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Effect Of 6 Weeks Of Core Strengthening Exercises On Pulmonary Function Test In Patients With Chronic Obstructive Pulmonary Disease.

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Abstract:

BACKGROUND: *Few studies have evaluated the effects of core strengthening exercises on various pulmonary conditions. Therefore, this study aims to evaluate the effects of core strengthening exercises using a Pressure Biofeedback Unit (PBU) with breathing exercises on Pulmonary Function Test (PFT) in patients with Chronic obstructive pulmonary disease (COPD).**OBJECTIVE:*** *This study aimed to compare core strengthening exercises with PBU along with breathing exercises and breathing exercises alone on Pulmonary Function Test (PFT).**METHODS:*** *Sixteen patients with mild to severe COPD based on PFT reports were assigned to either the exercise group (EG) - core strengthening exercise with PBU along with breathing exercises or the control group (CG) - breathing exercises. All participants underwent PFT, core strength test, COPD assessment test (CAT), and MMRC dyspnea grading pre and post to intervention. The intervention protocol for EG was 3 days/week for 6 weeks which was provided in Pulmonary rehabilitation setup of D.Y. Patil Hospital, Navi Mumbai, and for CG was 5 days/week for 6 weeks through tele-rehabilitation. The results obtained were analyzed using Paired 't' test for dependent measures, the Unpaired 't' test for independent measures, and 'Z' test for qualitative data with a significance threshold of $p<0.05$.**RESULTS:*** *There were 8 participants in each group. Both EG and CG showed no significant effects of protocol post 6 weeks on PFT values. Comparison between EG and CG shows a higher value in CG for FEV 1 with $p=0.0002$ and FEV 1 /FVC with $p=0.0001$ in post 6 weeks as well as in baseline. No significant difference was noted between both groups for the CAT score. Significant improvement was noted in the core strength test with $p=0.0001$ and MMRC with $p=0.0001$ post 6 weeks for EG.* ***CONCLUSION:*** *Results obtained from the study suggest that core strengthening exercise with PBU along with breathing exercises has no superior effects in comparison with breathing exercises alone on Pulmonary Function Test (PFT) in patients with COPD.*

KEYWORDS: *Core strengthening exercise, Chronic obstructive pulmonary disease, Pressure Biofeedback Unit, Pulmonary Function Test.*

Introduction:

COPD is known as a diverse lung disorder characterized by chronic respiratory symptoms (dyspnea, cough, expectoration, exacerbations) produced by airway abnormalities (bronchitis, bronchiolitis) and/or alveoli (emphysema) that produce persistent, frequently worsening airflow obstruction. Tobacco smoking and the inhalation of harmful particles and gases from indoors as well as outdoors are the major environmental exposures leading to COPD, whereas other environmental and host variables can also be contributing factors.[1] The majority of people with COPD are smokers and older than 40. Age-related prevalence rises,and it is today the third leading cause of illness and mortality globally. Over 3.2 million people died globally in 2015 as a result of COPD, which affected 174 million people worldwide.[2] Respiratory muscle dysfunction in people with COPD is a defining factor in both acute and chronic respiratory failure. The diaphragm, the main respiratory muscle, is defective in all stages of COPD. The major causes of diaphragm dysfunction are pulmonary hyperinflation. Diaphragmatic stability and core strength are crucial for breathing.[3] The majority of core muscles, including the abdominal muscles, aid in breathing. The diaphragm can relax and rise gradually because the core muscles tighten the abdominal muscles, putting more pressure on the abdomen. The diaphragm serves as the ceiling of the core. When inhaled, it contracts, enlarging the thoracic cavity (the external intercostal muscles also participate in this enlargement). When the cavity widens, the intra-thoracic pressure decreases, and suction is created, drawing air into the lungs. Air is expelled through the lungs, and the thoracic cavity's elastic rebound increases as the diaphragm relaxes.[4] While inspiration and expiration are regulated by opposing activity of the diaphragm and abdominal muscles to change the shape of the pressurized abdominal cavity, co-activation of the diaphragm and abdominal muscles generates a prolonged risein intra-abdominal pressure. By depressing its central tendon and raising the lower ribs, diaphragm contracts, resulting in inspiratory airflow that widens the thoracic cavity's vertical and transverse dimensions.[5] Particularly, the contractility of the transversus abdominis and diaphragmaffects the partial stabilization of the lumbar spine and functions as a kind of regulatory system, generating variations in breathing patterns.[6] Studies show that vocalists with strong core muscles have increased respiratory muscle endurance and breathing ability.[4]
Several studies have shown COPD patients can benefit from exercise rehabilitation. Moreover, studies based on breathing exercises combined with and without core strengthening exercises conducted on healthy individuals, asthmatic individuals, and children with bronchiectasis have shown an increase in pulmonary function in the groups where core exercises were combined with breathing exercises.
However, there is a lack of literature on the effects of core strengthening on the improvement ofrespiratory function in COPD patients.Hence, the purpose of this research is to study the effect of 6 weeks of core strengthening exerciseson respiratory parameters in COPD patients.

