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Original Research Article

Effectiveness of Aerobic Exercise on Peak Expiratory Flow Rate, Exercise Capacity and Quality of Life in Post COVID-19 Patients

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ABSTRACT

BACKGROUND AND OBJECTIVES: The COVID-19 is a highly infectious respiratory tract disease caused by Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-Cov-2). Post COVID-19 condition is defined asthe illness that occurs in people who have a history of probable or confirmed SARS-CoV-2 infection, usually 3 months from the onset of COVID-19 with symptoms that can last for few months to many years post recovery. Post COVID-19 patients are facing a lot of persistent symptoms such as increased interstitial thickening, evidence of fibrosis, decreased peak expiratory flow rate due to diminished respiratory muscle strength and decreased quality of life. These persistent symptoms will lead to pulmonary complications causing morbidity and mortality. So, pulmonary rehabilitation among Post COVID-19 patients is very important to prevent pulmonary complications. Pulmonary rehabilitation is effective, feasible and safe to improve exercise performance, lung function and quality of life in Post COVID-19 patients. The purpose of this study is to find out the effectiveness of Aerobic exercise on peak expiratoryflow rate, exercise capacity and quality of life in Post COVID-19 patients.

METHODOLOGY: 30 subjects were selected based on inclusion and exclusion criteria, then divided equally into two groups. Group A (Experimental group n=15) received aerobic exercise and diaphragmatic breathing exercise (40 minutes of aerobic exercise and 10 minutes of diaphragmatic breathing exercise). Group B (Control group n=15) received diaphragmatic breathing exercise (10 minutes of diaphragmatic breathing exercise). Exercise program was held for five days a week for 5 weeks. Peak expiratory flow rate, exercise capacity and quality of life were measured at the beginning and five weeks after intervention using peak expiratory flow meter, 6-minute walk test and SF-36 questionnaire.

RESULT: The results were analysed using paired and unpaired t test. The significant level was kept as $p<0.05$. The post test result in case of peak expiratory flow rate, $p< 0.05$, shows there is a significant difference in post test scores between experimental and control group.

The post test result in case of exercise capacity, $p< 0.05$, shows there is a significant differencein post test scores between experimental and control group.

The post test result in case of Physical Component Summary (PCS), $p< 0.001$, shows there is a significant difference in post test scores between experimental and control group.

The post test result in case of Mental Component Summary (MCS), $p< 0.001$, shows there is a significant difference in post test scores between experimental and control group.

CONCLUSION: The study concluded that, there is improvement in peak expiratory flow rate, exercise capacityand quality of life in experimental and control group. The experimental group shows more significant improvement than control group in all the three parameters.

KEYWORDS: Post COVID-19, Aerobic exercise, Diaphragmatic breathing exercise, Peak expiratory flow rate, Exercise capacity, Six-minute walk test, Quality of life.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) outbreak first appeared in December 2019 in Wuhan, Hubei Province, China, and has now spread globally.[1] COVID-19 is a highly infectious respiratory tract disease caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-Cov-2), which spreads rapidly by respiratory droplets and aerosols from infected people to the wider population (World Health Organization [WHO], 2020). Post COVID-19 patients continue to experience symptoms of COVID-19, such as dry cough, shortness of breath, and a lower quality of life, even after the corona virus infection has been declared cured.[2]

According to the World Health Organization (WHO), the illness that arises in patients who have a history of suspected or confirmed SARS-CoV-2 infection, is known as Post COVID-19 syndrome. The term "Post COVID-19 condition," also known as "long COVID," refers to a group of long-lasting symptoms that some people endure after having COVID-19. Globally, the 25-39 age group has the highest percentage of Post COVID-19 cases, with the 25-64 age group accounting for around half of all cases. Fatigue, shortness of breath or difficulty breathing, concentration or sleep issues, persistent cough, throat pain, muscular aches, loss of smell or taste, sadness or anxiety are the most prevalent symptoms of Post COVID-19 syndrome.[3]

The severity of coronavirus disease 2019 (COVID-19) might vary substantially. 40% of COVID-19 participants develop mild disease (defined as symptomatic patients without evidence of viral pneumonia or hypoxia); 40% develop moderate disease (with clinical signs of pneumonia); nearly 15% develop severe disease (requiring oxygen therapy); and 5% develop critical disease (with complications such as respiratory failure, acute respiratory distress syndrome, thromboembolism, sepsis, and/or death). Older age, smoking, and pre-existing comorbidities have all been linked to a more severe COVID-19 course and greater mortality.[4]

Although COVID-19 primarily affects the respiratory system, it has been discovered that the disease also affects other systems, eventually leading to mortality in severe cases due to impaired physical and pulmonary functioning. COVID-19 can lead to lung issues such pneumonia and, in the most severe cases, ARDS (acute respiratory distress syndrome). Another possible COVID-19 complication is sepsis, which can cause long-term damage to the lungs and other organs.

Patients may experience a variety of symptoms, including impaired lung function, physical deconditioning, muscle atrophy, muscle weakness, acute cerebrovascular diseases, venous thromboembolism, neurological complications, psychological disorders, and cognitive impairments, depending on the severity of COVID-19. Patients in the intensive care unit (ICU) are generally bedridden for long periods of time.[1] The severe form of disease causes lung damage and can lead to respiratory failure. As a result of the process of lung injury repair, the affected patients may develop pulmonary fibrosis. After recovery, the symptoms can persist from around a few months to many years. Functional impairment caused by COVID-19 can limit an individual's capacity to do daily activities, reduce functionality, affect professional performance, and obstruct social interaction.[5]

According to a study, pulmonary rehabilitation is a conservative treatment that includes a variety of programmes for patients with lung conditions, including aerobic exercises, strengthening exercises, health education, and breathing techniques. These exercises have been shown to improve cardiorespiratory fitness and health-related quality of life in Post-COVID- 19 patients.[6]

According to the American College of Sports Medicine, "Aerobic exercise is any activity that includes large muscle groups, can be done continuously, and is rhythmic in nature”. As the name implies, aerobic metabolism is used to extract energy in the form of adenosine triphosphate (ATP) from amino acids, carbohydrates, and fatty acids in muscle groups stimulated by this sort of exercise. The ACSM defines aerobic capacity as the product of the skeletal muscle's ability to use oxygen.(7) A study conducted by Ishtiaq Ahmed et al, 2021 on effectiveness of aerobic exercise training program on cardiorespiratory fitness and quality of life in patients recovered from COVID-19 concluded that cardiorespiratory fitness and quality of life are improved after undergoing aerobic exercise training.(8)

According to a study, fatigue, dyspnea, sleep problem, difficulty in concentrating, exertion intolerance, and myalgia were the most commonly reported symptoms of post COVID-19 patients.(9) Pulmonary rehabilitation is essential for Post COVID-19 patient’s recovery. Breathing exercises and respiratory muscle training including diaphragmatic breathing, pursed- lip breathing, relaxation, and body posture exercises are all part of pulmonary rehabilitation. Pulmonary rehabilitation reduces the physical and psychological symptoms of lung disease (e.g., chronic obstructive pulmonary disease (COPD)) by improving oxygen exchange, preventing lung collapse, strengthening breathing, and lowering the requirement for artificial ventilation. Pulmonary rehabilitation lowers complications, improves dyspnea symptoms, prevents and improves dysfunction, and improves quality of life (QOL) in COVID-19 patients.(10)

The aim of this study is to find out the effectiveness of Aerobic exercise on Peak Expiratory Flow Rate, Exercise Capacity and Quality of Life in Post COVID-19 patients. The outcome measures are Peak Expiratory Flow Rate (PEFR), Exercise Capacity and Quality of Life.

