Effects of a Diaphragmatic Stretching on Pulmonary Function, Exercise Tolerance, and Quality of Life in COVID-19 Survivors

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ABSTRACT
Coronavirus causes pneumonia and acute respiratory distress syndrome that leads to respiratory failure because of this covid patients require mechanical ventilation. The principal muscle used in inspiration is the diaphragm, which appears to be more affected by extended mechanical ventilation. Diaphragm inactivity during mechanical ventilation is the grave cause of diaphragm weakness

Objective: This study aimed to explore the effects of diaphragm stretching on pulmonary function, exercise tolerance, and quality of life in Covid survivors.

Methodology: In a single-blinded, quasi-experimental study, 59 subjects who recovered from Covid aged 35–60 were included. Spirometry, a 6-minute walk test, and a Shortform-8 questionnaire were used as outcome measures for pulmonary function, exercise tolerance, and quality of life. Participants received 18 treatments for three sessions for a total 6-week period. Outcome measures were taken following the first treatment session (Pre-1 and Post-1), after the ninth treatment session (Pre 9th and Post 9th), and after the 18th treatment session (Pre 18th and Post 18th). Data were analyzed by SPSS version 23.

Results: The result showed improvement in FVC, FEV1, and FEV1/FVC ratio with a significant p-value of 0.000 after diaphragmatic stretching in Covid survivors. Borg-scale mean with a significant p-value of 0.00, 6MWD mean with a significant p-value of 0.001, and SF-8 (MCS and PCS) mean with a significant p-value of 0.002 showed that diaphragmatic stretching improved pulmonary function, exercise tolerance and quality of life of covid survivors.

Conclusion: It concluded that diaphragmatic stretching helped in improving pulmonary function, exercise tolerance, and quality of life in Covid survivors.

Indexed Terms- Coronavirus, stretching technique, respiratory function, exercise capacity, quality of life

I. INTRODUCTION

Coronaviridae, viruses are enclosed, single-stranded, positive-sense RNA viruses that mainly cause respiratory illnesses in humans. In December 2019, Wuhan, Hubei Province, China, reported an ongoing pneumonia outbreak attributed to a new coronavirus, causing severe acute respiratory syndrome (SARS). Infections spread throughout China and other nations in the following weeks. The World Health Organization (WHO) labeled the epidemic a Public Health Emergency of International Concern on 30th January 2020.(1) In 2020, on February 26th, the virus was confirmed to have arrived in Pakistan, and two cases were reported (one case was reported by a student in Karachi who had just come back from Iran and the other was reported in the territory of Islamabad).(2) In Pakistan, 1,537,947 confirmed cases of COVID-19 with 30,401 mortalities have been reported to WHO until the 4th of July, 2022.(3) Studies also revealed that coronavirus-infected patients were more probable to be admitted to the intensive care unit (ICU), with rates ranging from 3 to 100% of established cases. The rate of mortality among critical care patients with coronavirus infection was also very high, and it went from 6 percent to 86 percent of admitted patients.(4)

The most severe pulmonary consequence, acute respiratory distress syndrome (ARDS), has a substantial fatality rate. In the patients with SARS or COVID-19, Diffuse alveolar damage (DAD) was the most communal histological finding. Acute respiratory failure causes worsening of abnormal gaseous exchange, inspiratory muscle weakness, multiple organ failure, and demise in many COVID-19 patients.(5) One-third of COVID-19 patients had a lower VO2max, with deconditioning being the most common cause of exercise limitation, lower effort, a smaller peak oxygen pulse, a larger HRR, and a more comprehensive breathing reserve. Physical deconditioning causes a decrease in exercise capacity in patients with COVID-19. With a noticeable reduction in exercise capacity, the patients exhibited an early anaerobic threshold, demonstrating a developed notch of physical deconditioning.(6)

Invasive mechanical ventilation is essential for many COVID-19 patients with acute respiratory failure to avert a further decline in respiratory muscle function, maintain optimal gas exchange, to prevent organ failure and death. Invasive mechanical ventilation is used for several weeks in critically ill patients.[7] The principal muscle used in inspiration is the diaphragm, which appears to be more affected by extended mechanical ventilation and life- threatening diseases than peripheral muscles. In ventilator-dependent ICU patients, diaphragm function may decrease further. Diaphragm weakness is associated with 3 problematic ventilator liberation, elevated risks of ICU and hospital readmissions, and death. Strong evidence advocates that diaphragm inactivity during mechanical ventilation is the grave cause of diaphragm weakness.[8] Covid-19 infected patients&; health-related quality of life (HRQoL) in the short and long run. HRQoL is a multi-faceted concept that encompasses physical, mental, social, and emotional well-being. It is documented that in COVID-19 survivors 30-40% experience psychological issues such as anxiety, depression, and sleep problems.[9]

