International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Benefits of Inspiratory Muscle Training in COPD Patients

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Abstract: ***Background**: Chronic Obstructive Pulmonary Disease (COPD) is a primary lung disease .The hyperinflation induces increased strain on the respiratory muscles, which are forced to work in a limited range of movement with negative pressure/effort relationship, leading to fatigue and increased dyspnoea. So purpose of this study is to assess the effect of Inspiratory Muscle Training on PImax and 6 Minute Walk Distance (6MWD).**Objective: To** assess the effectiveness of inspiratory muscle training on inspiratory muscle performance (PImax) & Exercise capacity in COPD. **Materials and Methods**: An Interventional study was conducted on 40 COPD patients having mild to moderate severity, to assess the pre and post differences in PImax, and 6MWD by applying inspiratory muscle training. **Result**: Statistical analysis showed that there is significant improvement in all outcomes after application of inspiratory muscle training. **Conclusion**: It can be concluded from the present study that Inspiratory Muscle Training has significant effect on PImax and 6MWD in COPD patients.*

Keywords: Inspiratory Muscle Training, COPD, PImax, 6MWD

1. Introduction

The term Chronic Obstructive Pulmonary Disease (COPD) refers to chronic disorder that disturbs airflow. COPD is a major cause of morbidity and mortality in india.[1]COPD is a preventable and treatable disease with some significant extra-pulmonary effects that may contribute to the severity in individual patients. Its pulmonary component is characterized by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and associated with an abnormal inflammatory response of the lung to noxious particles or gases.[2]Both GOLD [2] and ATS/ERS agree that COPD is to be suspected when there is a history of exposure to risk factors for the disease, chronic cough, sputum production and/or dyspnoea and that diagnosis must be confirmed by spirometry. When forced expiratory volume in one second (FEV_1) divided by forced ventilator capacity (FVC) is < 70%, even after administration of a bronchodilator, the diagnosis is confirmed[1]. In patients older than 70 years a somewhat lower ratio (< 65%) has been suggested.[3]Some guidelines claim that besides $FEV_1/FVC < 70\%$, the FEV_1 should be < 80% of predicted value for diagnosis of COPD.[4]

Expiratory airflow is limited because of the obstruction, leading to air trapping and hyperinflation. This accentuates when the minute ventilation or respiration rate is increased, for example during exercise.[5] The hyperinflation induces increased strain on the respiratory muscles, which are forced to work in a limited range of movement with negative pressure/effort relationship, leading to fatigue and increased dyspnoea.[6,7]

To avoid the distressing feeling of dyspnoea, the patients with COPD tend to avoid physical exertion and adapt a more sedated lifestyle than healthy elderly subjects.[8] This, in turn, leads to a vicious cycle of reduced exercise capacity inducing increased dyspnoea during exercise which leads to a further avoidance of exercise and so on. Exercise capacity is impaired in COPD, both peak exercise capacity and functional exercise capacity. Besides lung hyperinflation and physical inactivity, ventilation-perfusion mismatch, hypoxemia, cardio-vascular problems and muscular changes contribute to the reduced exercise capacity. Functional exercise capacity is one of the key prognostic factors of morbidity and mortality in COPD[9] and correlates strongly with physical activities in daily life.[8]

Both the loss of the lung's elastic recoil, and the development of expiratory flow limitations promote progressive air trapping, with an increase in the end-expiratory lung volume and a decrease in inspiratory capacity (IC). Hence, this static lung hyperinflation, and its increase during exercise (dynamic hyperinflation), have been associated with limitations in the functional capacity of those patients.[10]Respiratory muscle dysfunction is attributed to multiple factors related to the presence and severity of COPD. Indeed, intrinsic (muscular and metabolism mass) as well as extrinsic factors (changes in chest wall geometry and diaphragm position, and systemic metabolic factors) may alter respiratory muscle function.[11]

In COPD, there is an imbalance in these two opposing forces. As elasticity decreases, an increase in the A-P diameter (more of a barrel shape) of the hyperinflated thorax is apparent, along with flattening of the diaphragm at rest. The range of motion, or excursion, of the thorax is limited. Although the basic problem in COPD is an inability to exhale, it is clear that inspiratory reserve is compromised. Hyperinflation affects not only the bony components of the chest wall but also the muscles of the thorax. The fibers of the diaphragm are shortened, decreasing the available range of contraction. The angle of pull of the flattened diaphragm fibers becomes more horizontal with a decreased zone of apposition. In severe cases of hyperinflation, the fibers of the diaphragm will be aligned horizontally. Contraction of this flattened diaphragm will pull the lower rib cage inward, actually working against lung inflation.[12]

