# The Description of Lung Function in Stable Chronic Obstructive Pulmonary Disease (COPD) Patients after Following Respiratory Muscles Training based on Assessment of Peak Expiratory Flow Rate and Chest Expansion

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Keywords : Chronic Obstructive Pulmonary Disease (COPD), Respiratory Muscles Training, Peak Expiratory Flow Rate (PEFR), Chest Expansion (CE)

Abstract : This study aimed to evaluate the effect of respiratory muscles training to peak expiratory flow rate (PEFR) and chest expansion (CE) in COPD patients and to provide new information about the effect of a short training program (only 4 weeks) on respiratory function. It was 4-weeks experiment with pre and post design. Six stable COPD patients have enrolled to this study. Respiratory muscles training consisted of expiratory muscles training, inspiratory muscles training, and breathing excercise. In this study found that all levels of CE increased after respiratory muscles training. The average of upper CE increased from 2.3 cm to 5.3 cm (p 0.000), the average of middle CE increased from 4.5 cm to 6.2 cm (p 0.011), and the avarage of lower CE also increased from 4.2 cm to 6.5 cm (p 0.005). The average value of PEFR also increased from 267.7 L/min to 319.3 L/min (increased 19%, p 0.046). This study found a significant improvement on CE and PEFR value after following short respiratory muscles training (only 4 weeks). The training in this study can be an option for management of COPD to improve patient's health outcomes.

## 1 INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a chronic disease. The characteristics of this disease are persistent respiratory symptoms and airflow limitation. Patients with COPD are often hospitalized due to exacerbations (Dhamane et al, 2015). After an exacerbation, a patient may experience a degradation of functional ability and impaired quality of life. (Shah et al, 2016).

COPD is a systemic inflammatory disease, it can cause repercussion on several systems like skeletal muscle dysfunction and weight loss (Barreiro & Gea, 2015; Lee et al, 2017). Changes in body composition that result in a reduction in muscle mass which leads to atrophy in all muscle fibers, decreasing muscle oxidative capacity, and making muscles more prone to fatigue (Man et al, 2009).

Muscle fatigue caused by the deleterious effect of COPD may compromised respiratory muscle function (Barreiro & Jaitovich, 2018). Among the respiratory muscles involved, the diaphragm is mechanically disadvantaged due to airway obstruction and lung hyper insufflation (Rocha et al, 2017). The mechanical detriment of the diaphragm associated with loss of mass can lead to reduce diaphragm movement, therefore contributing to respiratory distress and exercise intolerance (Barreiro & Gea, 2015).

The guideline from The Global Strategy for the Diagnosis Management, and Prevention of COPD and Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2018 explains the steps to reduce symptoms and risk factors which can aggravate the disease. One of the steps is pulmonary rehabilitation program (Vaes et al, 2018)



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The success of pulmonary rehabilitation in COPD patient has been demonstrated in several studies (Houchen-Wollof et al, 2017). Although pulmonary rehabilitation is a multi-dimensional therapy, muscle training appears to be its most effective component. As mentioned in several studies, expiratory muscles have been found to be active in COPD patients both at rest and during exercise, mostly at the end of expiration. Unfortunately, there are not enough studies that explained about the benefit of short-term expiratory muscle training program on lung function (Mota et al, 2005).

The main program is associated with the chief complain that it has disturbed the daily activity and caused the lack of productivity, such as dyspnea and excessive sputum production. Increased sputum production is a common feature of COPD that frequently require initiation of early therapy to decrease its impact upon clinical outcomes (Langer et al, 2009; Sahin et al, 2016). Prescription of mucolytic and/or mucoactive agents may target reductions in sputum viscosity, concurrently with non-pharmacological therapies like airway clearance techniques (ACTs). There are many types of ACTs used in clinical practice, including breathing exercise such as active cycle of breathing technique (ACBT), autogenic drainage, and hand-held positive expiratory pressure (PEP) devices such as mask, mouthpiece or oscillatory PEP. Coughing is involved in ACTs (Osadnik CR et al, 2015).

