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Effectiveness of Diaphragmatic Stretching versus Rib Stretching on improving Pulmonary Function and Thoracic Excursion in Subjects with COPD

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Abstract:-

Background: Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable and treatable disease that is characterized by acute Exacerbation causing breathless, cough, and respiratory distress. Review of various studies indicated that diaphragmatic stretching and rib stretching improves pulmonary function.

Aim of the study: The Aim of the study to compare the effectiveness of diaphragmatic stretch and rib stretch on improving pulmonary function and thoracic excursion in subjects with COPD along with conventional physiotherapy.

Methods: Total of 72 subjects were selected, out of those 66 subjects were included who met the inclusion criteria and willing to participate in the study after obtaining the consent form were included. These 66 subjects are divided into two groups by sample of convince. In which 6 subjects dropped from the study due to change in the medication. The study was completed with the sample of 60 subjects, Group A (N=30) Diaphragmatic Stretching and Group B (N=30) Rib Stretching exercises. Both groups performed intervention for 1 hour a day, 5 days a week for 4 weeks. The outcomes of the study were FEV1/FVC ratio and thoracic excursion.

Results: Paired T test was used to access the statistical significance within the group, Independent T test was used to access the statistical significance between the groups, Statistical analysis of the data revealed that diaphragmatic stretching group has more difference when compared to rib stretching group.

***Keywords*:-** *Diaphragmatic Stretching, Rib Stretching, Pulmonary Function, Thoracic Excursion, FEV_1/FVC Ratio, Chest Expansion.*

I. INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable and treatable disease which is characterized by acute exacerbation causing breathless, cough, and respiratory distress. The primary cause for COPD is repeated exposure to cigarette smoking, although occupational exposure may also contribute towards its development. Comorbidities may have an impact on morbidity and mortality of the COPD subjects[1].

The prevalence of the disease is estimated to be around 10% in the population aged 40 years and could reach around 20%–30% according to gold criteria.

Stages of COPD according to Gold Criteria are, Stage I mild (FEV1/FVC <0.7 andFEV1>80 % predicted), Stage II Moderate (FEV1/FVC <0.7 and 50% <FEV1< 80% predicted), Stage III Severe (FEV1/FVC <0.7 and30% < FEV1 <50% predicted), Stage IV Very Severe (FEV1/FVC <0.7 and FEV1 <30% predicted or FEV1 <50% predicted plus chronic respiratory failure)[2].

In most cases of moderate to severe form of COPD, lung elasticity is greatly reduced limiting the lung recoil combined with expiratory flow limitation eventually leading to lung hyperinflation during the course of the disease[3].

The lung can be hyper inflated both at rest (static hyperinflation) and during exercise (dynamic hyperinflation) so due to this circumstance ventilatory requirements has been increased and expiratory time is shortened.

Hyperinflation affects the respiratory muscle interaction which leads to length changes in the diaphragm and intercostal muscles. So due to this chronic adaptability occurring in the skeletal muscles there will be reduction of number of sarcomeres in the muscle fibres by which the force generating capacity of the muscles will be altered and acquires the shortened position which leads to reduction of mobility in the muscles of respiration causing chest tightness and decreased chest expansion[4].

Patients with respiratory abnormalities exhibit alternate use of either the diaphragm or chest wall cyclically, so diaphragm and rib cage movements are progressively reduced and causes resistance to chest wall which leads to increased work of breathing due to demand placed on respiratory muscles[5].

Pulmonary rehabilitation is a multidisciplinary program based on a thorough patient assessment followed by patient – tailored therapies. But these are not limited to exercises training or education but also concentrate on behaviour change and improvement in the physical and psychological condition of people with COPD and to promote the long – term adherence to health –enhancing behaviours. So, It has been proven that health related quality of life and exercises capacity are greatly improved in individuals with COPD and studies suggest that pulmonary rehabilitation is useful in patient with moderate to severe COPD[6].

Physiotherapy is the milestone in the structure of pulmonary rehabilitation in which various techniques like Inspiratory Muscle Training (IMT), Cycle Ergometer Training (CET), pulmonary rehabilitation (PR), resistance training, manual diaphragmatic release technique, muscle energy technique (MET), Yoga, Aerobic Exercise, Diaphragmatic Breathing Technique, upper limb and breathing exercises are being used for overall well-being of COPD subjects. Although manual therapy techniques are less used in cardiorespiratory physiotherapy now a day's extensive research is being conducted on them and there is ongoing debate on respiratory muscle stretching in many chronic respiratory conditions[7].