The disadvantages of these biomechanical alterations of hyperinflation are compounded by the increased demand for ventilation in COPD. More work is required of a less

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effective system. The energy cost of ventilation, or the work of breathing, in COPD is markedly increased. In particular, it has also been demonstrated that placing a load on the respiratory muscle during contraction is sufficient in increasing strength, thus causing a meaningful reduction of breathlessness and an increase of physical exercise ability.[13]

Respiratory muscle weakness is often in patients with COPD.[14]Adaptation of the diaphragm result in greater fatigue resistance and improved muscle function.[15]Muscles of inspiration, however, are like other skeletal muscles: they can adapt in response to exercise when challenged with a sufficient load.[16]

Objective of this study was to assess the effectiveness of inspiratory muscle training on inspiratory muscle performance (PImax)& Exercise capacity in COPD.

2. Materials and Methods

- **Study Design:** Interventional study (Before and after with control)
- **Sample Design:** Convenient sampling
- **Sample Size:**40 Patients
- **Duration of Study:** 6months

2.1 Selection Criteria

Inclusion Criteria: Patients diagnosed as having COPD by the physician. The diagnosis was confirmed by COPD questionnaire clinically, Age: 45- 65 years, Sex: male, Patients with mild to moderate severity according to GOLD classification, Patients who are able to comprehend commands, Patients who are willing to participate, Patients who are clinically stable (out of acute exacerbation or hospitalization)

Exclusion Criteria: Patients with unstable vital parameters, Those who have active lung infection, Patients with congenital heart disease, ischemic heart disease, rheumatic heart disease, Patients with any musculoskeletal or neurological problem, Patients with continuous Oxygen therapy, Patients with lung surgery

2.2 Materials

Figure 1: Instruments used for study

Figure 2: PImax –Threshold Device (RMS)

Ambulatory Pulse Oxi meter (PM-60), Cloth Measure tape, Stethoscope, Pulmonary Function Test, PImax –measuring instrument(RMS), 30 meter length corridor without any obstruction, Two indicators, Stop watch, Sphygmomanometer, Inspiratory threshold loading device (Threshold IMT; Respironics,Cedar Grove, NJ, USA), Back supported plinth and chair

2.3 Outcome Measure

<u>Inspiratory Muscle Perfomance (Pimax)</u>:
Measurement of the maximum static inspiratory pressure thata subject can generate at the mouth (PImax) or the maximum staticexpiratory pressure (PEmax) is a simple way to gauge inspiratoryand expiratory muscle strength.[17]

When respiratory muscle weakness occurs, the PImax can be moresensitive than the VC because the relationship between VC andPImax is curvilinear[18], so that decreases in respiratorymuscle strength occur before decreases in lung volume can beidentified.

The test should be performed by whoshould strongly urge subjects to make maximum inspiratory (Muellermaneuver) and expiratory (Valsalva maneuver) efforts at or nearRV and TLC, respectively. Subjects are normally seated and nose clipsare not required. Because this is an unfamiliar maneuver, carefulinstruction and encouraged motivation are essential. Subjectsoften need coaching to prevent air leaks around the mouthpieceand to support the cheeks during the expiratory efforts, andthis may be helped by having them pinch their lips around themouthpiece. Once the operator is satisfied, the maximum valueof three maneuvers that vary by less than 20% is recorded. Lessvariability may be necessary in a research setting, but evenlow variability may not guarantee that maximal efforts havebeen made[19]. The overall function of the diaphragm and accessory inspiratorymuscles showed significant changes after training in the inspiratorymuscle training group as expressed by an increase,first, in the inspiratory muscle strength (PI_{max}) and second, in the inspiratory muscle endurance.