Not all coughs are effective in clearing excess mucus from the lungs. Explosive or uncontrolled coughing induces airways to collapse and spasm, trapping mucus. The effective or controlled cough comes from deep within the lungs and has just enough force to loosen and carry mucus through the airways without causing them to narrow and collapse. Controlled coughing saves energy and therefore, oxygen (Osadnik CR et al, 2015)

We modified the exercise to train respiratory muscles and taught the patients to cough effectively. We trained expiratory muscles with Positive Expiratory Pressure (PEP) device. Inspiratory muscles were trained with LVR method which was performed with insufflation technique which used a simple hand-held resuscitation bag, and the ACTs was performed with breathing exercise as called as Active Cycle of Breathing Technique (ACBT). This cycle of exercise was performed to improve lung function which could be assessed by the values of peak expiratory flow rate and chest expansion. (Malaguty et al, 2009; Ozgocmen et al, 2014; McKim et al, 2011).

The aim of this present study was to evaluate the effect of respiratory muscles training on Peak Expiratory Flow Rate (PEFR) and Chest Expansion (CE) in COPD patients, and to provide new information about the effect of a relatively short training program (only 4 weeks) on respiratory function. This outcomes can be considered as the major short-term targets in the treatment of COPD patients.

# 2 METHODS

This was 4 weeks experiment with pre and post design. We collected the subjects with purposive sampling method. This study was carried out in Aulia Hospital, Pekanbaru, Riau, Indonesia.

## 2.1 Ethic and Subjects

Study participants provided written informed consent to a potocol approved by Aulia Hospital ethical committees. Thirty COPD patients visited Aulia Paru Center a month before we did the research. We predicted these patients would come back to meet pulmonologist to control their disease. Only 18 patients met the inclusion and exclusion criteria. Twelve patients refused to follow this study due to some reasons. So, we prospectively recruited 6 patients with mild to severe COPD admitted to our Pulmonology Center dedicated outpatient between June 24th until July 13th 2019.

## 2.2 Inclusion and Exclusion Criteria

The inclusion criteria were as follows: 35-65 years of age, FEV1 more than 30% predicted, FEV1/FVC ratio <0.7, not having an exacerbation, taking medicine from pulmonologist regularly, and the patients agreed to follow this study. Exclusion criteria were severe exacerbation of COPD or the hospitalization for COPD within 4 weeks recruitment, the patients who suffered cardiac disease, cor-pulmonale disease, joint disorder, rheumatoid arthritis, neurologic disorder, cognitive disorder which was assessed by Mini Mental State Exam (MMSE), and inability to comply with study procedures or the rejection from the patient to attend the study.

## 2.3 Study Design

This study consisted of a screening visit and 2 weeks of optimalization of medical therapy from pulmonologist. The patients were scheduled to follow the program 3 sections in a week for 4 weeks. Every section needed 20-30 minutes.

Patients who met inclusion criteria on screening visit (following from clinical manifestation and confirmed by spirometry testing) were enrolled and instructed to register all data during the study period. Values of lung function were assessed by PEFR and CE. These values were assessed before program, in the first, second, third, and fourth week of the program.

## 2.4 Measurements and Outcomes

At registration, patient's anthropometric and physiological characteristics were recorded. Respiratory measurements included short of breathing (dyspnea), cough and sputum scale, as well as health status assessment evaluations and respiratory functions like FVC, FEV1, FEV1/FVC, FEF 25 %predicted, FEF 50 %predicted, PEFR and CE.

Diagnosis and severity of COPD have been confirmed by using GOLD Guidelines. Respiratory function test (FVC, FEV1, FEV1/FVC, FEF 25 %predicted, FEF 50 %predicted) was assessed using CHEST SPIROMETER type HI-105 that has been calibrated before conducting the study. Each patient was sitting during spirometry test. They were asked to blow into the straw and measurement of FVC, FEV1, FEV1/FVC, FEF 25 %predicted, FEF 50 %predicted were recorded.