Stretching of muscle fibres promotes increase in the number of sarcomeres in shortened muscles and increases muscle length[8]. An adequate length of respiratory muscles would promote an overall improvement in their contractile capacity and an increase in thoracic Expansion and providing benefits in the performance of respiratory mechanics [8].

The diaphragm, which is the chief inspiratory muscle, generates a craniocaudally movement of its dome during contraction and again goes to resting state as the increased abdominal pressure pushes the diaphragm up during exhalation phase.

The two main features in COPD are air trapping and lung hyperinflation this will impair the function of the diaphragm, shortening its operating length and changing the mechanical linkage between its various parts thereby placing it at mechanical disadvantage. These pathological changes affect the diaphragm's ability of raising and expanding the lower rib cage which may lead to a decrease in the transverse diameter of the lower ribcage during inspiration. So, the diaphragmatic stretch technique is designed to relax and enhance contraction in the diaphragm, thereby creating a greater pressure gradient between the thorax and abdomen.[9]

Rib muscles are widely spread throughout the rib cage, inter costal muscles help both in inspiration and forced expiration, even though these muscles help in respiration, they are morphologically and functionally skeletal muscles and it helps in upward and outward movement of the ribs which results in pump handle and bucket handle movements in the upper thorax in which anterior-posterior and transverse diameters of the thoracic cavity increases during inspiration and comes to normal position during expiration[12]. Due to air entrapment, there will be expiratory airflow limitation in COPD which leads to shortening of the intercostal muscles. Various research studies demonstrated that IC stretching improved expired tidal volume by which the level of dyspnoea decreased (increase respiratory rate) and increased chest expansion clinically which results in better gaseous exchange. [10]

So, these change in the chest excursion because of restricted chest wall mobility were objectively measured with spirometry. The criterion for diagnosis defined in guidelines is based on the FEV1/FVC ratio and its severity is based on forced expiratory volume in one second (FEV1) from measurements obtained during maximal forced expiratory manoeuvres.[11]

Spirometry is the primary outcome employed to measure pulmonary function in this study and secondary outcome measure is thoracic excursion which is measured with inch tape is a common practice employed to measure thoracic excursion in which axillary ,nipple and xiphysternal level of thorax are measured.[15] Both the outcomes are valid, reliable and cost effective. This study is being conducted to find out the best stretching protocol as both the diaphragmatic exercises and rib stretching's exercises are effective in treating COPD complications[12, 13].

NEED OF THE STUDY

COPD with hyperinflation shows abnormalities in chest wall movements and develops barrel chest in the later on stages of the disease. As the rib cage stays particularly in the expanded position all the time due to the entrapment of air in lungs. As the diaphragm muscle and intercostal muscles will be in shortened position. So various studies are being conducted for improving the chest wall motion and decrease in the hyperinflation of the lung.

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Recently few studies were conducted on respiratory muscle stretching but results are not consistent and also a long term studies have been conducted which are above 6 weeks duration. So I urged to conduct this study to set the protocol in shortest duration that is in 4 weeks and to know which technique will show the best results. So lack of clear evidence on this topic and very few studies on manual therapy techniques in cardio- respiratory conditions motivated me to conduct this study on effectiveness of diaphragmatic stretching versus rib stretching on improving pulmonary function and thoracic excursion in subjects with COPD.

II. METHODOLOGY

Study setting: Department of Pulmonology, KIMS Medical College and General Hospital and, A Subbarao Hospital, Amalapuram.

STUDY DESIGN: Experimental pre-test post-test design, comparative in nature.
STUDY SAMPLING: Convenience sampling

Method of data collection: Total of 72 subjects were selected, out of which 66 subjects were included who met the inclusion criteria and willing to participate in the study after obtaining the consent form. These 66 subjects are divided into two groups by sample of convince. In which 5 subjects dropped from the study due to exacerbations and change in medication. Remaining 1 person made to leave the study to divide the groups equally. The study was completed with the sample of 60 subjects.