2. Materials and methods:

2.1 Study Design:
This non-randomized experimental study was conducted in D Y Patil Hospital, Nerul, Navi Mumbai. Participants fulfilling inclusion criteria were selected from the Pulmonary Medicine Department of
D. Y. Patil Hospital, Nerul, Navi Mumbai, and were informed regarding the study procedure. Ethical approval was obtained from the Institutional Ethical Committee (IEC) for Biomedical andHealth Research. D. Y. Patil School of Medicine, Navi-Mumbai (IEC Ref. No: DYP / IECBH / 2022/230).
Participants were allocated in a non-randomized manner. Written consent was taken from the individuals participating in the study.
Inclusion criteria: a) Participation in the study voluntarily. b) COPD patients with mild to severe obstruction based on PFT reports. (40 – 80 yrs./ BothMale and Female) Exclusion criteria: a. Having physical or mental disability. b. having visual, hearing, and/or verbal impairments. c. History of surgery for cardiovascular diseases. d. Severe hypertension, critical medical conditions. e. Congenital chest deformity, rib fracture. d. Patients denying participation.

2.2 Sample size:
The sample size of 32 patients was determined using the estimates of mean and standarddeviation values from literature using the formula for sample size calculation. Due to lack of feasibility, a total of 16 subjects had been taken in the study i.e., 8 subjects in eachgroup.

2.3 Interventions:
The participants were randomized assigned to either exercise group or control group. Demographic data (name,

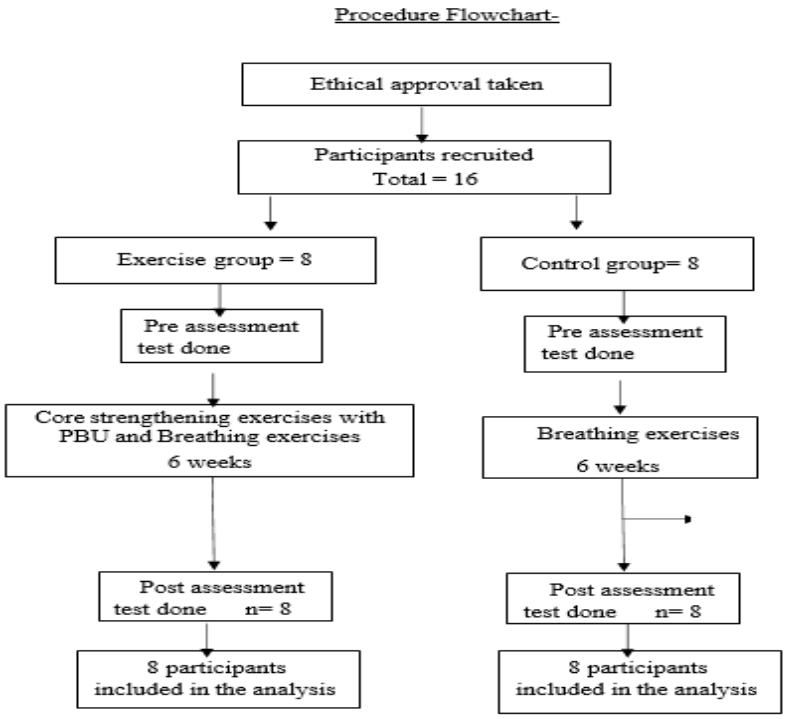
age, gender, height, weight) was collected from the participants before the intervention. Each participant in the exercise group (EG) underwent an exercise protocol consisting of core strengthening exercises using PBU and breathing exercises for 3 consecutive days in a week for a total of 6 weeks and each participant in the control group (CG) underwent an exercise protocol consisting of breathing exercises for 5 days in a week for a total of 6 weeks.