<u>The Six Minute Walk Distance (6MWD):</u>

The 6-min walk distance (6MWD) is a test used to assess thefunctional status of patients with COPD. Introduced in 1976as a 12-min walk test to measure exercise capacity for patientswith chronic lung disease[20], over time it has proved to bereliable, objective, inexpensive and easy to apply regardlessof the patient's age or educational level .[21,22]

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If the6MWD represents a measurement that changes independently of FEV_1, it perhaps could be used as a parameter to evaluate theclinical status of patients, particularly those with the mostsevere COPD, in whom FEV_1 may not completely reflect functionaland health status.[23]

2.4 Detailed Procedure

40 patients were selected according to inclusion and exclusion criteria from OPD of Pulmonary Medicine Department, Civil hospital Ahmedabad. Consent of these patients was taken. These patients were divided randomly into two groups (20 in each groups), one group was interventional and other being the controlgroup. We measured the PImax&6 minute walk distance in both groups

In interventional group patients were given relaxation by half lying positioning with supported pillows and supported sitting position. Then patients were asked to do pursed lip breathing &Diaphgramatic exercise. Then patients were given inspiratory muscle training. In interventional group one patient could not complete 6- week training.

2.5 Inspiratory Muscle Training:[24]

Duration & Frequency

3 times per week for 6 weeks. Each session lasted 20 min & comprised of an inspiratory threshold loading device followed by of rest.

Training was supervised and took place three times a week for6 weeks. A interval-based IMT programme using amodified threshold training device (Threshold IMT; Respironics,Cedar Grove, NJ, USA) was applied, which comprised seven cyclesof 2 min loaded breathing followed by a 1-min rest.[25]To familiarize subjects with the handheld training device, alow inspiratory load (45% of the pre-training $P_{I,max}$) was appliedduring the first training session. The load was increased sothat following the third session, subjects were generating inspiratorypressures equivalent to ~60% of the pre-training $P_{I,max}$ witheach breath. Subjects were permitted to choose their own breathingpattern. The load was further increased over the 6-week.

Control group: patients are given relaxation by half lying positioning with supported pillows. Then patients are asked to do pursed lip breathing and diaphragmatic breathing exercises.

2.6 Data Analysis

Comparison of data for PImax and 6MWD were done using paired t test.

Table 1: Difference in means of Age

Group A	55.05±5.95¥
Group B	54.15±5.72¥

¥: Mean ± SD

3. Result

Table 2: Difference in means of INSPIRATORY MUSCLE PERFOMANANCE (PImax):

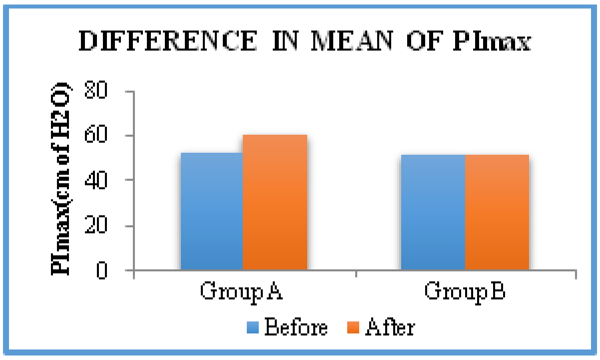
	Before¥	*After*¥	*t-value*	*p value*
Group A	52.95±17.98	60.68±19.00	7.608	<0.0001
Group B	51.25±17.62	51.75±17.62	3.249	0.0042

¥: Mean ± SD

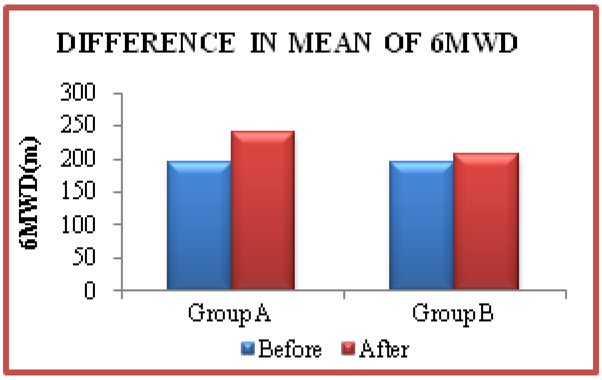
Table 3: Difference in means of 6MWD:

	Before¥	After¥	t-value	p value
Group A	193.68±63.36	240.95±74.13	8.672	<0.0001
Group B	193.25±69.28	205.85±78.44	2.420	0.0257

¥: Mean ± SD



Graph 2: Difference in Mean of PImax



Graph 2: Difference in Mean of 6MWD

4. Discussion

The study was conducted to find out the effect of Inspiratory Muscle Training in COPD patients who had mild to moderate severity and is based on randomized case control study. The study was conducted for 6 months. Subjects were assigned to either Interventional Group in which patient are given IMT with conventional treatment & pursed lip breathing exercise and diaphragmatic breathing exercise in a relaxed positioning as a conventional treatment in a control group.