SAMPLING SIZE: 60
Group-A: 30 patients were assigned to this group and were trained diaphragmatic stretching.
Group-B: 30 patients were assigned to this group and were trained rib stretching.
STUDY DURATION: 4 weeks
STUDY PERIOD: July 2020 to June 2021

ETHICAL CLEARANCE: Ethical clearance was taken from ethical committee of konasemma institute of medical science and research foundation at Amalapuram

RECORDING MATERIALS:
Digital Spirometer
Assessment Proforma
Data collection chart

INCLUSION CRITERIA
- Subjects with stable COPD who are diagnosed by pulmonologist or physicians were taken.
- Both genders were included.
- The age group of 35 to 65 years who are able to understand local language were included.
- Subjects who are ambulatory were recruited into the study.
- Patients with moderate to severe COPD according to gold criteria (Gold 2: moderate FEV1; 50-79%, Gold 3: severe FEV1; 30-49% were taken into the study).

EXCLUSION CRITERIA:
- acute exacerbations of COPD
- unstable Hemodynamic parameters
- who have undergone recent Cardiothoracic or abdominal surgery
- A recent history of chest wall or abdominal trauma
- History of psychiatric illness
- Unstable vital signs
- Arrhythmia, Ventricular tachycardia
- Cardiovascular problems
- Musculo skeletal disorders
- Acute rib fractures
- Severe osteoporosis

MATERIALS
- Bed sheet
- Pillows
- Foam roller
- Recording sheet
- Assessment Preform
- Data collection chart
- Daily Assessment chart

OUTCOME MEASURE
- FEV1/FVC ratio which will be measured by digital spirometry.
- Thoracic excursion by using inch tape at axillay,nipple and xyphisternal levels .

PROCEDURE
Total of 60 subjects after fulfilling the inclusion criteria were taken by sample of convenience. All the subjects were explained about the condition and mode of assessment and written informed consent were obtained from them and pre- test is done and divided into 2 groups, group A (N=30) and group B (N=30). Subjects were scheduled to attend exercise session for 1 hour 5 days a week for 4 weeks. During training program all the patients were allowed to continue their pharmacological therapy, counselling about smoking cessation, food habits and life style modification was given commonly. And for both groups conventional physiotherapy was given commonly.

GROUP A - DIAPHRAGMATIC STRETCHING
Diaphragmatic Stretch Technique. The subjects were asked to sit in the erect position and the therapist will stand behind the subject passing his or her hands around the thoracic cage, introducing fingers in the subcostal margins and subject's trunk was rounded slightly to relax the rectus abdominis. As the subject exhales, the therapist ease their hands caudally grasping the lower ribs at the subcostal margin. Thus firm, but gentle, traction was maintained as the patient inhales[29].

Hold time: The stretching was performed once and the tension was maintained for 15-30secs
Frequency: 5 times a week

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GROUP B - RIB STRETCHING

Subjects were asked to lie in supine and lateral position on a half moon-shaped foam roller in the infra - axillary region with forearms flexed and hands resting on the occipital region; the therapist uses both palmar regions of the hands to mobilize the ribs in the cranio -caudal direction[30].

Hold time: the stretching was performed once and the tension was maintained for 15-30 seconds.
Frequency: 5 times a week

CONVENTIONAL PHYSIOTHERAPY

Breathing techniques and positioning Teach patients ways to breathe to reduce the work of breathing and maximize the amount of air entry to the lungs. The patient's position is important in order to achieve relaxation of respiratory muscles.
The positions most commonly used are:
Half lying
Side lying with the upper arm supported on a pillow
High side lying with the arm supported on a pillow
Sitting in a comfortable upright chair

Mucus clearance techniques Forced Expiratory Techniques has been shown to increase the efficiency in the clearance of bronchial secretions, without causing or increasing bronchospasm. It consists of one or two huffs from mid-lung volume to low-lung volume followed by a period of relaxed diaphragmatic breathing. This period of relaxed diaphragmatic breathing is essential part of the technique to prevent the aggravation of any bronchospasm.

Shoulder mobility exercises:
Shoulder Flexion-Extension exercises
Shoulder Rotation exercises
Shoulder Bracing Exercises

These exercises are performed in sitting position; these will stretch the shortened muscles in COPD patients and improving the chest expansion and lung function.