2.3.1 Exercise Group (EG) - Consisted of core strengthening exercises using Pressure BiofeedbackUnit (PBU) and breathing exercises.

Exercises / Weeks	Diaphragmatic breathing while maintaining core activation	Combination of Diaphragmatic breathing and bilateral shoulder flexion while maintaining core activation	Combination of Diaphragmatic breathing and extension of each knee while maintaining core activation	Breathing control, Diaphragmatic breathing, Pursed lip breathing
1st week	5 repetitions/1 set			5 repetitions/1 set
2nd week	5 repetitions/2 sets			5 repetitions/1 set
3rd week and 4th week	5 repetitions/3 sets	5 repetitions /3 sets		5 repetitions/2 sets
5th week and 6th week	5 repetitions/4 sets	5 repetitions /3 sets	5 repetitions/ 3 sets	5 repetitions/4 sets

2.3.2 Control Group (CG) – Consisted of breathing exercises.
Breathing control, Diaphragmatic breathing, Pursed lip breathing
1st week and 2nd week- 5 repetitions/1 set
3rd week and 4th week- 5 repetitions/ 2 sets
5th week and 6th week- 5 repetitions / 4 sets

Fig 1.: Flowchart of methodology



2.4 Outcome measures:
The measurements were performed at baseline and after 6 weeks of training for every outcome measure.

2.4.1 Pulmonary Function tests:
Pulmonary function tests were performed using portable spirometry. Measurements were performed using American Thoracic Society (ATS) and European respiratory society (ERS) guidelines.

2.4.2 Core strength using Pressure Biofeedback Unit:
Core muscle strength was assessed by using Stabilizer's biofeedback unit with the help of Richardson and Joule's core muscle grading method. As this method is reliable and valid methos for grading core muscle strength. The subject was instructed to be in crook lying position. The transverse abdominis muscle activation i.e., indrawing maneuver was taught to the subject. The inflatable bag was placed at lumbar lordosis raising the pressure to 40 mm of Hg. The subjects were instructed to maintain the contraction and then they were graded as per the above mentioned grading method.[5]

2.4.3 Dyspnea:
The levels of dyspnea were assessed using modified Medical Research Council (mMRC) dyspnea grading scale.

2.4.4 COPD Assessment Test:
The COPD Assessment Test (CAT) was done as it assesses the impact of COPD on patient's overall health.
Follow-up sessions of the protocol of the exercise group (EG) were carried out in the Pulmonary Rehabilitation setup of D. Y. Patil Hospital, Nerul, Navi Mumbai, and for the control group (CG) was carried out through tele- rehabilitation. Assessments and tests conducted before the interventionwere also conducted after 6 weeks.

2.5 Statistical Analysis:
Statistical analysis was done by descriptive statistics such as mean, SD, percentage, proportions, etc. Student's Paired 't' test was applied to compare mean values of outcome measures – PFT and CAT score from Pre to Post in Control and Exercise groups. Student's Unpaired 't' test was applied to compare mean values of outcome measures – PFT and CAT score from Post to Post in between Control and Exercise groups. The p value > 0.05 was considered to be statistically significant for comparisons. Z test of the difference between two proportions is also applied to compare Core strength and mMRC Post values in Control and Exercise groups at 5% ($p<0.05$) and 1% ($p<0.01$) level of significance. Statistical analysis software namely SYSTAT version 12 (made by Crane's software, Bangalore) a licensed copy was used to analyse the data.