### 2.4.1 Chest Expansion Measurement

A measuring tape was used to measure chest expansion (CE) in centimeters (cm) at three levels of the rib cage. For upper CE, the anatomical markers were the 3rd intercostal space (front aspect) and 5th thoracal spinosus process (back aspect) to measure lung expansion for upper and medial lobe. For middle CE, the 4th intercostal space (front) and 6th thoracal spinosus process (back) was expected to predict lung expansion in medial lobe, while xyphoid process (front) and 10th thoracal spinosus process (back) was measured as lower CE to predict expansion in lower lobe (Reddy et al, 2019; Mulyo et al, 2015). The measurement was held by one person to all patients from the beginning until the end of the program.

### 2.4.2 Instructions to Subjects

The instruction given by the examiner to patient during breathing was standardized. Prior to the thoracic measurement, patients were asked to "inhale slowly and rhythmically through the nose against the measuring tape to open up the lung as much as you can", and then the patients were asked to "exhale through the mouth completely." CE measurement was taken at the end of the inspiration and expiration cycle. The patients were in a standing position with their arms were at the side of their body. The examiner placed the "0" point of the measuring tape on the back aspect. Holding measuring tape was standardized by crossing the tape close to the skin. The measurement was taken three times, and the mean of these values was collected for each levels.

### 2.4.3 Peak Expiratory Flow Rate (PEFR) Measurement

The PEFR measurement was performed using a Philips respironic peak flow meter. The best PEFR was adopted from three correct blows when patients exerted maximal expiratory efforts in a sitting up straight position. We calculated the average of three values of PEFR on each patients. PEFR measurement was collected before training. We evaluated this value on the first, second, third, and fourth week of the training.

## 2.5 Respiratory Muscles Training

### 2.5.1 Expiratory Muscles Streghtening

This training used PEP device (PHILIP RESPIRONIC threshold PEP) to train expiratory muscles. We asked patient to put nose clip on nose, breathe through mouth, seal lips around mouthpiece, take a full breathe in and breathe out 2 or 3 times longer than breathe in. Due to the absence of respiratory pressure meter, we modified the technique to determine initial dose of treatment.

We started from the lowest number of resistance dose and asked patients to continue this pattern for 10 times. We increased the dose and assessed the patient's degree of dyspnea by using BORG Scale. A higher number equals greater effort. When the patients were unable to complete 10 Repetitive Movement (RM), initial dose was determined by 80% of the last dose that patient could complete 10 RM correctly. We took this exercise for 3 sets, 1 set consisted of 10 RM and it took 30-60 seconds to rest before continuing the next set.

#### 2.5.2 Lung Volume Recruitment (LVR)

The second exercise was Lung Volume Recruitment (LVR) to train inspiratory muscles. This method was performed with insufflation technique which used a simple hand-held resuscitation bag. The patient was ordered to breathe in through the mask slowly while the instructor squeezed the bag 3 times, and then the patient was asked to cough effectively 3 times. We took this method for 3 sets, 1 set consisted of 3 RM, and it took 30-60 seconds to rest before continuing the next set.

#### 2.5.3 Breathing Exercise

The last was breathing exercise which was called as ACBT technique. It consisted of 3 stages. There were breathing control, thorax expansion exercise, and forced expiratory technique. Each stage was repeated for 5 times and ended with cough effectively. This cycle was repeated for 3 times, and it took 30-60 seconds to rest before continuing the next set.

## 3 RESULTS

### 3.1 Demographic Data

Demographic data were shown in Table 1.

Table 1: Demographic data.

| Variables | n | % |
|---|---|---|
| Sex | | |
| Male | 6 | 100 |
| Female | 0 | 0 |
| Age | | |
| 45-50 | 2 | 33.3 |
| 51-55 | 0 | 0.0 |
| 56-60 | 0 | 0.0 |
| 61-65 | 4 | 66.7 |
| History of smoking | | |
| Yes | 5 | 83.3 |
| No | 1 | 16.7 |
| Brinkman Index | | |
| <200 (Mild) | 2 | 40 |
| 200-600 (Moderate) | 3 | 60 |
| >600 (Severe) | 0 | 0 |
| Staging of COPD | | |
| Mild | 1 | 16.7 |
| Moderate | 3 | 50.0 |
| Severe | 2 | 33.3 |

### 3.2 Chest Expansion (CE), Peak Expiratory Flow Rate (PEFR), and Spirometry Test

These data were shown in table 2-4.