Thoracic mobility exercises:

Lateral flexion of the trunk on both sides with stretched upper limbs, forward and backward bending with stretched upper limbs. These exercises are performed sitting or standing position; these will increase the mobility of ribs and improving the thoracic and cervical spine range of movement, finally improving the chest expansion and lung function.

OUTCOME MEASURES
PULMONARY FUNCTION

Pulmonary function test was performed by using a portable electronic spirometer, to assess FEV1/FVC ratio. Initially name, age, height and weight of the patient were entered in to the data of the machine in order to get percentage predicted values. The patient is placed in a comfortable high sitting position and was instructed to put the mouth piece of the spirometer in to the mouth and inhale as much as possible and then exhale rapidly and forcefully for as long as flow can be maintained. This was repeated for three times until the largest value of FEV1/FVC ratio was given out automatically by spirogram with flow volume chart[30].

THORACIC EXCURSION

Chest mobility was assessed by thoracic excursion, i.e. the difference between thoracic circumference at peak inspiration and expiration in the standing position with arms alongside the trunk24. The reliability of this methodology for upper and lower thoracic excursions is high (ICC=0.84-0.91)24. One researcher measured the thoracic circumference with a measuring tape held around the chest on two levels: upper and lower thorax.

Upper thoracic excursion was assessed by placing the tape on the 3rd intercostal space at the midclavicular line and the 5th thoracic spinous process. Lower thoracic excursion was measured at the tip of the xiphoid process and the 10th thoracic spinous process. Participants were asked to hold their breath at peak inspiration and expiration for data collection. A practice trial was allowed for participants to be familiar with testing procedures[31, 32].

III. RESULTS

The aim of the study was to compare the effectiveness of diaphragmatic stretching versus Rib stretching on improving pulmonary function and thoracic excursion in subjects with COPD. The consort flow chart of the study showed the study organization in terms of subjects screening, random allocation and analysis following the intervention.

A total number of 72 subjects were screened for eligibility, in which 60 patients were recruited in to the study. All the subjects who met inclusion criteria were included in to the study had undergone a baseline assessment and these subjects were randomized in to two equal groups in which each group consists of 30 patients.

The results of this study were analysed based on the outcome parameters, which includes FEV1/FVC ratio and thoracic excursion.

STATISTICAL ANALYSIS

Statistical analysis: T paired test

Statistical analysis was performed by using spss software version21.0 and Microsoft excel – 2007 descriptive statistical data were present in the form of mean +/- in standard deviation and mean differences percentages were calculated and presented.

Between the groups: independent student t test was performed to verses the statistical significance difference in mean value between groups for diaphragmatic stretching and rib stretching

Within groups: paired student t test was performed to assess statical difference with in the groups for diaphragmatic stretching and rib stretching

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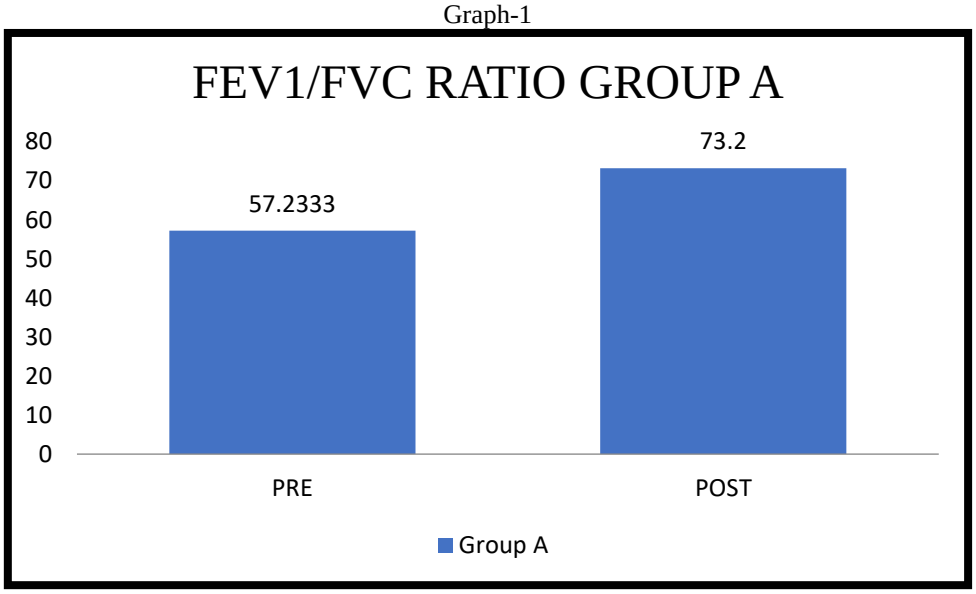
Table – 1: Analysis of FEV1/FVC pre and post interventions Group A