The diaphragm manual stretching technique stretches the muscular fibers of the diaphragm and enhances chest wall mobility. As reported by several researchers, the vital capacity of the lungs can be improved by stretching respiratory muscles, promoting thoracic movement, and reducing dyspnea.[10] The diaphragmatic stretch technique, also known as diaphragmatic doming, aims to relax the diaphragm's resting condition, which strengthens its contracting and relaxing activities and generates a more significant compression difference between the thoracoabdominal cavity.[11] It was proposed that stretching the diaphragm would enhance its contractile properties, thereby increasing respiratory function. Previous studies were about the diaphragmatic stretching technique being performed on healthy subjects or on mostly COPD patients and CP children to see its effect on pulmonary function, but this study is subjected to see its impact on COVID survivors who were critically ill. None of the above studies directly measured the effect of diaphragmatic stretching on exercise tolerance. For patients with COVID-19, there is inadequate evidence of physiotherapy, specifically in the acute phase and in patients on ventilators. In the current study, we researched the immediate effects of diaphragmatic stretching on pulmonary function, exercise tolerance, and the quality of life in critically ill covid survivors.

II. Materials and METHODS

A quasi-experimental study design was used since there was only one intervention, eliminating the requirement for a control group, the burden of covid was declining during the study period, and participants who had survived covid were not eager to visit clinics for treatment. At the time, we only had a tiny population; thus, it was convenient to conduct a quasi-experimental study. Study duration was from July 2021 to April 2022. So, the research work was started after taking consent from the ethical team. The review panel of University's ethics committee granted ethical approval, with the reference number REC/RCR&AHS/21/0337 (027666). The Iranian Registry of Clinical Trials has approved this study. IRCT number is IRCT20211224053506N1. The sample size of 53 was calculated using Epitool. [11] with an assumed population standard deviation of 7.4, acceptable error of 2, and the level of confidence interval 0.95.[11,12] By Adding a 10 percent attrition rate, the sample size was 59. Data collection was done by a convenient sampling technique. It was collected by the representative. Participants were recruited and asked to take part in the study based on the inclusion and exclusion criteria. Our inclusion criteria were: covid survivors (diagnosed with covid-19, have had a severe respiratory illness, were on mechanical ventilation and discharged from the hospital six weeks ago), and aged 35 to 60 years—gender (Male and Female). Participants had no medical diagnosis of psychiatric illness and no fever for less than one week. Furthermore, our exclusion criteria were: any subject who has experienced recent sickness in the previous week. History of any of the subsequent in the past 14 days: fever greater than 38.2 degrees Celsius; new or deteriorating respiratory symptoms (e.g., dyspnea, cough), pregnancy, and participants who refused to give consent. Each study participant provided their written informed consent, which guaranteed the confidentiality of their data.[22] The tools for data collection were: Spirometry, Borg Scale, 6 Minute Walk Test, and SF- 8 questionnaires for QOL. Participants received 18 treatments session, on alternate days, for six weeks. Pulmonary function was the primary outcome, whereas exercise tolerance and quality of life were secondary outcome measures. Results were evaluated before and immediately 5 following the first treatment session (Pre-1 and Post-1), the ninth treatment session (Pre-9th and Post-9th), and the eighteenth treatment session (Pre-18th and Post-18th). COVID safety measures were taken during the treatment sessions. The intervention was given by an experienced therapist.

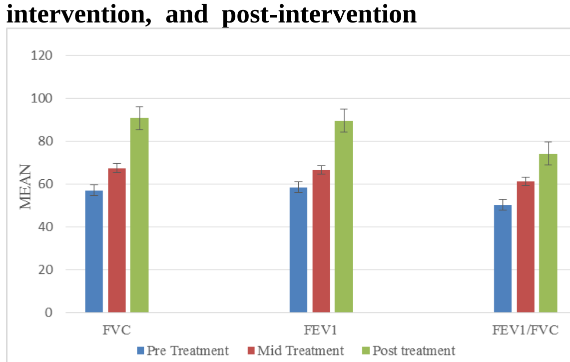
The treatment intervention was a diaphragmatic stretching technique that was performed by asking every participant to lay supine. The therapist's position was to stand on the side of the participant. The participants were asked to hug the trunk with the knees a bit so that the rectus abdominals could relax. Then the therapist progressed his hands from the front and surrounded the rib cage, keenly putting fingers beneath the costal margins. The therapist slowly pulled lower ribs and costal margins down and put his hands down while the participant was doing expiration. Stretching was performed once and maintained for 7 to 8 minutes.(13) Software SPSS version 23 for Windows was used to analyze the data. The statistical level of significance was set at 0.05. For descriptive metrics including age, gender, and BMI demographics; percentages, means, and standard deviations were computed. To evaluate the normal distribution of the data, normality testing was performed. Repeated measure ANOVA with a Greenhouse-Geisser correction was used to interpret the outcome measures on the baseline, mid-session, and post-treatment sessions within the group. To determine the statistically significant difference from pre-intervention to mid-intervention, pre-intervention to post-intervention, and mid-intervention to post-intervention, post hoc analysis with a Bonferroni adjustment was performed.