Table 2: CE value before respiratory muscle training.

| Pre Training | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| Upper CE | 2.33 | 0.516 | 2 | 3 |
| Middle CE | 4.50 | 1.049 | 3 | 6 |
| Lower CE | 4.17 | 0.753 | 3 | 5 |

Table 3: CE after respiratory muscle training.

| Post Training | Mean | SD | Mini-mum | Maxi-mum |
|---|---|---|---|---|
| Upper CE | 5.33 | 0.516 | 5 | 6 |
| Middle CE | 6.17 | 0.408 | 6 | 7 |
| Lower CE | 6.5 | 0.548 | 6 | 7 |

Table 4: PEFR Value.

| (PEFR) | Mean | SD | Mini-mum | Maxi-mum |
|---|---|---|---|---|
| Pre | 267.6 | 99.725 | 120 | 370 |
| Post | 319.5 | 136.141 | 133 | 476 |

### 3.3 Changes Test Between Upper, Middle, Lower CE, and PEFR Before and After Training

Results from Paired T Test showed significant changes between upper, middle, lower CE, PEFR value before and after training. These results were shown in table 5.

Table 5 : Paired T-Test Between Upper, Middle, Lower CE, and PEFR Before and After Training.

| Before Training | After Training | | | |
|---|---|---|---|---|
| | Upper CE | Middle CE | Lower CE | PEFR |
| Upper CE | p= 0.000 | | | |
| Middle CE | | p= 0.01 | | |

| | | | | |
|---|---|---|---|---|
| Lower CE | | | p= 0.005 | |
| PEFR | | | | p= 0.046 |

## 3.4 Post Respiratory Muscle Training Measurement

We evaluated the training based on the values of CE and PEFR. These values were increase after training. The enhancement of these values were shown in figure 1-6. Evaluation of spirometry test was shown in figure 7.

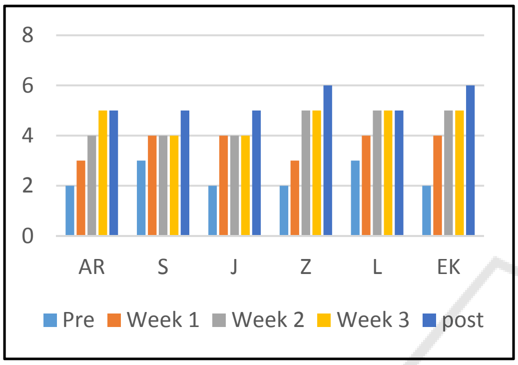


Figure 1 : Evaluation of Upper CE Every Week.

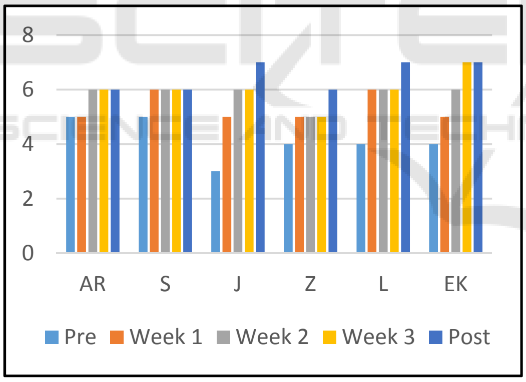


Figure 2 : Evaluation of Middle CE Every Week.

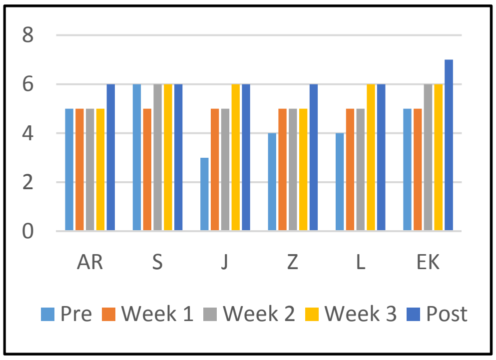


Figure 3 : Evaluation of Lower CE Every Week.