3. Results:

A sample size of 16 COPD patients were randomly assigned to the exercise group (n=8) and control group (n=8). The demographic data for both the groups were compared. For the exercise group, the number of male and female patients were equal and for the control group, it was unequal i.e. 6 males and 2 females. The age wise distribution was unequal in both groups,there were patients of all age groups in the exercise group and for control group there were patientsfrom the age of 50- 70 years. (Table 1 and graph 1) According to statistical analysis, there is an equal distribution of height and weight between bothgroups. (Table 2 and graph 2)

Pulmonary Function Test Parameters
The table no. 3 and graph no. 3 displays the comparison of the mean and standard deviation values of both the exercise and control groups at baseline and post protocol
There was no significant difference seen in the primary outcome measure i.e. PFT values (FEV_1, FVC, FEV_1/FVC) in between pre and post values of both the group's Exercise group (EG) and Control group CG.(Table No.4 and Graph No.3) The mean difference of both groups participants i.e. Exercise group and Control group post PFT results shows a significant difference inFEV_1 ($p=0.0002$) and FEV_1/FVC ($p=0.0001$) values and no significant difference in FVC values.(Table No.5)

Core Muscle strength Test Values
By applying 'Z' test of the difference between two proportions there was a significant difference between proportions of core strength from Pre to post level in the Exercise groupand no significant difference in control group participants and a significant difference from Post to Post levels between Exercise group and Control group ($p=0.0001$).(Table No.6 and Graph No.4)

CAT Scores

There was a significant mean difference from pre to post scores of CAT scores in the exercise group (p=0.0001) and control group (p=0.0001) participants by applying the Student's Paired 't' test.

The mean difference of both group'sparticipants i.e. EG and CG post CAT score results showed no significant difference by applying the Student's Unpaired 't' test,.(p=0.9178) (Table No.8 and Graph No.5)

mMRC Grades

There was a significant difference between proportions of mMRC grading from Pre to post grades in the Exercisegroup and Control group participants and a significant difference between Post to Post grades in the Exercise and Control group (p=0.0001) by applying 'Z' test of the difference between two proportions.(Table No.9 and Graph No.6)

Discussion:

The findings of this study reveal that there was no significant difference seen in the primary outcome measure i.e. PFT values (FEV1, FVC, FEV1/FVC) in between pre and post values of both the group's EG and CG and in comparison with EG's post mean value there is a significant increasein post mean value of CG's FEV1 and FEV1/FVC. Findings also suggest that patients recruited in the CG had increased FEV1 and FVC values compared to the EG at baseline. According to these findings, it can be concluded that core strengthening exercises using PBU with breathing exercises has no significant effects on PFT in comparison with breathing exercises alone in COPD patients. Thus, it is difficult to compare our present findings with previous studies as one study with the sameexercise protocol in asthma patients has shown significant improvements in PFT values post intervention in both the groups but no significant difference between both the group's baseline as well as their post values[7]. Another study on COPD patients using the respiratory and core-postural stabilization (RCS) breathing technique showed a significant improvement in PFT parameters compared to abdominal breathing (AB) exercise.[8] The probable reason for the decline in post PFT values in the EG of the present study can be due to abdominal muscle exhaustion which may be important to exercise performance in COPD since it either directly affects breathing or has indirect consequences. The abdominal muscles begin to contract as soon as even the smallest amount of movement is made.[9] End-expiratory lung capacity decreases when exercise intensity increases. While there is a constraint on expiratory flow, increasing abdominal muscle activation during exercising will not increase expiratory flow rates.[10]

Core strength test analysis demonstrated the improvement in the core strength of only 50% of individuals in EG and no improvement in CG. Improvement in core strength in this present study can be due to transversus abdominis and multifidus muscle co-activation which gives the spine segmental stability by attaching to the thoracolumbar fascia and raising intra-abdominal pressure, which stiffens the lumbar spine.[11]

Results of the CAT score analysis display significant improvement in both EG and CG from baseline to post 6 weeks. Between groups comparison shows no significant changes. The scores achieved post 6 weeks of the protocol are based on the overall symptomatic status of the patients. Itcan be stated that the protocol used for EG has no such greater effects on the symptomatic status ofthe patients and it is almost similar to the effects achieved in CG. Another reason for the reduction in symptoms is due to the medical treatment which was newly started when patients visited the outpatient setup during the baseline assessment. Previous studies based on breathing exercises or pulmonary rehabilitation have also shown positive results in the CAT score.[12, 13, 14]

The reason to include the CAT score in the present study is that it is considered as a useful tool to predict exercisetolerance in COPD.