The maximal expiratory flow rate achieved during the forced expiratory manoeuvre is known as the Peak Expiratory Flow Rate (PEFR). The peak expiratory flow rate (PEFR) is a measurement of how quickly a person can exhale (breathe out) air. It's one of many tests that determine how well our lung’s function. It is a simple and direct method of detecting moderate or severe disease by assessing airway obstruction.(11)

The maximum amount of physical exertion a patient can tolerate is referred to as exercise capacity. The six-minute walk test is a submaximal exercise test that can be used to determine exercise capacity and endurance. A study by Hanada M et al (2020) showed that aerobic and breathing exercise can improve exercise capacity.(12)

According to the World Health Organization, "An individual's perspective of their position in life in relation to their objectives, aspirations, standards, and concerns in the context of the culture and value systems in which they live”. Corona virus disease-2019 (COVID-19) spread quickly over the world, impacting people's physical, mental, and social well-being and causing significant disruption to their quality of life. The SF-36 questionnaire is primarily used to assess the quality of life of the general population. Pulmonary rehabilitation has been proved in several trials to improve one's quality of life. Rainer Gloeckl et al, 2021 concluded that pulmonary rehabilitation was helpful, feasible, and safe for improving exercise performance, lung function, and quality of life in COVID-19 patients.(4)

Hence the title of the study is stated as “Effectiveness of Aerobic Exercise on Peak Expiratory Flow Rate, Exercise Capacity and Quality of Life in post COVID-19 patients”.

METHODOLOGY

STUDY DESIGN

Pre and Post Experimental study

STUDY SETTING

Post COVID clinic in Taluk Hospital, Kollam

STUDY DURATION

Total study duration- 6 months Intervention period- 5 weeks Frequency- 5 days / week

SAMPLING

Sampling Method:

Convenient sampling

Sample Size:

n = 30

15 subjects in each group (group A and group B)

Inclusion Criteria:

- Patients with less than one year of COVID-19 infection
- Age: 20 years to 55 years
- Both males and females
- Those who are able to understand and obey commands

Exclusion Criteria:

- Patient with respiratory, cardiac and neurological pathology
- Patients unable to take deep breath effectively due to pain or diaphragmatic dysfunction
- Patients who were not willing to participate
- Recent surgery
- Patient with past history of cardiac and pulmonary surgeries
- Patients who had chronic diseases like cancer, congestivecardiac failure etc
- Pregnancy
- Cognitive and memory deficit
- Psychological illness
- Patients with uncontrolled hypertension
- Patients with thoracic deformities and congenital deformities
- Patients who cannot follow the instructions. Eg: Deaf and dumb, psychiatric patients, blind patients
- Athletes
- Smokers

Sampling Procedure

The total study duration was 5 weeks, 30 post COVID-19 patients, aged 20 to 55years were selected from post COVID clinic of Taluk Hospital in Kollam through convenient sampling method according to inclusion and exclusion criteria.

The subjects are divided in to two groups:

- Group A (experimental group) – 40 minutes of aerobic exercise and 10 minutes of diaphragmatic breathing exercise – 15 subjects
- Group B (control group) – 10 minutes of diaphragmatic breathing exercise – 15 subjects

METHODS OF DATA COLLECTION

Outcome measures and tools of data collection:

1. **Peak Expiratory Flow Meter – to measure Peak Expiratory Flow Rate**

Peak Expiratory Flow Rate is the maximum flow rate generated during a forceful exhalation, starting from full lung inflation. PEFR is measured using peak expiratory flow meter which is a portable easy to use device that measures how well the lungs are able to expel air. It measures the airflow through the bronchi and thus the degree of obstruction in the airways. The first PFM was invented by Martin Wright in 1956.

The PEFR is defined as the maximum velocity of flow with which air is forced out of the lungs and is expressed in L/min. The PEFR depends on respiratory muscle power. It is going to determine the functioning of especially large airways, during the initial 100-200 ms of forced expiration. PEFR is very sensitive and accurate index of airway obstruction and the strength of respiratory muscles. Many factors are known to affect its value such as age, gender, height and body surface area. The normal range of PEFR for male and female is 450-550 L/min and 320-470 L/min. Disposable mouth piece was also provided to each subjects for the prevention of cross infection.

Figure 1; Peak expiratory flow meter

2. The Six Minute Walk Test – to measure Exercise Capacity

Six-minute walk test is a submaximal exercise test developed by the American Thoracic Society and it was officially introduced in 2002. In 2002, the American Thoracic Society endorsed and published guidelines for performing the 6MWT in clinical settings, also considering the impact of factors such as gender, height, age, length of the walkway on the distance walked. It is used to assess exercise capacity and endurance. The six-minute walk test (6MWT) measures the distance an individual is able to walk over a total of six minutes on a hard, flat surface of distance 30 m.

Subjects were instructed to walk as fast as they could along an even, undisturbed 30 m and the complete distance walked during 6 min was measured using a tape measure. Encouragement was given every minute during the test until subject exhaustion using only standardized phrases as specified in the “ATS Statement: Guidelines for the Six-minute Walk Test.” The distance covered in 6 minutes by each subject was used as variable for the analysis. The subject’s pulse, respiratory rate, blood pressure and oxygen saturation were measured before the test and at test completion. In healthy subjects, the 6- min walk (6MWD) distance ranges from 400 to 700 m.

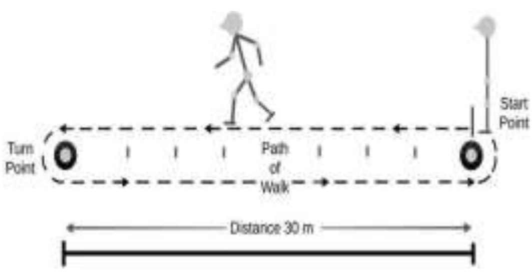


Figure 2; Six-minute walk test

3. SF-36 – To measure quality of life

SF-36 questionnaire was developed by Ware and Sherbourne. The SF-36 is considered to be a valid, reliable, concise and generic measure of state of health and is mainly used to evaluate the quality of life in the general population. Compared with other questionnaires designed to evaluate QOL, the SF-36questionnaire is short and flexible, which makes it much easier to administer. The SF-36 questionnaire can be completed manually or with the aid of a computer, by individuals, via a face-to-face interview or by telephone call with trained surveyors. The SF-36 questionnaire is widely used to monitor general population health status, to evaluate the efficacy of interventions, to monitor health status in patients with chronic disease and to determine the relative burdens of various disease.

The 36 questions on the SF-36 are meant to reflect 8 domains of health including physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role and mental health. Each item is scored on a 0 to 100 rangeso that the lowest and highest possible scores are 0 and 100. Higher score defines a more favourable health state and low score indicate poor health status. There are two distinct concepts measured by SF-36; Physical component summary (PCS) and Mental component summary (MCS). Physical component summary (PCS) includes physical functioning, physical role, bodily pain and general health. Mental component summary (MCS) includes vitality, social functioning, emotional role and mental health. The correct calculation of SF-36 measures PCS and MCS.

Materials Used:

Stop watch, Cones, Chair, Paper, Pen, Inch tape, Peak expiratory flow meter, Mouth piece, Meter measuring tape, Sphygmomanometer, Pulse oximeter, Stethoscope, Weighing machine, Thermometer, Stadiometer

Figure 3; Stop watch

Figure 4; Cones

Figure 5; Chair

Figure 6; Paper and pen

Figure 7; Inch tape

Figure 8; Mouth piece

Figure 9; Meter measuring tape

Figure 10; Sphygmomanometer

Figure 11; Pulse oximeter

Figure 12; Stethoscope

Figure 13; Weighing machine

Figure 14; Thermometer

Figure 15; Stadiometer

Pre-Intervention procedure

Ethical approval was obtained from the Ethical Committee of Medical Trust Hospital, Cochin for conducting the study. After explaining about the objective of the study and the test protocol, an informed written consent was obtained from participants. After signing the consent, a total of 30 subjects were taken and divided in to two groups. Instructions were also given to all subjects about how to use peak expiratory flow meter, how to perform 6-minute walk test and method of completion of SF-36 questionnaire. Pre-intervention measurements were taken for both groups using peak expiratory flow meter, 6-minute walk test and SF36 questionnaire.