Table – 1: Analysis of Pre and Post Interventions Group A		Mean	N	Std. Deviation	Std. Error Mean	p-value
FEV1/FVC	PRETEST	57.233	30	1.6955	0.3096	0.000*
	POSTTEST	73.2	30	7.5631	1.3808	

Graph-1

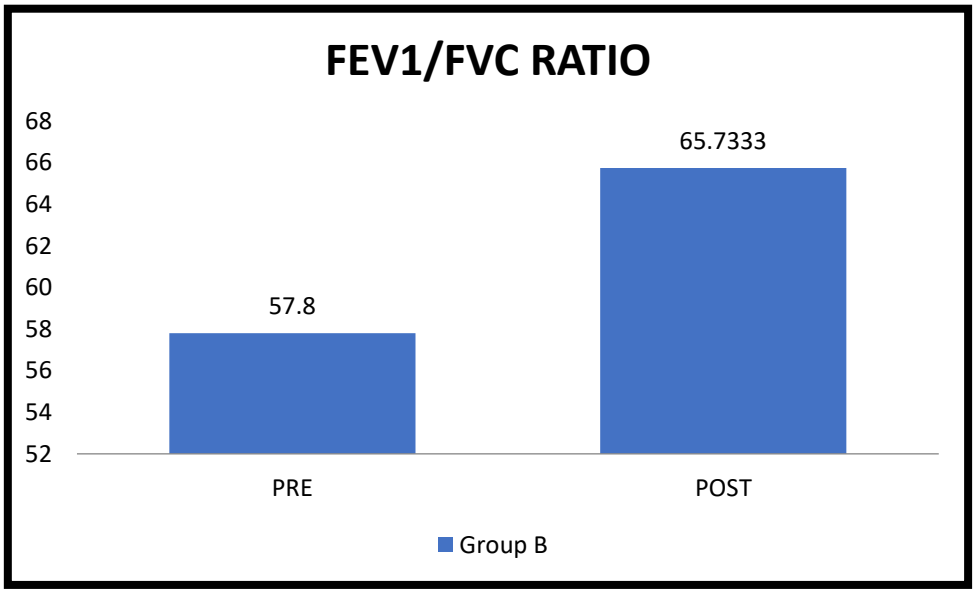


Result: the above table and graph shows significant improvement in FEV1/FVC ratio Group A)P value-0.000(

Table – 2: Analysis of Pre and Post Interventions Group B

		Mean	N	Std. Deviation	Std. Error Mean	p-value
FEV1/FVC	PRETEST	57.9	30	2.7216	0.4969	0.000
	POSTTEST	65.7333	30	4.4793	0.8178	

Graph-2



Result: the above table and graph shows significant improvement in FEV1/FVC ratio Group B)P value-0.000(