The mMRC dyspnoea scale is a subjective questionnaire used to assess the severity of shortnessof breath. The grades have shown significant improvement in 50% of individuals in both groups.

According to statistical analysis, there is a significant difference between groups as only 1 individual has shown clinically more improvement in EG than other individuals and CG. Hence, it can be concluded that core strengthening with PBU and breathing exercises has no greater effects on dyspnea compared to breathing exercises alone. Results from the present study coincide with the previous study based on the RCS breathing technique in COPD patients which has shown significant improvement from pre to post in both groups but no greater effect of the RCS breathingtechnique compared to AB exercise.[8] In the literature, many studies have reported that breathing exercises have contributed positive results toward the severity of dyspnoea.[15, 16, 17]

The study thus concludes that the 6 weeks of core strengthening exercises with PBU and breathingexercises have no significant improvement effects on Pulmonary function test (PFT) when compared to breathing exercises alone.

Limitations of the study: The sample size was relatively small, further studies could be done on a higher number of patients. Other outcome measures e.g. EMG can be included in future studies to get more accurate results on the activity of core muscles.

Conflict of interest: The authors declare that there is no conflict of interest.

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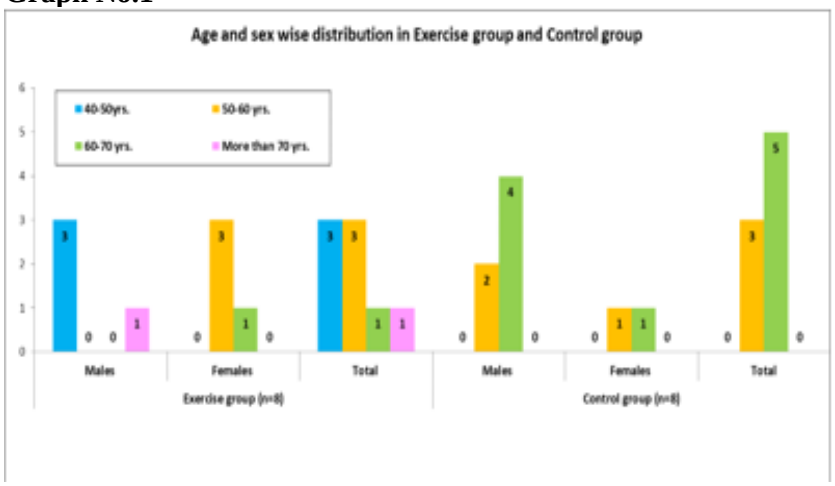
Table No.1: Age and sex wise distribution in Exercise group and Control group

Age in years	Exercise group (n=8)			Control group (n=8)		
	Males	Females	Total	Males	Females	Total
	No.	No.	No.	No.	No.	No.
40-50yrs.	3	0	3	0	0	0
50-60 yrs.	0	3	3	2	1	3
60-70 yrs.	0	1	1	4	1	5
More than 70 yrs.	1	0	1	0	0	0
Total	4	4	8	6	2	8
Mean ± SD	54.38 yrs.±10.53yrs.			62.75 yrs.± 4.65yrs.		