Instructions for using peak expiratory flow meter:

- Move the marker to the bottom of the numbered scale of peak expiratory flow meter.
- Sit or stand up straight.
- Take a deep breath.
- Hold the breath while placing the mouthpiece in the mouth.
- Blow out as hard and fast as possible.
- Move the marker back to the bottom and repeat all these steps two more times. The highest of the three numbers is the peak expiratory flow rate.

INTERVENTION

➢ **Control group**

A total of 15 post COVID-19 patients were recruited for control group. The control group received diaphragmatic breathing exercise for 10 minutes, 5 days per week for 5 weeks.

Guidelines:

- Patients should be in comfortable and relaxed position.
- Exercise should not be performed immediately after the meals.
- Patients should focus on the breathing technique and bodily sensations they feel while practicing it.

Procedure

- Sit comfortably, with knees bent and shoulders, head and neck relaxed.
- Place patient’s one hand on upper chest and the other hand placed over subcostal angle, at the base of the ribcage, tips of the fingers approximating just over the

dome of the diaphragm. This will allow to feel the movement of diaphragm.

- Breathe in slowly through the nose so that the stomach moves out against the hand. The hand on the chest should remain as still as possible.
- Gentle pressure should be applied to the ribcage and diaphragm by the patient throughout the expiration cycle.
- Exhalation should be done through mouth, pursed lip, slowly, in relaxed manner.

➢ **Experimental group**

A total of 15 post COVID-19 patients were recruited for experimental group. The experimental group received diaphragmatic breathing exercise for 10 minutes and aerobic exercise for 40 minutes (10 minutes of warm up, 20 minutes of aerobic exercise: walking and 10 minutes of cool down), 5 daysper week for 5 weeks.

Guidelines:

- Patient should be in comfortable and relaxed position.
- Exercise should not be performed immediately after the meals.
- If the patient experience shortness of breath or any discomfort in between the exercise, discontinue the exercise.

Procedure

The experimental group received diaphragmatic breathing exercise for 10 minutes and aerobic exercise for 40 minutes (10 minutes of warm up, 20 minutes of aerobic exercise: walking and 10 minutes of cool down), 5 days perweek for 5 weeks.

According to ACSM protocol, Aerobic exercise program consists of:

- Warm up - 10 minutes of deep Breathing exercise and initial warm up exercises which includes general body active exercises, upper and lower body stretching exercises.
- Conditioning - 20 minutes of aerobic exercise: walking
- Cool down - 10 minutes of deep breathing exercise and stretching exercise.
- Time duration for Aerobic exercise program: Treatment session will be 40 min / session, 5 days per week for 5 weeks and 10 minutes for diaphragmatic breathing exercise. Rest will be given between the exercise
- to reduce Fatigue. A recording sheet also need to be provided to the patient for daily documentation.

Aerobic training:

- Mode: 10 minutes of warm up exercise, 20 minutes of aerobic exercise: walking and 10 minutes of cool down period.
- Intensity: Moderate intensity 60-80% of maximum heart rate.
- Frequency: 40 minutes/ day, 5 days/week including warm up and cooldown period.

Warm Up Exercise:

- Shoulder shrugs
- Shoulder circles
- Side bends
- Knee lifts
- Ankle taps
- Ankle circles

Duration: 5 minutes

Repetition: 2-4 timesStretching Exercise:

- Side stretch
- Shoulder stretch
- Hamstrings stretch
- Calf stretch
- Quadriceps stretch
- Back stretch

Duration: 5 minutes

Repetition: 2-4 times (Hold the stretch for 15 to 20 seconds)

POST INTERVENTION PROCEDURE

The outcome measurements for peak expiratory flow rate, exercise capacity and quality of life were taken after 5 weeks using the peak expiratory flow meter, 6-minute walk test and SF-36 questionnaire.

PHOTOGRAPHS AND DESCRIPTION

Figure 1; Peak expiratory flow meter

Figure 2; Six-minute walk test

Figure 3; Diaphragmatic breathing exercise

Figure 4; Shoulder shrugs

Figure 5; Side bend

Figure 6; Ankle tap

Figure 7; Ankle circle

Figure 8; Shoulder stretching

Figure 9; Hamstrings stretching

Figure 10; Quadriceps stretching

Figure 11; Calf stretching

RESULT

The present study was designed to explore the Effectiveness of Aerobic exercise on peak expiratory flow rate, exercise capacity and quality of life in post COVID-19 patients.

DEMOGRAPHIC INFORMATION

Group	Mean age	Standard deviation	Minimum	Maximum
Experimental group	37.4	11.98	21	52
Controlgroup	42.46	7.62	28	54

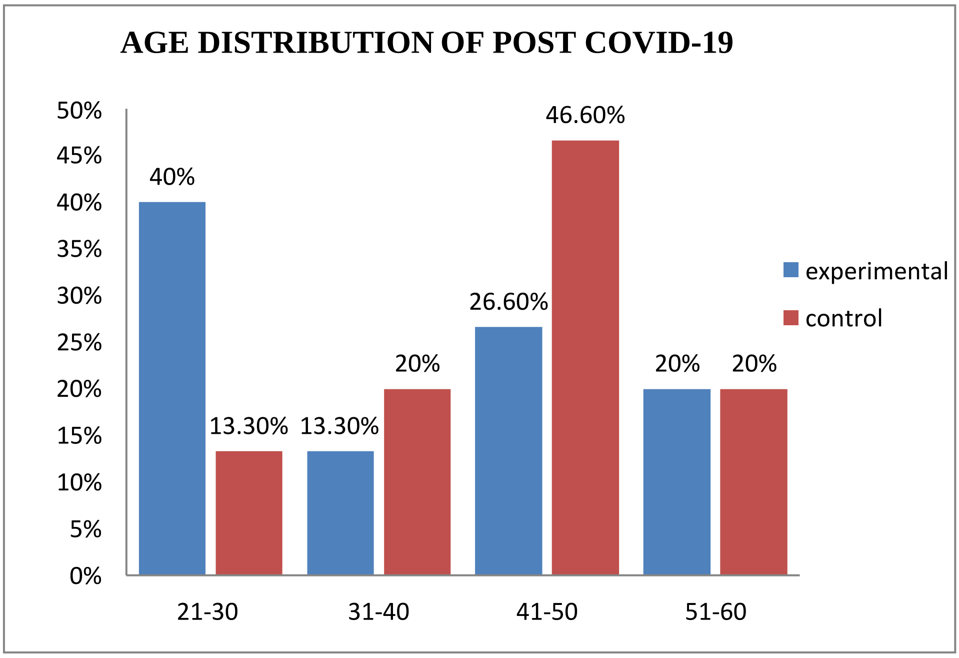
Table 1- Mean age in experimental and control group

The table 1 shows the age group taken for the study was between 20 to 55 years and the mean age of the experimental group was 37.4 with a standard deviation of 11.98 and the mean age of control group was 42.46 with a standard deviation of 7.62

Age	Experimental group		Control group	
	Frequency	Percentage	Frequency	Percentage
21-30 years	6	40%	2	13.3%
31-40 years	2	13.3%	3	20%
41-50 years	4	26.6%	7	46.6%
51-60 years	3	20%	3	20%

Table 2 – frequency and percentage of age in experimental and control group

The table 2 shows the frequency and percentage of age in both experimental group andcontrol group.



