	72.87 ± 3.42	73.93 ± 4.22	0.03	0.006	0.77
MD (% of change)	6.06 (8.09%)	1.4 (1.89%)	1.6 (2.12%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			
MHR (beats/min)						

Pre-treatment	145.86 ± 3.97	146.46 ± 4.24	144.13 ± 5.05	0.92	0.54	0.33
Post-treatment	130.86 ± 4.85	136 ± 3.70	140.86 ± 4.96	0.01	0.001	0.01
MD (% of change)	15 (10.28%)	10.46 (7.14%)	3.27 (2.27%)			
	p = 0.001	***p = 0.001***	***p = 0.03***			
6MWD (m)						
Pre-treatment	358.60 ± 40.12	360.33 ± 54.68	352.20 ± 61.13	0.99	0.94	0.91
Post-treatment	467.80 ± 44.56	416.20 ± 51.36	368.93 ± 55.29	0.02	0.001	0.03
MD (% of change)	-109.2 (30.45%)	-55.87 (15.51%)	-16.73 (4.75%)			
	p = 0.001	***p = 0.001***	***p = 0.001***			

(SD) Standard deviation, (MD) Mean difference, (p-value) Level of significance

DISCUSSION

The study's findings demonstrated that aerobic exercises, incentive spirometer, and traditional chest physiotherapy had a positive effect on improving the lung fibrosis parameters in all three groups in favor of group A which had aerobic exercise with traditional chest physiotherapy. This can be explained by the physiological effects of the aerobic exercises that placed a loading demand upon the cardio-pulmonary systems.

Aerobic exercises and incentive spirometer were designed to increase aerobic capacity, improve lung functions and prevent lung damage via improving lung and overall immunity through the role of boosting aerobic capacity as an antibiotic and antimycotic prophylactic. [13] and the function of regaining the natural suppleness of lung tissue as well as the strength and endurance of respiratory muscles, all of which contribute to improving ventilation, lung mechanics, and minimizing lung damage. [14] Moreover, boosting aerobic capacity has the antioxidant effect of reducing the generation of free radicals and oxidative damage. [15] Finally, the function of enhancing lung immunity and generating an autonomic modulation in reducing cough and cleaning respiratory airways. [16]

For people with chronic respiratory diseases, endurance exercise training is recommended three to five times a week. Maximizing physiologic advantages involves engaging in high-intensity continuous exercise (>60% maximal work rate) for 20 to 60 minutes per session (i.e., exercise tolerance, muscular function, and bioenergetics). Target training intensity is commonly defined as a Borg dyspnea or fatigue score of 4 to 6 (moderate to [very] severe) or a Rating of Perceived Exertion of 12 to 14 (very hard). [17]

The COVID-19 pandemic's aftermath had a significant negative influence on public health overall, with long-term repercussions that lower the physical capacity and general well-being of COVID-19 survivors. Within this framework, pulmonary rehabilitation —in all of its forms— plays a pivotal role by facilitating a progressive restoration of lung elasticity and ideal breathing flow, improving alveolar ventilation, and raising oxygenation levels. It has been shown that combining aerobic, respiratory, fitness, and strength training with neuropsychological considerations is a good way to improve health, well-being, and quality of life in post-acute COVID-19 patients. Additionally, it has improved fatigue and inhalation muscles strength, enhanced exercise capacity, and reduced anxiety and depression, all of which are common factors that can have a significant impact on patients' compliance—the latter of which is essential to the effective execution of a rehabilitation program. To restore total function and enhance the quality of life, it is therefore advised to expand the implementation of comprehensive and personalized rehabilitation protocols for COVID-19 patients, of which a significant portion is allocated to respiratory rehabilitation. [18]

Patients with post-COVID-19 demonstrated a promising good response to pulmonary rehabilitation. Exercise ability, dyspnea perception, depression symptoms, and patient information necessary for lung disease management were all improved. Post-COVID-19 patients should think about pulmonary rehabilitation. [19]

The goal of a systematic review is to compile data regarding fitness training for PF patients to enhance their ability to exercise, quality of life, and respiration. 13 randomized controlled trials out of 1468 publications were chosen for this analysis. A total of 456 PF patients were included in the study. In the exercise group, there was no significant change in quality of life or predicted lung diffusing capacity for carbon monoxide, but there was a significant increase in the 6-minute walking distance, predicted forced vital capacity, predicted forced expiratory volume at 1 second, and maximal rate of oxygen consumption when compared to usual care in the control group. The study found that individuals suffering from pulmonary fibrosis (PF) can greatly increase their capacity for exercise, lung function, and cardiovascular endurance with exercise training but doesn't affect the quality of life. Exercise training is an effective rehabilitation strategy for (PF). [20]