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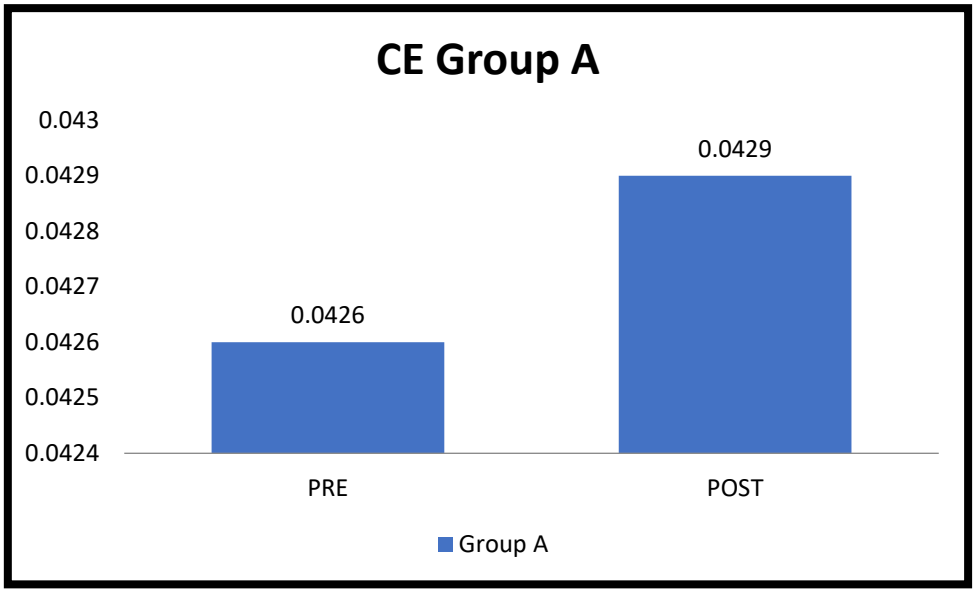
Table – 3: Analysis of Pre and Post Interventions Group A

		Mean	N	Std. Deviation	Std. Error Mean	p-value
CE	PRETEST	0.0426	30	0.0003	0.0001	0.000*
	POSTTEST	0.0429	30	0.0003	0.0001	

Graph-3

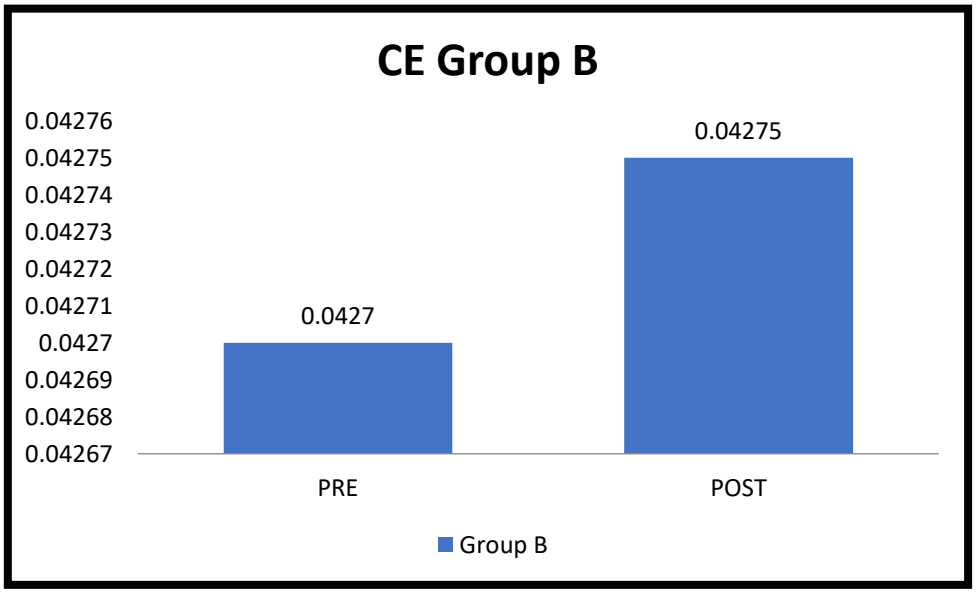


Result: the above table and graph shows significant improvement in Chest expansion Group A)P value-0.000(

Table – 4: Analysis of Pre and Post Interventions Group B

		Mean	N	Std. Deviation	Std. Error Mean	p-value
CE	PRETEST	0.0427	30	0.0004	0.0001	0.584
	POSTTEST	0.04275	30	0.0004	0.0001	

Graph-4



Result: the above table and graph shows no significant difference in Chest expansion Group B)P value-0.584(