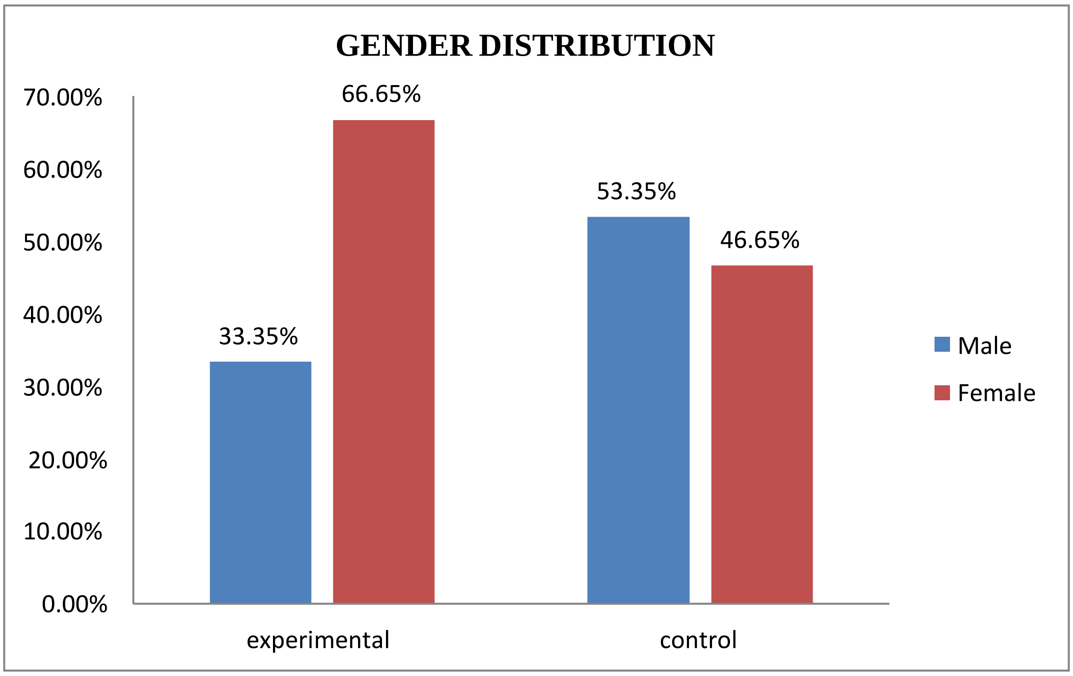
Graph 1- graphical representation of mean age in experimental group and control group

GENDER

Gender	Experimental group		Control group	
	Frequency	Percentage	Frequency	Percentage
Male	5	33.35%	8	53.35%
Female	10	66.65%	7	46.65%
Total	15	100%	15	100%

Table 3 – frequency and percentage of gender in experimental group and control group.

Table 3 shows the frequency and percentage of gender in both experimental group and control group.



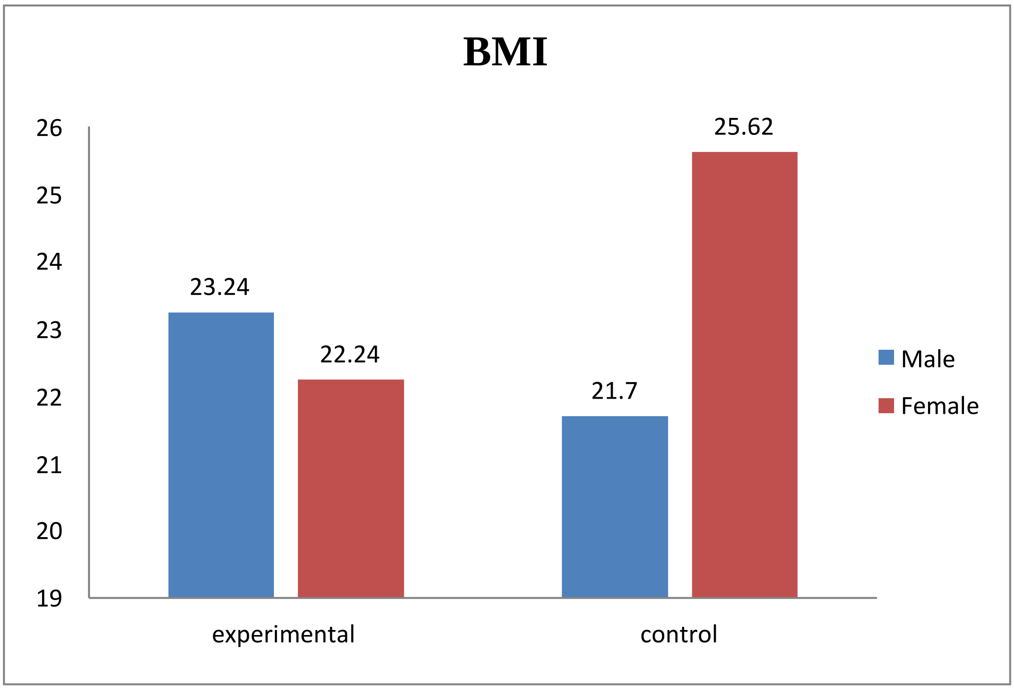
Graph 2 - graphical representation of gender in experimental group and control group

BODY MASS INDEX

Group	Gender	Height	Weight	BMI
ExperimentalGroup	Male	161±3.67	60±9.35	23.24±4.18
	Female	157.9±4.38	55.5±7.30	22.24±2.72
Control Group	Male	160.75±3.28	56.12±7.73	21.7±2.90
	Female	160.71±5.21	66.28±8.90	25.62±2.80

Table 4- height, weight and BMI of subjects in experimental and control group

Table 4 shows mean and standard deviation of height, weight and BMI of experimental and control group.



Graph 3- graphical representation of BMI in experimental group and control group

DATA ANALYSIS AND INTERPRETATION

The statistical analysis of the results was performed by using the SPSS Software (SPSS.20). Students t - test was used for the calculation of the results. Paired t test was used for the intra group comparison of pre and post test results. Unpaired t test (Independent t test) was used for the inter group comparison. Equations were used in;

$$\text{Sample } n \geq \frac{2\,\sigma^2\,(z\beta + z\alpha/2)^2}{\text{Difference}^2}$$

- n- Sample size in each group (assumes equal sized groups)
- σ Standard deviation of the outcome variable
- Zα - Represents the desired level of statistical significance (typically1.96)
- Zβ - Represents the desired power (typically 0.84 for 80% power)
- Differences - Effect size (the difference in mean)

  Independent Variables: Aerobic exercise, diaphragmatic breathing exercise Dependent Variables: peak expiratory flow rate, exercise capacity, quality of life.

COMPARISON WITHIN GROUP (paired t test)

COMPARISON OF PRE-TEST AND POST TEST VALUES OF PEAK EXPIRATORY FLOW RATE IN GROUP A (EXPERIMENTAL GROUP)

Test	Mean	SD	Mean improvement	n	t	df	p value
Pretest	312.66	49.63					
Post test	374	45.79	61.33	15	25.94	14	P < 0.001

Table 5- shows paired t test for peak expiratory flow rate in group A (experimental group)

The mean column displays the mean pre-test and post-test of peak expiratory flow rate among Post COVID-19 patients in the experimental group. SD is the standard deviations of the peak expiratory flow rate in pre & post respectively. Mean change 61.33 is the difference between pre-test and post-test mean peak expiratory flow rate (312.66 and 374). Since the t value 25.94, shows p < 0.001, there is a significant difference existing between the pre-test and post-test peak expiratory flow rate among Post COVID-19 patients in the experimental group. This proves the effect of Aerobic exercise in peak expiratory flow rate among Post COVID-19 patients.