III. RESULTS

The average mean age of participants was 47.28±8.457 years. 4 (7%) participants were aged between 30-35 years. 13 (22%) participants were having age range between 36-40 years. 11 (19%) participants had an age range between 41-45 years, and 13 (22%) participants had an age range between 46-50 years. And 2 (3%) participants had an age range between 51-55 years. 16 (27%) participants were aged between 56-60 years. 35 (59%) males and 24 (41%) females were included in the study. The mean height of participants was 5.72±0.321 inches. 18 (31%) participants had a height range between 5.0-5.5 inches. 36 (61%) participants had a height between 5.5-6.0 inches. 5 (8%) participants had a height range between 6.0-6.5 inches. Participants mean weight was 57.74±6.02kg. 6 (10%) participants had a weight between 40- 45 kg. 35 (59%) participants had a weight range between 50-60 kg, and 18 (31%) participants had a weight range between 60-70 kg. Body Mass Index (BMI) mean was 29.31±3.50 kg/m 2 . 1 (2%) of participants were underweight. 10 (16%) were normal. 17 (29%) were overweight, and 31 (53%) participants were obese.

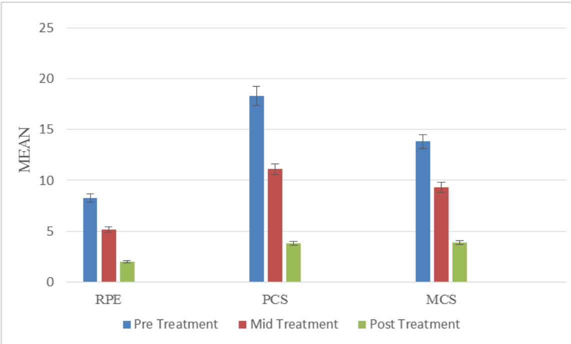
The result showed improvement in FVC (forced vital capacity), FEV1 (forced expiratory volume), and FEV1/FVC ratio with a significant p-value of 0.000 after diaphragmatic stretching in Covid survivors. Borg-scale mean with a significant p-value of 0.00, 6MWD mean with a significant p-value of 0.001, and SF-8 (MCS and PCS score) means with a significant p-value of 0.002 showed that diaphragmatic stretching improved exercise tolerance and quality of life of covid survivors. Results from the baseline to the post-intervention time points revealed significant differences statistically in the mean values of the outcome measures. These results are interpreted in the form of tables and graphs placed below.

(Figure 1): Cluster bar chart for comparison of mean values of FVC, FEV1, and FEV1/FVC at pre-intervention, mid-intervention, and post-intervention



(Figure2): Cluster bar chart comparing mean values of RPE, PCS, and MCS at pre-intervention, mid-intervention, and post-

intervention.



(Table 1): Within-group comparison of variables

Variables	Group (n=59)	Pre-Mean± St. Deviation	Mid Mean ± Std. Deviation	Post-Mean± Std. Deviation	P-value
			FEV1/FVC Ratio		
FVC	**A**	82.53±3.612	87.69±2.368	92.36±3.901	0.000
FEV1	**A**	51.53±4.546	63.37±2.242	73.69±4.195	0.000
FEV1/FVC	**A**	62.46±2.997	72.86±2.849	79.76±2.690	0.000
Borg Rating of Perceived Exertion (RPE)					
(RPE)	**A**	8.29±1.486	5.19±.798	2.02±.841	0.009
6-Minute Walk Distance (MWD)					
6MWD	**A**	119.36±36.891	297.46±26.543	560.68±100.03	0.001
PCS8 / MCS8					
PCS8	**A**	18.31±2.394	11.10±2.280	3.83±1.404	0.002
MCS8	**A**	13.83±2.018	9.32±1.105	3.85±1.375	0.002

[FVC: forced vital capacity, FEV1: forced expiratory volume in 1 second, RPE: the rating of perceived exertion, 6MWD: 6-minute walk distance, PCS: physical component score, MCS: mental component score]