Graph No.1

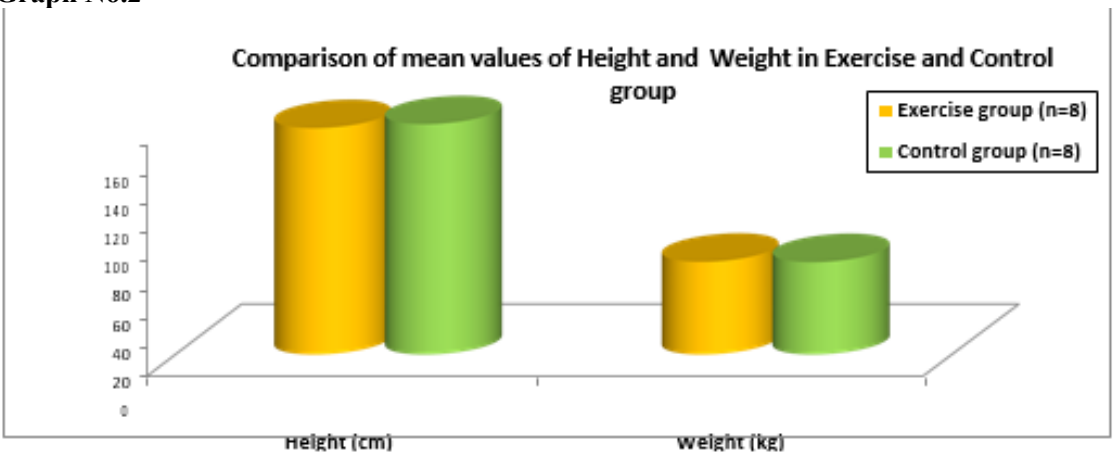


Comparison of mean values of Height and Weight in Exercise and Control group

Table No.2:

	Exercise group (n=8)	Control group (n=8)
	Mean ± SD	Mean ± SD
Height (cm)	157.00±10.27	159.75±6.56
Weight (kg)	64.13±14.79	63.88±15.38

Graph No.2



Comparison of mean and SD values of PFT in Exercise and Control groups

Table No.3:

Pulmonary Function Test (PFT)	Exercise group (n=8)		Control group (n=8)	
	PRE	POST	PRE	POST
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
FEV_1	1.07±0.46	0.73±0.18	1.19±0.46	0.93±0.49
FVC	1.63±0.56	1.46±0.38	1.69±0.51	1.47±0.24
FEV1/ FVC (%)	64.66±9.78	51.82±17.39	59.96±18.02	59.76±16.80

Graph No.3: .

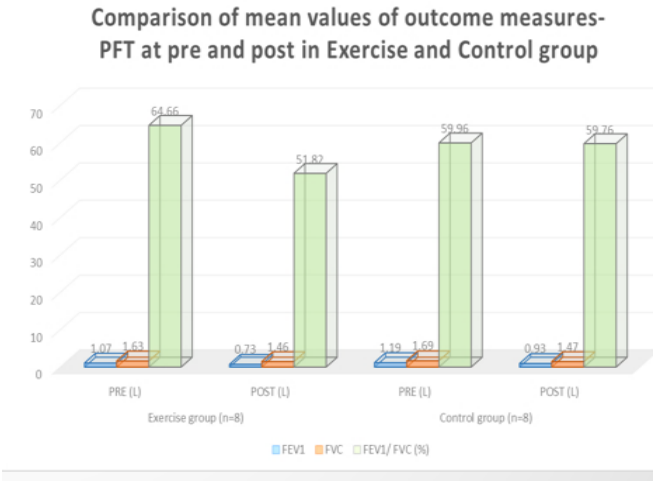


Table No.4: Student's Paired 't' test results and significance for PFT- Pre v/s Post in exercisegroup and control group

Pulmonary Function Test (PFT)	Exercise group (n=8)		Control group (n=8)	
	Difference from Pre L to Post	Student's Paired 't' test results and significance	Difference from Pre to Post	Student's Paired 't' test results and significance
FEV1	-0.34	t=0.9825, p=0.3425, not significant	-0.21	t=1.803, p=0.1144, not significant
FVC	-0.17	t=0,0835 p=0.9346, not significant	-0.22	t=0.1782, p=0.8636, not significant
FEV1/ FVC (%)	-12.84	t=1.121, p=0.2811, not significant	-0.20	t=0.1.172, p=0.2797, not significant

Table No.5: Student's Unpaired 't' test results and significance for PFT- exercise group Postv/s control group Post

Pulmonary Function Test (PFT)	Exercise group (n=8) V/s Control group (n=8)		
	Difference from Post to Post	Student's Unpaired 't' test value	'p' value and significance
FEV_1	-0.25	2.465	**p=0.0002, significant**
FVC	-0.01	1.997	p=0.0521, not significant
FEV_1/ FVC (%)	-7.94	2.991	**p=0.0001, significant**