COMPARISON OF PRE-TEST AND POST-TEST VALUES OF PEAK EXPIRATORY FLOW RATE IN GROUP B (CONTROL GROUP)

Test	Mean	SD	Mean improvement	n	t	df	p value
Pre test	309.33	62.95					
Post test	316	62.54	6.66	15	5.29	14	P < 0.05

Table 6- shows paired t test for peak expiratory flow rate in group B (control group)

The mean column displays the mean pre-test and post-test of peak expiratory flow rate among Post COVID-19 patients in the control group. SD is the standard deviations of the peak expiratory flow rate in pre & post respectively. Mean change 6.66 is the difference between pre-test and post-test mean peak expiratory flow rate (309.33 and 316). Since the t-value 5.29, shows p <0.05, there is a significant difference existing between the pre-test and post-test peak expiratory flow rate among Post COVID-19 in the control group. This proves the effect of diaphragmatic breathing exercise in peak expiratory flow rate among Post COVID-19 patients.

COMPARISON OF PRE-TEST AND POST-TEST VALUES OF EXERCISE CAPACITY IN GROUP A (EXPERIMENTAL GROUP)

Test	Mean	SD	Mean improvement	n	t	df	p value
Pretest	490.26	40.68					
Posttest	528.33	39.71	38.06	15	12.57	14	P < 0.001

Table 7- shows paired t test for exercise capacity in group A (experimental group)

The mean column displays the mean pre-test and post-test of exercise capacity among Post covid-19 patients in the experimental group. SD is the standard deviations of the exercise capacity in pre & post respectively. Mean change 38.06 is the difference between pre-test and post-test mean exercise capacity (490.26 and 528.33). Since the t-value 12.57, shows p < 0.001, there is significant difference existing between the pre-test and post-test exercise capacity scores among Post COVID-19 patients in the experimental group.

COMPARISON OF PRE-TEST AND POST-TEST VALUES OF EXERCISE CAPACITY IN GROUP B (CONTROL GROUP)

Test	Mean	SD	Mean improvement	n	t	df	p value
Pre test	478.46	30.24					
Post test	487.26	29.97	8.8	15	7.08	14	P < 0.05

Table 8- shows paired t test for exercise capacity in group B (control group)

The mean column displays the mean pre-test and post-test of exercise capacity among post COVID-19 patients in the control group. SD is the standard deviations of the exercise capacity in pre & post respectively. Mean change 8.8 is the difference between pre-test and post-test mean exercise capacity (478.46 and 487.26). Since the t-value 7.08, shows p<0.05, there is significant difference existing between the pre-test and post-test exercise capacity scores among post COVID-19 patients in the control group.

COMPARISON OF PRE-TEST AND POST-TEST VALUES OF PHYSICAL COMPONENT SUMMARY (PCS) IN GROUP A (EXPERIMENTAL GROUP)

Test	Mean	SD	Mean improvement	n	t	df	p value
Pre test	64.73	11.40					
Post test	81.8	4.72	17.06	15	7.55	14	P < 0.001

Table 9- shows paired t test for PCS in group A (experimental group)

The mean column displays the mean pre-test and post-test of PCS among post COVID-19 patients in the experimental group. SD is the standard deviations of the PCS in pre & post respectively. Mean change 17.06 is the difference between pre-test and post-test mean PCS (64.73 and 81.8). Since the t-value 7.55, shows p<0.001, there is significant difference existing between the pre-test and post-test PCS scores among post COVID-19 patients in the experimental group. This proves the effect of aerobic exercise on PCS among post COVID-19 patients.

COMPARISON OF PRE-TEST AND POST-TEST VALUES OF PHYSICAL COMPONENT SUMMARY (PCS) IN GROUP B (CONTROL GROUP)

Test	Mean	SD	Mean improvementt	n	t	df	p value
Pre test	62.4	11.27					
Post test	63.73	10.67	1.33	15	6.32	14	p < 0.05

Table 10 – shows paired t test for PCS in group B (control group)

The mean column displays the mean pre-test and post-test of PCS among post COVID-19 patients in the control group. SD is the standard deviations of the PCS in pre & post respectively. Mean change 1.33 is the difference between pre-test and post-test mean PCS (62.4 and 63.73). Since the t-value 6.32, shows p<0.05, there is significant difference existing between the pre-test and post-test PCS scores among post COVID-19 patients in the control group. This proves the effect of diaphragmatic breathing exercise on PCS among post COVID-19 patients.

COMPARISON OF PRE-TEST AND POST-TEST VALUES OF MENTAL COMPONENT SUMMARY (MCS) IN GROUP A (EXPERIMENTAL GROUP)

Test	Mean	SD	Mean improvement	n	t	df	p value
Pre test	69.33	9.22					
Post test	80.13	6.52	10.8	15	9.41	14	P< 0.001

Table 11 – shows paired t test for MCS in group A (experimental group)

The mean column displays the mean pre-test and post-test of MCS among Post COVID-19 patients in the experimental group. SD is the standard deviations of the MCS in pre & post respectively. Mean change 10.8 is the difference between pre-test and post-test mean MCS (69.33 and 80.13). Since the t-value 9.41, shows p< 0.001, there is significant difference existing between the pre-test and post-test MCS scores among post COVID-19 patients in the experimental group. This proves the effect of Aerobic exercise on MCS among Post COVID- 19 patients.

COMPARISON OF PRE-TEST AND POST-TEST VALUES OF MENTAL COMPONENT SUMMARY (MCS) IN GROUP B (CONTROL GROUP)

Test	Mean	SD	Mean improvement	n	t	df	p value
Pre test	63.66	10.12					
Post test	65.86	9.60	2.2	15	6.20	14	P< 0.05

Table 12 – shows paired t test for MCS in group B (control group)

The mean column displays the mean pre-test and post-test of MCS among Post COVID-19 patients in the control group. SD is the standard deviations of the MCS in pre & post respectively. Mean change 2.2 is the difference between pre-test and post-test mean MCS (63.66 and 65.86). Since the t-value 6.20, shows p<0.05, there is significant difference existing between the pre-test and post-test MCS scores among post COVID-19 patients in the control group. This proves the effect of diaphragmatic breathing exercise on MCS among Post COVID- 19 patients.

COMPARISON BETWEEN GROUPS (Independent t test/Unpaired t test)

COMPARISON OF PRE-TEST PEAK EXPIRATORY FLOW RATE BETWEEN GROUP A (EXPERIMENTAL GROUP) AND GROUP B(CONTROL GROUP)

Group	Mean	SD	Mean improvement	n	t	df	P value
Experimental group	312.66	49.63					
Control group	309.33	62.95	3.33	30	0.16	28	0.87

Table 13 – shows independent t test for pre-test peak expiratory flow rate between group A (experimental group) and group B (control group)

The Mean column in the t test table displays the mean pre-test peak expiratory flow rate in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (3.33) shows the difference between mean in two groups (312.66 and 309.33). Since the t-value 0.16, shows p-value > 0.05, there is no significant difference in pre-test peak expiratory flow rate between the experimental and the control groups. So we can consider the groups as homogenous in the baseline level.