IV. DISCUSSION

A coronavirus infection can cause hypoxemic respiratory failure along with the symptoms of acute respiratory distress syndrome in severe cases of severe acute respiratory syndrome. The COVID-19 treatment plan required additional consideration due to the seriousness of the illness. Therefore, we assessed the patients pulmonary function, exercise tolerance, and quality of life in Covid survivors using manual diaphragmatic stretching. Forced vital capacity, forced expiratory volume, and FEV1/ FVC ratio were measured, and the results showed a significant improvement in these values after diaphragmatic stretching in Covid survivors. The Borg-scale, physical component, and mental component scores of the SF8 questionnaire showed improvement in exercise tolerance and quality of life after diaphragmatic stretching in Covid survivors. Thus, diaphragmatic stretching improves pulmonary function, exercise tolerance, and quality of life in Covid survivors. Our results are reliable to those formerly testified by other writers. In their study, Liu, Zhang, et al [14] concluded that the mean difference was statistically significant between FEV1, FVC, and FEV1/FVC ratio when the interventional and control groups were compared after six weeks duration of pulmonary rehabilitation. Liu, Zhang, et al [14] also checked exercise capacity through a 6-minute walk test, and their results showed an improvement in 6MWD (6-minute walk distance test). Francisco Jose González-Alvarez et al [11] conducted a randomized controlled study to examine the impact of a stretching technique on the diaphragm's respiratory function in 80 physically fit subjects. Spirometry tests were performed on participants at baseline, right after the intervention, and at five and 20-minutes post-treatment. This study found that stretching the diaphragm increased FVC, FEV1, and peak respiratory pressures.

Abdelaal Ashraf AM et al [15] investigated the effects of the diaphragm and coastal manipulation on the ability to carry out actions and respiratory activity in patients with COPD who had not participated in a prior therapy for at least four months before the study and who were not currently experiencing viral or bacterial aggravations during the two calendar months and then diaphragm doming and release procedures were administered , and the study findings showed that the two techniques had practical uses. This study discovered a significant increase in FVC, FEV1, and 6MWT after using the Redoming of the Diaphragm technique. In another study conducted by González-Lvarez et al [13] on healthy volunteers, it was found that the diaphragmatic stretch technique improved the kinematics of the posterior chain. Bennett, Secretariat et al [16] concluded that the Manual Diaphragmatic stretching 11 process in CP children increased diaphragmatic mobility considerably throughout therapy, with an 18mm difference between group improvements. The study also measured the effect of the diaphragmatic stretching technique on pulmonary functions in CP children. No significant difference was seen in pulmonary function testing among both groups.

Aishwarya Nair, et al [17] conducted a study to examine the impact of the diaphragmatic stretch technique on chest expansion and diaphragmatic excursion in individuals with mild to moderate chronic obstructive pulmonary disease. The results were clinically and statistically significant and consistent with the current study results. H. Minoguch et al [18] carried out a study in which it was discovered that the diaphragmatic stretch technique had a statistically significant within-group difference. This may be clarified by the transient stimulation of the muscle spindle fetched on by muscular stretching, which augments sensory afferent stimulation, increases neuromotor response, and eventually advances muscle tension and viscoelasticity, which lessens muscle stiffness and helps thoracic motion. Another study by Jakub Stępnik et al [19] showed that osteopathic manual therapy techniques could improve respiratory function, i.e., the diaphragm stretch technique in healthy people. Li, Xia, et al [20] conducted a study to see how effective can be a telerehabilitation program for COVID-19 survivors (TERECO). In the study, a 6-minute walk test was measured to examine exercise capacity, and the accustomed between the mean difference of groups was in a change in 6MWD at the baseline and follow-up. The results of this study were consistent with the current research. In a previous study, the SF-12 questionnaire was used to assess the quality of life, although there was no statistically significant difference between the groups to suggest improvements in the SF-12 MCS and PCS. However, the current study gradually improved the SF8 questionnaire score by decreasing physical and mental stress on covid survivors. Many studies also supported that stretching the respiratory muscles enhances vital capacity, promotes thoracic movement, and reduces dyspnea [21] Correspondingly, the results of the current study showed that diaphragmatic stretching could counteract the consequences of COVID-19.

Recommendations:

In the future, this study may help to keep in view the effects of diaphragm stretching on pulmonary function, exercise tolerance, and quality of life in Covid survivors. The diaphragmatic stretching technique can be included in the physical rehabilitation program. This technique will help the cardiopulmonary physical therapists to adapt this technique if this pandemic prevails again. Moreover, the method improves the quality of life, which will also motivate the patients, enhancing the impact of the therapy.

V. Conclusion

It was concluded that diaphragmatic stretching improves pulmonary function, exercise tolerance, and quality of life in Covid survivors. The technique can be safely recommended for patients with clinically stable Covid to improve diaphragmatic excursion and chest expansion.

Conflict of Interest

There was no conflict of interest.

Financial Statement

No fundings were given by any authorities; it was a project thesis of doctor of physical therapy.

Data availability

Data will be provided on the demand by corresponding author.

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