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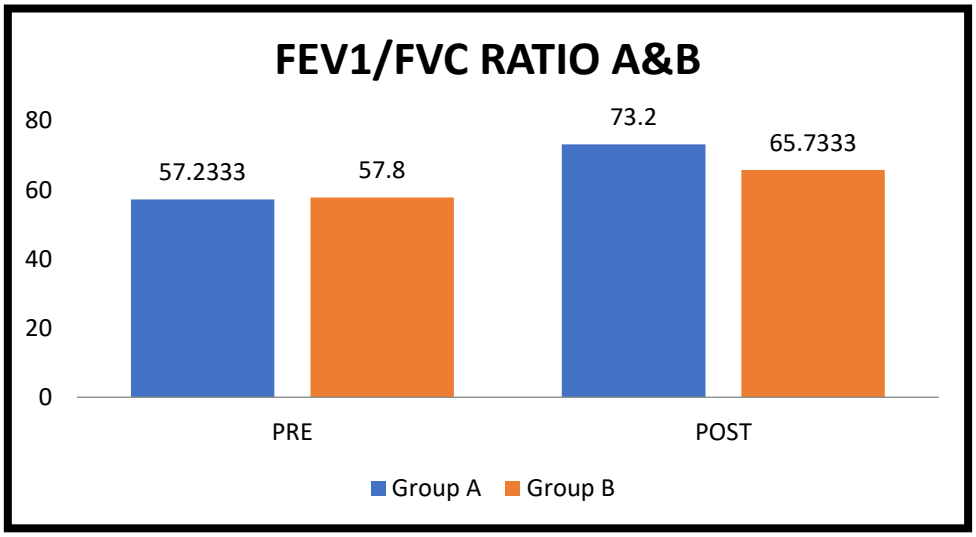
Table – 5: Analysis of Post test scores of FEV1 between Group A and Group B

GROUPS	FEV1/FVC RATIO	N	Mean	Std. Deviation	Std. Error mean	P value
GROUP-A	**PRE-TEST**	30	57.233	1.6955	0.3096	**0.169**
GROUP-B	**PRE-TEST**	30	57.8	2.7216	0.4969	
GROUP-A	**POST-TEST**	30	73.2	7.5631	1.3808	**0.000**
GROUP-B	**POST-TEST**	30	65.733	4.4793	0.8178	

Graph-5

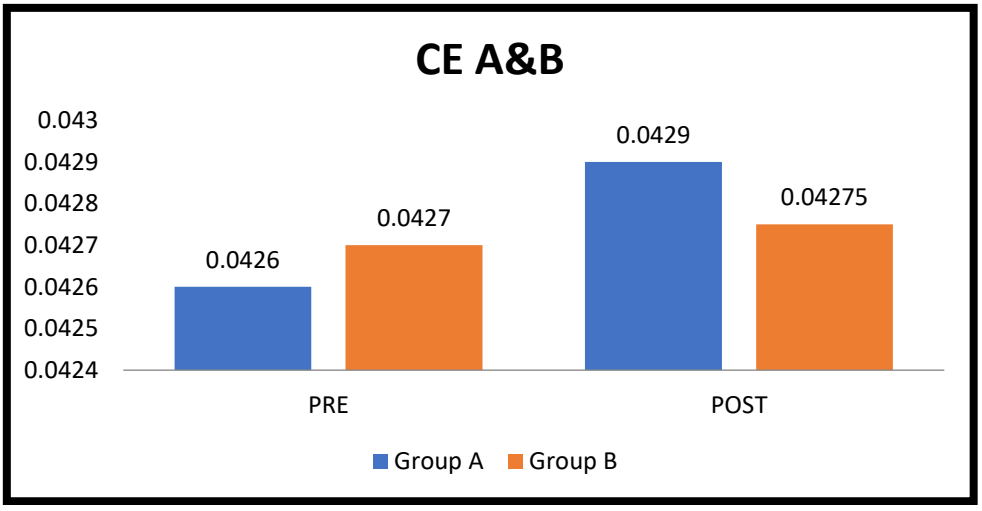


Result: the above table and graph shows significant improvement in FEV1/FVE ratio Group A & B.)P value-0.000(

Table – 6: Analysis of Post test scores of CE between Group A and Group B

GROUPS	CE	N	Mean	Std. Deviation	Std. Error mean	P value
GROUP-A	**PRE-TEST**	30	0.0426	0.0003	0.0001	**0.000**
GROUP-B	**PRE-TEST**	30	0.0427	0.0004	0.0001	
GROUP-A	**POST-TEST**	30	0.0429	0.0003	0.0001	**0.021**
GROUP-B	**POST-TEST**	30	0.04275	0.0004	0.0001	

GRAPH-6



Result: the above table and graph shows significant improvement in Chest expansion Group A & B.)P value-0.021(

IV. DISCUSSION

Patients with COPD had hyperinflation that affects the respiratory muscle interaction which leads to length changes in the respiratory muscles. Due to this chronic adaptability, reduction of number of Sarcomeres in the respiratory muscles occurs. However, regular stretching of respiratory muscles has been associated with reduced risk of hyperinflation in COPD subjects.