COMPARISON OF POST-TEST PEAK EXPIRATORY FLOW RATE BETWEEN GROUP A (EXPERIMENTAL GROUP) AND GROUP B (CONTROL GROUP)

Group	Mean	SD	Mean improvement	n	t	df	p value
Experimental group	374	45.79					
Control group	316	62.54	58	30	2.89	28	P< 0.05

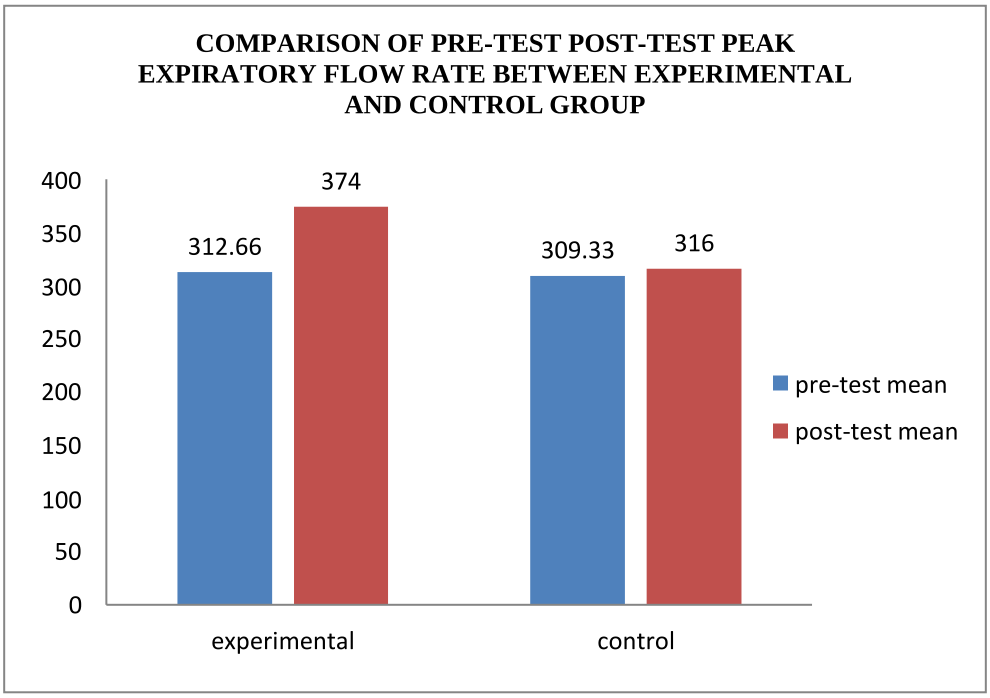
Table 14 – shows independent t test for peak expiratory flow rate between group A (experimental group) and group B (control group)

The Mean column in the t test table displays the mean post-test peak expiratory flow rate in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (58) shows the difference between mean in two groups (374 and 316). Since the t-value, 2.89 shows p-value< 0.05, there is a significant difference in post-test peak expiratory flow rate between the experimental and the control groups. The score in the experimental group is significantly higher than that in the control group. Hence Aerobic exercise is effective in improving peak expiratory flow rate in post COVID-19 patients.

COMPARISON OF PRE-TEST POST-TEST PEAK EXPIRATORYFLOW RATE IN GROUP A (EXPERIMENTAL) AND GROUP B (CONTROL GROUP)

Group	Pre-test mean	SD	Post-test mean	SD
Experimental group	312.66	49.63	374	45.79
Control group	309.33	62.95	316	62.54

Table 15 – shows comparison of pre-test post-test peak expiratory flow rate in group A (experimental group) and group B (control group)



Graph 4 - graphical representation of comparison of pre-test post- test peak expiratory flow rate in group A (experimental) and group B (control group)

COMPARISON OF PRE-TEST EXERCISE CAPACITY SCORES BETWEEN GROUP A (EXPERIMENTAL) AND GROUP B (CONTROL GROUP)

Group	Mean	SD	Mean improvement	n	t	df	P value
Experimental group	490.26	40.68					
Control group	478.46	30.24	11.8	30	0.90	28	0.375

Table 16 – shows independent t test for pre-test exercise capacity between group A (experimental group) and group B (control group)

The Mean column in the t test table displays the mean pre-test exercise capacity scores in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (11.8) shows the difference between mean in two groups (490.26 and 478.46). Since the t-value 0.90, shows p-value > 0.05, there is no significant difference in pre-test exercise capacity scores between the experimental and the control groups. So, we can consider the groups as homogenous in the baseline level.

COMPARISON OF POST-TEST EXERCISE CAPACITY SCORES BETWEEN GROUP A (EXPERIMENTAL) AND GROUP B (CONTROL GROUP)

Group	Mean	SD	Mean improvement	n	t	df	p value
Experimental group	528.33	39.71	41.06	30	3.19	28	P< 0.05
Control group	487.26	29.97					

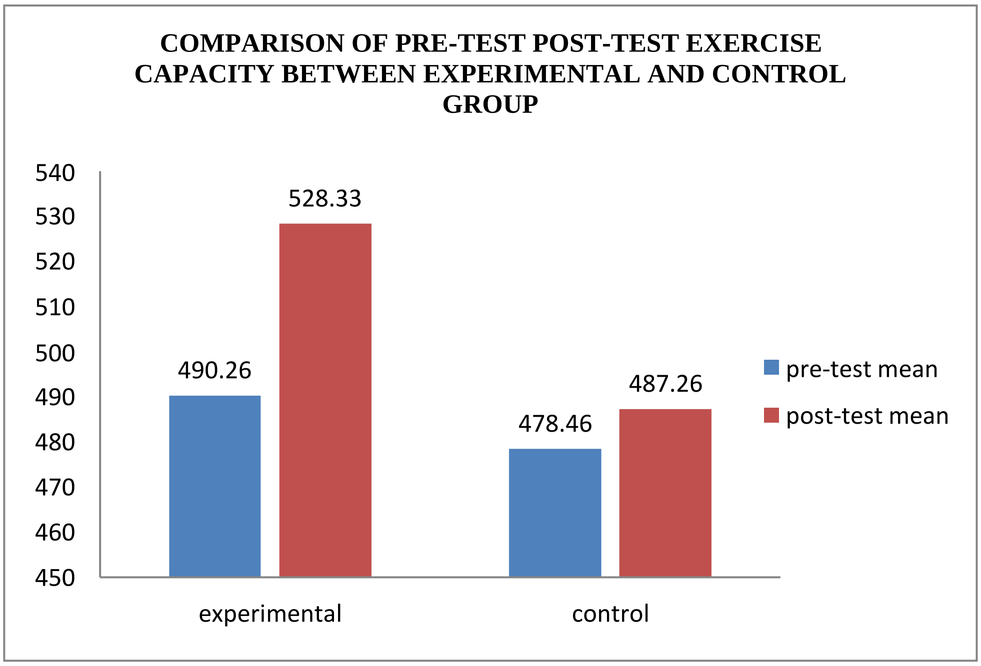
Table 17 – shows independent t test for post-test exercise capacity between group A (experimental group) and group B (control group)

The Mean column in the t test table displays the mean post-test exercise capacity scores in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (41.06) shows the difference between mean in two groups (528.33 and 487.26). Since the t-value 3.19, shows p-value< 0.05, there is a significant difference in post-test exercise capacity scores between the experimental and the control groups. The scores in the experimental group is significantly higher than that in the control group. Hence Aerobic exercise is effective in improving exercise capacity in post COVID-19 patients.

COMPARISON OF PRE-TEST POST-TEST EXERCISE CAPACITY SCORES IN GROUP A (EXPERIMENTAL) AND GROUP B (CONTROL GROUP)

Group	Pre-test mean	SD	Post-test mean	SD
Experimental group	490.26	40.68	528.33	39.71
Control Group	478.46	30.24	487.26	29.97

Table 18 – shows comparison of pre-test post-test exercise capacity in group A (experimental group) and group B (control group)



Graph 5 - graphical representation of comparison of pre-test post-test Exercise Capacity in group A (experimental) and group B (control group)

COMPARISON OF PRE-TEST PCS SCORES BETWEEN GROUP A (EXPERIMENTAL) AND GROUP B (CONTROL GROUP)

Group	Mean	SD	Mean improvement	n	t	df	P value
Experimental group	64.73	11.40					
Control group	62.4	11.27	2.33	30	0.56	28	0.57

Table 19 – shows independent t test for pre-test PCS score between group A (experimental) and group B (control group)

The Mean column in the t test table displays the mean pre-test PCS scores in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (2.33) shows the difference between mean in two groups (64.73 and 62.4). Since the t-value 0.56, shows p-value > 0.05, there is no significant difference in pre- test PCS scores between the experimental and the control groups. So we can consider the groups as homogenous in the baseline level.

COMPARISON OF POST TEST PCS SCORE BETWEEN GROUP A (EXPERIMENTAL GROUP) AND GROUP B (CONTROL GROUP)

Group	Mean	SD	Mean improvement	n	t	df	p value
Experimental group	81.8	4.72					
Control group	63.73	10.67	18.06	30	5.99	28	p< 0.001

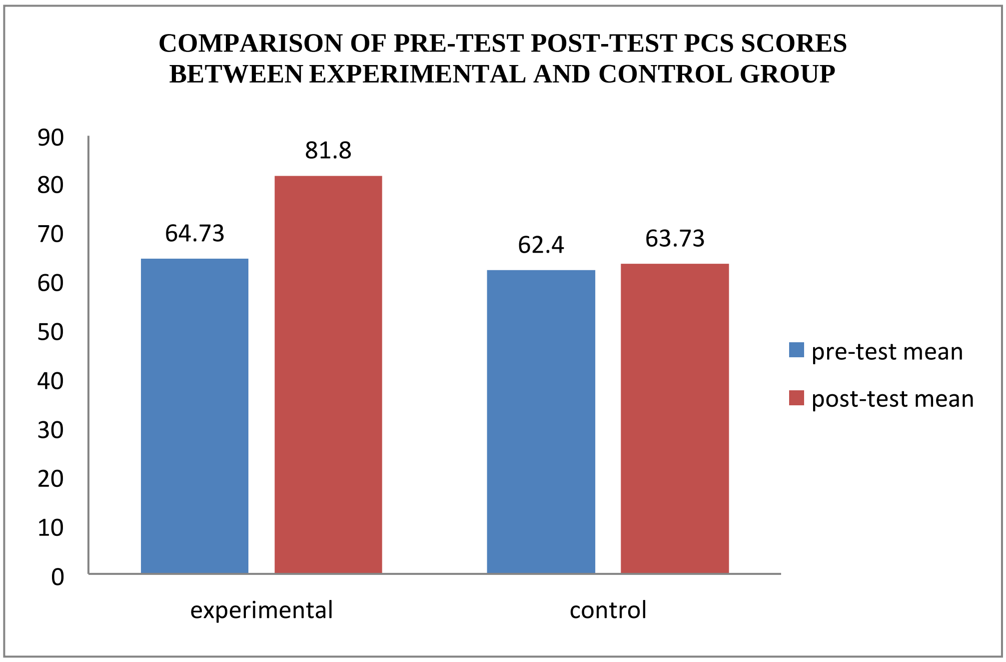
Table 20 – shows independent t test for post-test PCS score between group A (experimental group) and group B (control group)

The Mean column in the t test table displays the mean post-test PCS scores in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (18.06) shows the difference between mean in two groups (81.8 and 63.73). Since the t-value 5.99, shows p-value <0.001, there is significant difference in post-test PCS score between the experimental and the control groups.

COMPARISON OF PRE-TEST POST-TEST PCS SCORES BETWEEN GROUPA (EXPERIMENTAL) AND GROUP B (CONTROL GROUP)

Group	Pre-test mean	SD	Post-test mean	SD
Experimental group	64.73	11.40	81.8	4.72
Control group	62.4	11.27	63.73	10.67

Table 21- shows comparison of pre-test post-test PCS in group A (experimental group) and group B (control group)



Graph 6 - graphical representation of comparison of pre-test post-test PCS scores in group A (experimental) and group B (control group)

COMPARISON OF PRE-TEST MCS SCORE BETWEEN GROUP A (EXPERIMENTAL) AND GROUP B (CONTROL GROUP)

Group	Mean	SD	Mean improvement	n	t	df	P value
Experimental group	69.33	9.22					
Control group	63.66	10.12	5.66	30	1.60	28	0.12

Table 22 – shows independent t test for pre-test MCS between group A (experimental group) and group B (control group)

The Mean column in the t test table displays the mean pre-test MCS scores in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (5.66) shows the difference between mean in two groups (69.33 and 63.66). Since the t-value 1.60, shows p-value > 0.05, there is no significant difference in pre-test MCS scores between the experimental and the control groups. So we can consider the groups as homogenous in the baseline level.

COMPARISON OF POST-TEST MCS SCORE BETWEEN GROUP A (EXPERIMENTAL) AND GROUP B (CONTROLGROUP)

Group	Mean	SD	Mean improvement	n	t	df	p value
Experimental group	80.13	6.52					
Control group	65.86	9.60	14.26	30	4.75	28	p< 0.001

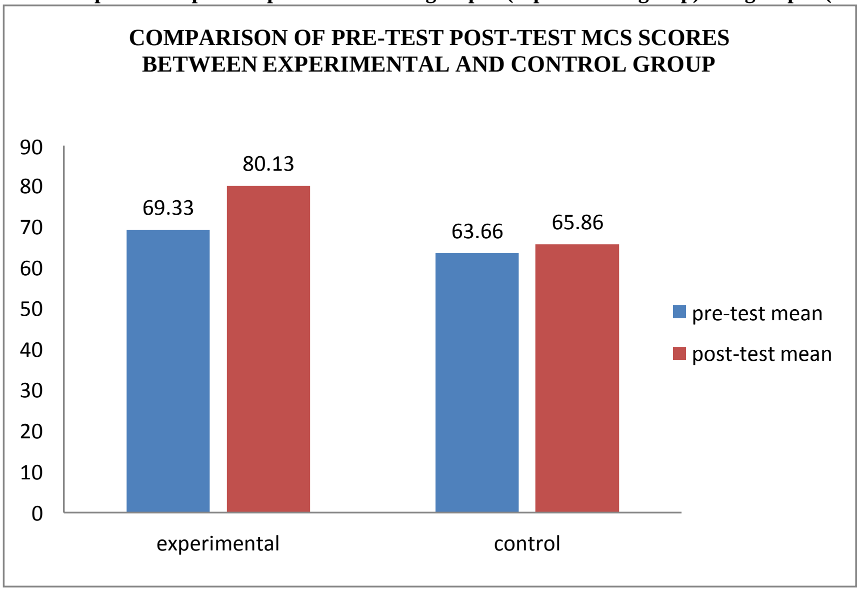
Table 23 – shows independent t test for post-test MCS between group A (experimental group) and group B (control group)

The Mean column in the t test table displays the mean post-test MCS scores in experimental and control group respectively. The standard deviation column displays the standard deviation of the scores in two groups. The difference (14.26) shows the difference between mean in two groups (80.13 and 65.86). Since the t-value 4.75, shows p-value <0.001, there is a significant difference in post- test MCS score between the experimental and the control groups. The scores in the experimental group is significantly higher than that in the control group. Hence Aerobic exerciseis effective in improving MCS score among post COVID-19 patient.