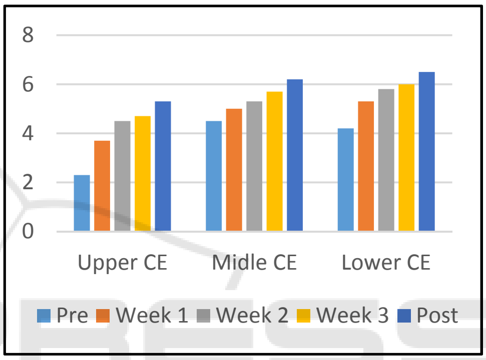


Figure 4 : Average of CE Expansion Every Week.

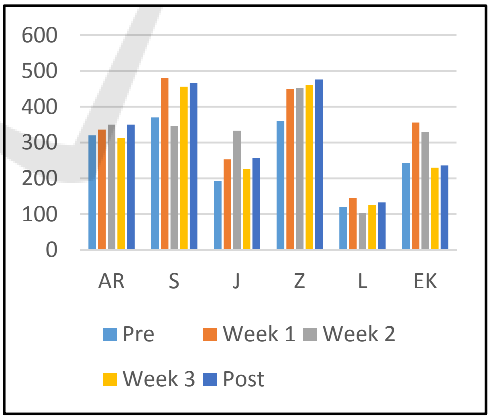


Figure 5: Evaluation of PFM Every Week.

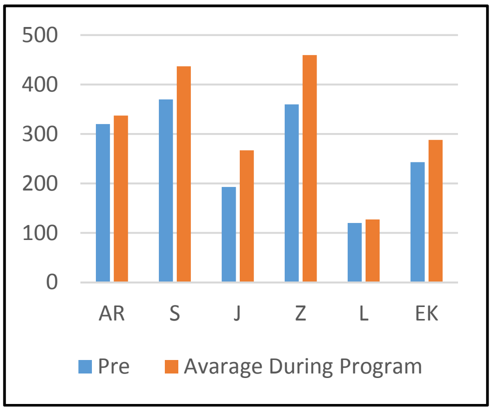


Figure 6: Comparison of PFM (Pre and The Average During Program).

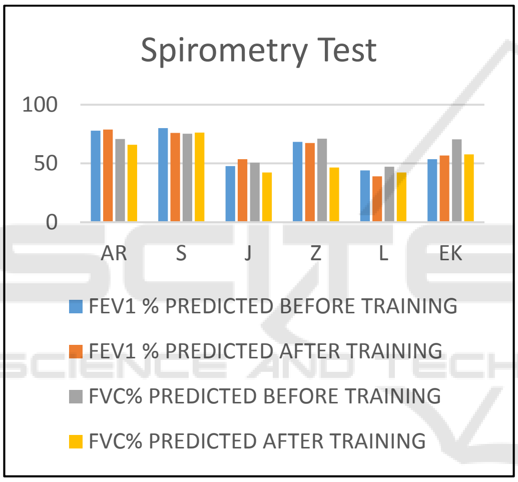


Figure 7: Comparison of spirometry test (pre and post training).

## 4 DISCUSSIONS

The main finding of this present study is the improvement in CE and PEFR in COPD patients after following a short respiratory muscles training period (only 4 weeks). Although the study on respiratory muscles only a few, it is known that in COPD patients these muscles can exhibit weakness, as evidenced by either mild reduction in maximal force and/or endurance (Weiner et al, 2003). Since muscle weakness might be improved through different mechanisms by training, our hypothesis is that specific respiratory muscles training program using an appropriate schedule would promote clinical benefits. This study was designed to respond to the relative lack of information about the impact of respiratory muscles training on respiratory function.