The aim of the study is to compare the effectiveness of diaphragmatic stretching and rib stretching on improving pulmonary function and thoracic excursion in subjects with COPD. The results of the study have shown substantial improvement in outcome measures which were attained in both the groups along with conventional therapy, but diaphragmatic stretching is superior to rib stretching in case of pulmonary function and thoracic excursion. So, after acquiring the results, my study accepted alternate hypothesis as there is a significant difference in FEV1/FVC ratio and thoracic excursion when compared post mean and p values between the groups.

This is the first study to compare the diaphragmatic stretching and rib stretching in shortest duration of 4 weeks. A total of 66 subjects were included in the study with 6 not meeting the inclusion criteria and 6 dropouts 3 from the diaphragmatic stretching and 3 from the rib stretching groups. The pre and post-test values measured in the study were FEV1/FVC ratio and thoracic excursion.

The underlying mechanism behind the diaphragmatic stretch technique is to relax the resting state of the diaphragm and enhance its contraction and relaxation functions, thereby creating a greater pressure gradient between the thorax and abdomen. The results of my study are similar to the study conducted by Gonzalez-´ Alvarez FJ et al. on diaphragmatic stretching to check ribcage and abdominal excursion in unhealthy subjects and found a significant improvement at xiphoid level.

The results of this study showed a statistically significant improvement in FEV1/FVC ratio (p=0.000), and thoracic excursion (p=0.000) in pre and post-test of values within diaphragmatic stretching group.

Rib stretching group also showed improvement on pulmonary function and thoracic excursion. IC stretching may have activated the stretch receptors in the chest wall, thereby distending the thorax which could be neurologically linked to medulla with efferent nerve cells. This neuro-physiological facilitator stimulus may account for more normal respiratory patterns among unconscious subjects. The results of the study showed a statistically significant improvement in FEV1/FVC ratio (p=0.000), thoracic excursion (p=0.000) within the rib stretching group.

So, the present study was conducted with respiratory stretches along with conventional chest physiotherapy to understand its short-term effects in patients with COPD. Maybe the addition of conventional physiotherapy to both the experimental groups showed improvement in pre to post-test values which are not included in the other studies.

Therefore, based on the analysis of present study, both diaphragmatic stretching and rib stretching along with conventional physiotherapy helps in improving pulmonary function and thoracic excursion in COPD subjects. But there is significant difference in FEV1/FVC ratio (p=0.000), thoracic excursion (p=0.021) when compared between the two groups.

In the diaphragmatic stretch group, the significant changes may be due to increase in the transverse and vertical diameter of the rib cage, but intercostal muscles mostly act on the upper part of the rib cage. So, based on the analysis these study findings suggest that four weeks of diaphragmatic stretching along with conventional physiotherapy will significantly improve pulmonary function and thoracic excursion in COPD subjects.

LIMITATIONS

- The sample size studied was small.
- The frequency of the treatment sessions is less.
- The study did not include long term follow-up.

REOMMENDATIONS

- Sample size can be increased with inclusion of a greater number of subjects to generalize the effects of these techniques in larger population.
- Further studies can be done to check the effects of these techniques on other conditions.
- Study can be done on males and females separately.
- Further studies can be done in chronic bronchitis and emphysema separately.

V. CONCLUSION

The results had shown that both Group-A (Diaphragmatic stretching Group) and Group-B (Rib stretching Group) who received four weeks of therapy has improved significantly on pre and post-test values within the groups but when compared between these groups statistical significance is noted in Group-A. So, study concludes that Diaphragmatic stretching exercises are effective when compared to Rib stretching exercises in improving pulmonary function and thoracic excursion in subjects with COPD

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