Inspiratory muscle performance (PImax) and exercise capacity (6MWD) values were taken as outcome measure for the study. The results showed highly significant effect on Inspiratory muscle performance (PImax) and exercise capacity (6MWD) values in interventional group. There was improvement in Inspiratory muscle performance (PImax) and exercise capacity (6MWD) in control group.

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Expiratory airflow is limited because of the obstruction, leading to air trapping and hyperinflation. This accentuates when the minute ventilation or respiration rate is increased, for example during exercise.[5]

The hyperinflation induces increased strain on the respiratory muscles, which are forced to work in a limited range of movement with negative pressure/effort relationship, leading to fatigue and increased dyspnoea.[6,7] To avoid the distressing feeling of dyspnoea, the patients with COPD tend to avoid physical exertion and adapt a more sedated lifestyle than healthy elderly subjects.[8] This, in turn, leads to a vicious cycle of reduced exercise capacity inducing increased dyspnoea during exercise which leads to a further avoidance of exercise and so on.

In COPD there is hyperinflation of the thoracic cavity and air trapping after an expiration. The rationale of the inspiratory muscle training of reducing dyspnea, improving inspiratory muscle performance and exercise performance is decreasing PI/PImax ratio by increasing PImax will result in less dyspnea.[26]

Exercise capacity is impaired in COPD, both peak exercise capacity and functional exercise capacity. Besides lung hyperinflation and physical inactivity, ventilation-perfusion mismatch, hypoxemia, cardio-vascular problems and muscular changes contribute to the reduced exercise capacity. Functional exercise capacity is one of the key prognostic factors of morbidity and mortality in COPD[9] and correlates strongly with physical activities in daily life.[8]

In particular, it has also been demonstrated that placing a load on the respiratory muscle during contraction is sufficient in increasing strength, thus causing a meaningful reduction of breathlessness and an increase of physical exercise ability.[20]

Three basic principles of skeletal muscle training are overload, specificity, and reversibility.[27]The training used in our study rested on a training incentive of sufficient intensity to produce a training effect (overload), and the training and testing devices used the same training modality (specificity). The reversibility principle states that the effects of conditioning decline after training ceases. Therefore, when patients finish the training period, recommendation that they continue performing breathing exercises regularly in order to maintain the obtained improvements.

IMT increases the velocity of inspiratory muscle shortening, the reducing time for inspiration and allowing more time for expiration. IMT reduces the activity of metabo-reflex (respiratory), allowing more blood flow to the exercising peripheral muscles.

Baraka Shahin in 2008, in their study " Benefits of short inspiratory muscle training on exercise capacity, Dyspnoea& inspiratory fraction(IF) in COPD patients" and had concluded that in patient with COPD, inspiratory muscle training results in improvement in performance , exercise capacity, sensation of dyspnoea& moreover an improvement in the prognostic factor.[28]

The results of other studies[29,30] that attribute the greater distance covered by trained patients to desensitization to dyspnea as a benefit of IMT. No patient had followed any exercise program specific to the lower limbs. Patients were accustomed to inactivity, and when the sensation of dyspnea decreased they showed greater mobility, resuming activities that they had abandoned and experiencing emotional improvement along with better control of their disease.

F. Lotters, B Van Tolet. al. in 2002, in their study "Effects of controlled inspiratory muscle training in patient with COPD", and had concluded that IMT alone significantly improves muscle strength and endurance, sensation of dyspnoea in patient with COPD. No significant additional effect of IMT on exercise performance were found.[26]

The trained patients tolerated the walking exercise better since, as indicated in the study by Lisboa et al,[29] there were no changes in dyspnea intensity for more substantial effort. The findings of reduced hyperinflation as a sole of primary mechanism of improved exercise tolerance has not been supported by multiple other studies.

5. Conclusion

Inspiratory muscle training along with Conventional Therapy showed significant improvement in Inspiratory Muscle Performance as seen in PImax, improved Exercise capacity as seen in 6MWD. Inspiratory muscle training is the definite tool for the improving functional capacity of the patient of COPD with mild to moderate severity. So it should be included as a part of Pulmonary Rehabilitation the patient of COPD with other exercise treatment strategies.

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