Previous study showed CE measurements significantly correlate with lung function parameters (FVC, FEV1, FEV1/FVC, and VC). Therefore maintaining chest wall mobility may be an important element for preserving FVC and FEV1/FVC in elderly male patients with COPD. There was a reduction of chest expansion value in COPD patients which compared with healthy nonsmoker (Reddy et al, 2015). Mean value of upper chest expansion in healthy subjects was 6.2 cm, 6.86 cm for middle chest expansion, and 7.25 cm for lower chest expansion (Mulyo A.N.D et al, 2015). Debouche et al found the mean of upper CE in young healthy men was 5.9 cm and 7.1 cm for the lower CE (Debouche et al, 2016). Reddy et al found mean value of upper CE was 3.7 cm and 4.9 cm for lower CE in COPD patients. Our study has similar finding that the mean value of upper CE was 4.5 cm, 4.1 cm for middle CE, and 4.96 cm for lower CE before training.

The reduction of CE value in this study may because patients with respiratory problems like COPD may present with abnormalities in chest biomechanics. Rib cage mobility might be decreased as a consequence of airway obstruction and hyperinflation which happened in COPD patients (Debouche et al, 2016). The normal range of CE tends to decline with age (decline up to 50-60% between ages 15 and 75 years) and to be 20% greater in men (Lanza FC et al, 2013), which also explained the low mean of CE in our study, because the subjects in our study were between 45-60 years old and all the subjects were male.

Currently, PEFR reduction was one of the most common alternative tools suggestive of the presence of airflow limitation and employed in COPD case-finding studies (Martinez et al, 2017). Normal individuals may produce a PEFR as great as 720 L/min and occasionally higher in healthy individuals (Homnick DN, 2007). Su et al found that PEFR value range in non COPD subjects was 472±113 L/min, while in COPD patient, the range was 290 ±120 L/min (Su et al, 2018). Similarly with our study which also found the reduction of PEFR value in COPD patients before respiratory muscles training. We found that the mean value of PEFR was 267.6 L/min. Sivasothy et al suggested that premature peripheral airway closure, exacerbation of hyperinflation with insufflation, or induced bronchoconstriction might have contributed to the reduced PEFR and volumes in the patients with COPD (Sivasothy, 2001).

We found improvement of CE and PEFR measurement after respiratory muscles training in every patient. Increasing of CE happened in every level. The mean value of upper CE became 5.33 cm (p 0.000), middle CE became 6.17 (p 0.011), and lower CE became 6.5 cm (p 0.005). The improvement of PEFR value from 267.6 L/min to 319.5 L/min (p 0.046). Abdominal muscle is critical during expiration, such as forced expiration and coughing.

Wang et al reported that the FVC% and FEV1% in two groups were improved compared with that before breathing training (Wang et al, 2019). Contrary with our study, not all patients showed enhancement of FVC% and FEV1%, and PEFR value after training in our study also did not show a normal value. This might be because that respiratory muscles training helps slow down or stop the disease progression, but cannot reverse the lung lesions that have occurred.

There were significant changes when we observed the value of upper, middle, lower CE, and PEFR before and after attending the program. These data can become preliminary data for futher research which can collect larger amount of subjects.

# 5 CONCLUSIONS

Our study found significant improvement on respiratory functions which were assessed by CE and PEFR value after following short respiratory muscles training (only 4 weeks). Thus, this training in this study can be an option for management of COPD to improve patient's health outcomes. Guidelines for the referral of patients with COPD to pulmonary rehabilitation recommend referral of those who are motivated, medically stable, and symptomatic with impairment in daily activities.

In our experience, this sort of training is easy to incorporate into clinical practice and has no adverse effects. Furthermore, its simplicity suggests that respiratoy muscles training could probably also be performed at home, given a few supervised session to ensure correct procedure on the part of the patient.

Both primary care providers and pulmonology center have crucial role to play in realizing the full potential of rehabilitation strategies. Since the stable COPD patients come to these units after hospitalized due to exacerbation. These units can refer COPD patients to physical medicine and rehabilitation unit for following respiratory muscles training as the additional strategy to treat COPD patients.

There were some limitations in our study. First, the short time for collecting the subjects. Second, the sample size of this study was very small that we cannot correlate the CE and PEFR value to other lung function values which were observed by spirometer. Even so, these results also had clinical significance for the therapy of COPD. To sum up, we confirm that short training of respiatory muscles improves lung functional as assessed by CE and PEFR.

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