According to another study, people with idiopathic pulmonary fibrosis (IPF) may benefit from pulmonary rehabilitation (PR) in terms of their quality of life and ability to exercise. Furthermore, PR may help individuals with IPF delay the deterioration of their lung function. [21]

The use of chest physical therapy programs significantly improved patients' lung capacity, gas diffusion, and quality of life in those with idiopathic pulmonary fibrosis, according to the findings of a comprehensive analysis. Applying chest physiotherapy programs resulted in a significant increase in pulmonary function, activity capacity, and quality of life, according to the meta-analysis. Analyzing the inclusion of chest physical therapy in pulmonary rehabilitation requires taking into account both the modality of the chest physical therapy and any potential physiological effects. In this vein, additional research on instrumental breathing techniques is necessary to evaluate the findings. [22]

As to patients with chronic obstructive pulmonary disease (COPD), PR is a crucial component of interstitial lung disease (ILD) patients' overall therapy. In spite of evidence supporting PR's benefits in ILD, this field is still developing. Key concerns that still need to be resolved are how to best tailor PR to the unique needs of individuals with ILD and how to prolong the benefit's duration. [23]

The most often used exercise technique in pulmonary rehabilitation is endurance exercise training, such as walking or cycling. Pulmonary rehabilitation can make use of the framework suggested by the American College of Sports Medicine (ACSM) Guidelines for Exercise Testing and Prescription on Frequency, Intensity, Time, and Type (FITT). [24]

In COVID-19 survivors, incentive spirometry exercises significantly raise peak expiratory flow values; therefore, they may be a viable alternative therapy for improving lung function. A secure medical tool called incentive spirometry offers visual feedback that may inspire and boost exercise compliance. [25]

There is a rarity of studies evaluating the effect of incentive spirometer as a therapeutic technique on patients with pulmonary fibrosis as a result of post-COVID syndrome. Generally, the results regarding the effectiveness of the incentive spirometer therapy are different in several studies.

Since pulmonary problems are the primary causes of morbidity and mortality, the medical community as a whole needs to give them special attention. To minimize or avoid postoperative pulmonary problems and to exercise the lungs, the incentive spirometer is a simple tool for inspiratory muscle training in pulmonary rehabilitation. When it comes to diagnosing, treating, and overseeing the care of patients who should get pulmonary rehabilitation, the inter-professional team plays a crucial role. [26]

A strong correlation was seen between the implementation of incentive spirometry and a lower mortality rate among 326 adult COVID-19 hospitalized patients. 37 patients had been treated with IS at least ten times per hour while they were awake, out of the 326 inpatient contacts that were found. With a Z-score of -2.017, the analysis's p-value is 0.02. There is statistical evidence that IS lowers the death rate of COVID-19 patients at a significance level of 0.05, based on the p-value of 0.02. The mortality risk is approximately 1.6 times higher for individuals with confirmed COVID-19 who did not receive IS. [27]

However, considering the benefits of PR, efforts ought to be taken to guarantee that it is extensively accessible throughout the range of ILD. To increase adherence rates, it would be crucial for facilitators to incorporate tactics for raising the caliber of information provided to patients and educating medical personnel about the significance and advantages of PR.

Finally, it could be concluded that the application of both the Aerobic Exercises (AE) and Incentive Spirometer Therapy (IST) had valuable effects in the treatment of post-COVID pulmonary fibrosis. The study's findings confirm the hypothesis that incentive spirometer therapy (IST) and aerobic exercises (AE) are both useful interventions for post-COVID lung fibrosis. However, the Incentive Spirometer Therapy (IST) proved less helpful than the Aerobic Exercises (AE).

CONCLUSION

The application of both aerobic exercises and incentive spirometer therapy had a valuable effect in the treatment of post-COVID pulmonary fibrosis. However aerobic exercises had the greatest positive effect. On the other hand, the use of traditional chest physiotherapy alone has proven to be of little effect in the treatment of post-COVID lung fibrosis. So, the best results are seen by using a combination of all aforementioned methods.

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