COMPARISON OF PRE-TEST POST-TEST MCS SCORES IN GROUP A (EXPERIMENTAL) AND GROUP B (CONTROL GROUP)

Group	Pre-test mean	SD	Post-test mean	SD
Experimental group	69.33	9.22	80.13	6.52
Control group	63.66	10.12	65.86	9.60

Table 24 – shows comparison of pre-test post-test MCS in group A (experimental group) and group B (control group)



Graph 7 - graphical representation of comparison of pre-test post-test MCS scores in group A (experimental group) and group B (control group)

DISCUSSION

The Post COVID-19 patients suffer from a phenomenon known as 'long' or 'chronic' COVID-19, or more recently, post-acute sequelae of COVID-19 or post-acute COVID-19 Syndrome (PACS). The COVID-19 mainly affects the respiratory system, it has been shown that the disease affects other systems which may lead to death in severe cases, due to diminished physical and pulmonary functions. COVID-19 can lead to lung complications such pneumonia and, in the most severe cases, ARDS (acute respiratory distress syndrome). Another possible COVID-19 complication is sepsis, which can cause long-term damage to the lungs and other organs. Increased mortality occurs as a result of COVID complications.

A study conducted by A Demeco et al (2020) on Rehabilitation of patients post COVID-19 infection concluded that pulmonary rehabilitation, including aerobic exercise (walking, brisk walking, jogging, swimming), strength training, balance training, breathing training improved pulmonary function, physical and psychological efficiency and quality of life of post COVID-19 patients. Physiotherapists will be increasingly involved in the care of post COVID-19 patients, to improve pulmonary function, physical and psychological efficiency, and to restore a good patient quality of life.[1]

The outcome measures used were peak expiratory flow rate, exercise capacity and SF36 questionnaire. The results were analysed using t- test. Paired t test was used to compare the results within the group and unpaired t test (independent t test) was used to compare the results between the group. Significance level kept as p value < 0.05.

The result in case of the Peak Expiratory Flow Rate, has shown that, in paired t test, since the t-value, 25.94 shows p < 0.001, there is a significant difference existing between the pre-test and post-test Peak Expiratory Flow Rate in group A (experimental group). The t-value, 5.29 shows p < 0.05, there is a significant difference existing between the pre-test and post-test Peak Expiratory Flow Rate in group B (control group) also. The results showed improvement in both groups. In the independent t test, since the t-value 2.89, shows p-value < 0.05, (p=0.0072) there is a significant difference in post-test Peak Expiratory Flow Rate between the experimental and the control groups. The mean difference, 58 shows the difference between mean in two groups group A (374) & group B (316) respectively. The scores in the experimental group were significantly higher than that of the control group.

Improvement in Peak Expiratory Flow Rate occurred because the aerobic exercise strengthens the respiratory muscles (diaphragm and intercostals). This may have further helped in better chest expansion and therefore increasing the chest cavity. Thus, larger chest cavity means more air could be inspired, therefore increasing the vital capacity and enabling more capillaries to be formed around the alveoli so that more gaseous exchange can take place. During aerobic exercise, minute ventilation increases and an increased load is placed on the respiratory muscles.[13] The above reasons might be responsible for the improvement of peak expiratory flow rate in experimental group.

The result in case of the Exercise Capacity has shown that, in paired t test, since the t-value, 12.57 shows p < 0.001, there is a significant difference existing between the pre-test and post- test Exercise Capacity scores in the experimental group (group A). The t-value, 7.08 shows p< 0.05, there is a significant difference existing between the pre-test and post-test Exercise Capacity scores in the control group (group B) also. The results showed improvement in both groups. In the independent t test, since the t value 3.19, shows p-value <0.05 (p=0.0034) there is a significant difference in post-test Exercise Capacity scores between the experimental and the control groups. The mean difference, 41.06 shows the difference between mean in two groups (group A and B) 528.33 & 487.26 respectively. The scores in the experimental group were significantly higher than that of the control group.

This study shows that there is improvement in exercise capacity in experimental and control group. The experimental group shows higher significance than the control group, which may be due to the increase in inspiratory muscle strength and improved exercise endurance which in turn increases the aerobic capacity and exercise capacity.

According to a study conducted by Masatoshi Hanada et al (2019), Aerobic exercise along with breathing exercise showed greater benefits compared to Aerobic exercise alone. This study reported a significant increase in exercise capacity and decrease in dyspnea symptoms.This was because the increased inspiratory muscle strength can improve the efficiency of respiratory muscle, required for ventilation. Furthermore, improved exercise endurance resulted in improved aerobic capacity and hence reduced ventilator load during exercise.[12]

The result in case of the PCS, has shown that in paired t test, since the t- value, 7.55 shows $p< 0.001$, there is significant difference existing between the pre-test and post-test PCS scores in group A (Experimental group). The t-value, 6.32 shows $p <0.05$, there is significant difference existing between the pre-test and post-test PCS scores in group B (Control group) also. The results showed improvement in both groups. In the independent t test, since the t value 5.99, shows p-value < 0.001 (p= 0.00000186) there is significant difference in post-test PCS scores between group A (experimental group) and group B (control group). The mean difference, 18.06 shows the difference between mean in two groups group A (81.8) & group B (63.73) respectively. The scores in the experimental group were significantly higher than that of the control group.

In case of the MCS, it was found that in paired t test, since the t-value, 9.41 shows $p < 0.001$, there is significant difference existing between the pre-test and post- test MCS scores in group A (Experimental group). The t-value, 6.20 shows $p < 0.05$, there is significant difference existing between the pre-test and post-test MCS scores in group B (control group) also. The results showed improvement in both groups. In the independent t test, since the t value 4.75, shows p-value <0.001 (p= 0.000053) there is significant difference in post-test MCS scores between the experimental and the control groups. The mean difference, 14.26 shows the difference between mean in two groups 80.13 and 65.86 respectively. The scores in the experimental group were significantly higher than that of the control group.

The quality of life score showed a more significant disability in post COVID-19 patients. The fear of getting an infection and staying in isolation might affect patient’s confidence and self- esteem, resulting in decreased quality of life. A study has shown that patients discharged after a severe illness due to COVID-19 may experience post intensive care syndrome that impacts patient’s mental health and quality of life. Alveolar damage due to COVID-19 disease has significantly affected the physical health of patients. All the factors mentioned above resulted in a significantly lower score in all domains of SF-36.

According to a study conducted by Ahmed I et al (2021), aerobic exercise showed improvement in quality of life.[8] In this study quality of Life has been significantly improvedin post COVID-19 patients in both experimental and control group after 5-weeks of aerobic exercise training. The experimental group shows more significance than the control group. The physical and mental health was significantly improved, indicating that participant’s confidence and self-esteem were significantly increased, which resulted in improvement of quality of life. By performing aerobic exercise, there is relief of symptoms, which leads to the improvement of pulmonary function and overall wellbeing. Therefore, aerobic exercise is beneficial to improve quality of life of post COVID-19 patients.

STRENGTH OF THE STUDY

- Number of participants were equal in both groups.
- Cost effective programme.
- No equipment or apparatus needed for exercise.
- Can be performed anywhere without any barrier.

LIMITATIONS OF THE STUDY

- As the measurements were taken manually, this may introduce human error, which could threat the reliability of the study.
- Both genders were included which may affect the outcome measures.

FUTURE RESEARCH

- The sample size of the study can be increased; hence it may lead to better results.
- Can be administered in other populations.
- A follow-up study could ensure the long-term effect of the treatment programme.
- The treatment duration of the study can be increased.

CONCLUSION

From the above study, it was obtained that there is significant difference among the experimental and control group when the values were analysed. The study concluded that the analysis of peak expiratory flow rate, exercise capacity and quality of life shows improvement within the group as well as between the groups. But the Experimental group shows significantly higher improvement in all the three parameters when compared to the control group.

Hence, the study concluded that the aerobic exercise is effective in improving peak expiratory flow rate, exercise capacity and quality of life in Post COVID-19 patients. So, aerobic exercise plays an important role in Post COVID rehabilitation programme, which will help to prevent pulmonary complications and improve quality of life.

Declaration by Authors

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