Table No.6: Comparison of core strength

Core strength	Exercise group (n=8)		Control group (n=8)	
	Pre	Post	Pre	Post
0	2(25%)	0(0%)	2(25%)	3(37.5%)
Ia	2(25%)	3(37.5%)	3(37.5%)	3(37.5%)
Ib	4(50%)	4(50%)	2(25%)	1(12.5%)
2a	0(0%)	1(12.5%)	1(12.5%)	1(12.5%)
Total	8(100%)	8(100%)	8(100%)	8(100%)

Graph No.4

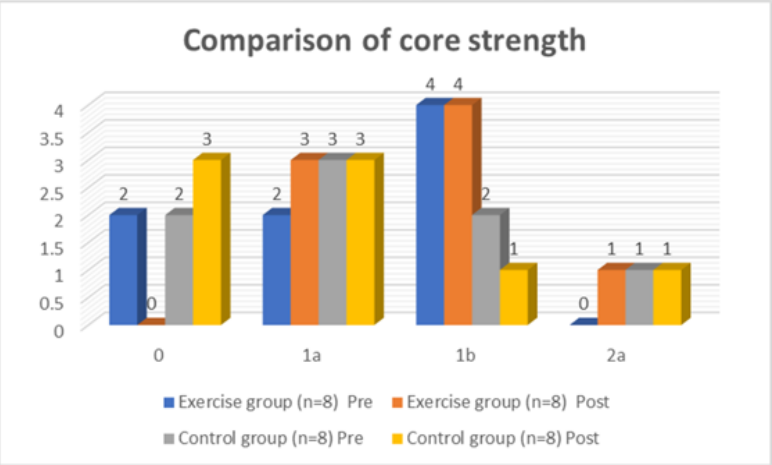


Table No.7: Comparison of mean and SD values of CAT score in exercise and control group and Student's Paired 't' test results and significance of Pre v/s Post

CAT score	Exercise group (n=8)				Control group (n=8)			
	PRE Mean ± SD	POST Mean ± SD	Difference Pre to Post	Student's Paired 't' test and significance	PRE Mean ± SD	POST Mean ± SD	Difference Pre to Post	Student's Paired 't' test and significance
	12.88±6.08	8.50±5.29	4.38	**Value of t=4.0236, p=0.0001, significant**	12.25±6.82	7.75±6.58	4.50	**Value of t=3.9979, p=0.0001, significant**

Student's Unpaired 't' test results and significance for CAT score- exercise groupPost v/s control group Post

Graph No.5

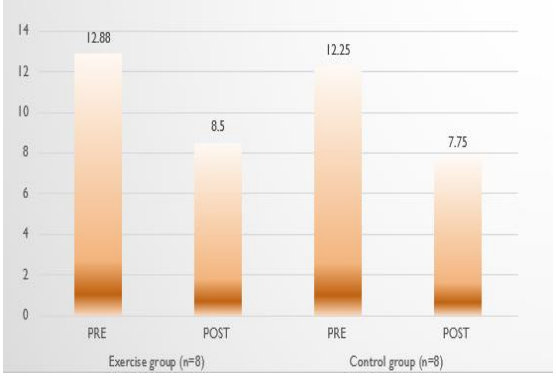


Table No.8:

CAT score	POST Mean ± SD	POST Mean ± SD	Difference from Post to Post	
	8.50±5.29	7.75±6.58	0.75	Value of t=0.5874, p=0.9178, not significant

Comparison of mMRC grade

Table No.9:

MMRC grade	Exercise group (n=8)		Control group (n=8)	
	Pre grade	Post grade	Pre grade	Post grade
0	0(0%)	2(25%)	0(0%)	2(25%)
1	4(50%)	3(37.5%)	3(37.5%)	3(37.5%)
2	3(37.5%)	2(25%)	2(25%)	1(12.5%)
3	1(12.5%)	1(12.5%)	3	2(25%)
Total	8(100%)	8(100%)	8(100%)	8(100%)

Graph No.6: