Maximum Respiratory Pressure in relation to Practice Respiratory Muscle Training Program in Chronic Obstructive Pulmonary Disease Patients

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ABSTRACT

Background and Purpose: *Patients with chronic obstructive pulmonary disease (COPD) had reduced maximal respiratory pressure as a result of respiratory muscle weakness. The purpose of this study was to evaluate the effect of practicing respiratory muscle training program on the level of maximal respiratory pressure, exercise tolerance and dyspnea perception in stable COPD patients.* ***Subjects and Methods:*** *Twenty-eight male patients aged 62.25 ± 1.79 years with moderate stable COPD participated in the study. The strength of respiratory muscle was determined by measuring maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) levels by using respiratory pressure gauges. Six-minute walk test (6-MWT) was applied to determine the six-minute walk distance (6-MWD) which was the maximum distance the patient covered during 6-MWT. Dyspnea perception score was determined by using Modified Borg scale before and after practicing 6-MWT. Patients were categorized randomly into two groups (training and control). Patients of the control group were instructed to practice their usual daily activities and to keep in contact with the researches. Patients of the training group were engaged in a supervised exercise program for strengthening respiratory muscles. The program consisted of 8-weeks (thrice weekly) of total 24 sessions.* ***Results:*** *The results showed a significant increase of mean MIP, MEP, 6-MWD and dyspnea score of the training group, where it was 63.86 ± 8.19 vs. 82.36 ± 8.29 (cm H_2O) for MIP, 72.21 ± 8.20 vs. 88.36 ± 7.14 (cm H_2O) for MEP, 513.57 ± 37.86 vs. 575.93 ± 36.16 (m) for 6-MWD and 7.21 ± 0.70 vs. 4.57 ± 1.09 for dyspnea score for pre- and post-measures respectively (P<0.001). Comparing the mean post-measures of MIP, MEP, 6-MWD and dyspnea score between the training and control groups, the results showed significant differences, where it was 82.36 ± 8.29 vs. 67.29 ± 6.56 (cm H_2O) for MIP, 88.36 ± 7.14 vs. 74.14 ± 8.54 (cm H_2O) for MEP, 575.93 ± 36.16 vs. 523.86 ± 42.63 (m) for 6-MWD and 4.57 ± 1.09 vs. 6.79 ± 0.89 for dyspnea score for training and control groups respectively (P<0.001).* ***Conclusions:*** *Respiratory muscles training program was reported to increase maximal respiratory pressure, decrease dyspnea perception and improve exercise tolerance in moderate stable COPD patients.*

Keywords: *COPD, maximum inspiratory pressure, maximum expiratory pressure, respiratory muscles training, dyspnea, exercise tolerance.*

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is characterized by a progressive airway limitation which is not completely reversible[1]. Cigarette smoking is considered the most important risk factor for the development of COPD[2].

A clinical diagnosis of COPD should be considered in any patient who has dyspnea, chronic cough or sputum production. The diagnosis should be confirmed by spirometry after the administration of an adequate dose of a short-acting inhaled bronchodilator. According to FEV_1 (forced expiratory volume in the first second) and FVC (forced vital capacity); a post-bronchodilator FEV_1 / FVC < 0.70 confirms the presence of airflow limitation that is not fully reversible[3].

Reduced strength of the inspiratory muscles and low maximal respiratory pressure were frequently observed in COPD patients[4]. The respiratory muscles weakness is generally attributed to a reduction in the mechanical advantage of the inspiratory muscles due to hyperinflation. The hyperinflation interferes with the ability of the respiratory muscles to generate sub-atmospheric pressure and it increases the load upon them[5].

Maximum inspiratory pressure (MIP) is the lowest pressure developed during a forceful inspiration against an occluded airway. It is primarily measures inspiratory muscles strength. It depends on the function of the diaphragm, intercostal and inspiratory muscles. Healthy adults can generate inspiratory pressure greater than -60 centimeter water (cm H_2O)[6]. While maximum expiratory pressure (MEP) is the highest pressure that can be developed during a forceful expiratory effort against an occluded airway. It measures the pressure generated during maximal expiration. It depends on the function of the abdominal muscles and accessory muscles of respiration and the elastic recoil of the lungs and thorax. Healthy adults can generate MEP values more than 80 to 100 cm H_2O. In general, a MIP of -80 cm H_2O and a MEP of +80 cm H_2O excludes important weakness of the respiratory muscles[6].

The decreased maximal respiratory pressure which associated with COPD may contribute to the perception of dyspnea[7]. The severity of dyspnea has been demonstrated to be related to the proportion of MIP required for each breath[8].

Dyspnea during exercise is usually measured with a category scale such as the Borg scale or visual analogue scale. Borg scale could be used to evaluate dyspnea score before and after practicing 6-MWT. This test has been practiced in order to grade the severity of dyspnea according to the degree of breathlessness associated with a particular task[9].

Respiratory muscles dysfunction in COPD patients is associated with reduced exercise tolerance[4]. The six-minute walk test (6-MWT) is a practical and simple test that requires no exercise equipment or advanced training for technicians. This test measures was applied to determine the six-minute walk distance (6-MWD) that the patient can quickly walk on a flat, hard surface. 6-MWT assesses the sub-maximal level of functional capacity and reflects the functional exercise level for daily physical activities[10].

The overall approach to manage stable COPD should be individualized to deal with symptoms and improve quality of life. Smoking cessation is the single most effective and cost effective intervention in most people to reduce the risk of developing COPD and stop its progression[3]. None of the existing medications for COPD have been shown to modify the long-term decline in the associated lung function[11,12].

Physical exercise programs have become cornerstone of management of COPD because they lead to clinically improvements of exercise capacity and health-related quality of life[13]. Respiratory muscles training have beneficial effects in patients with COPD[7]. Strengthening of the inspiratory muscles has been shown to be highly effective in reducing the intensity of perceived dyspnea, thus leading to improvement of lung function[14].

Pursed lips breathing is a technique consisting of exhalation through a resistance created by constriction of the lips. This maneuver is often spontaneously adopted by COPD patients and it is also routinely taught as a breathing retraining exercise in pulmonary rehabilitation programs because it is thought to alleviate dyspnea[15].

Diaphragmatic breathing, or slow and deep breathing, are commonly applied in physical therapy practice attempting to correct abnormal chest wall motion, decrease work of breathing, accessory muscles activity and dyspnea, increase efficiency of breathing and improve distribution of ventilation[16].

These non-pharmacological interventions have a strong theoretical rational and improve exercise tolerance as well as quality of life. Furthermore, several breathing methods such as pursed lips breathing, diaphragmatic breathing and nose breathing exercises have been reported to be effective in reducing the level of perceived dyspnea[14].

The purpose of the present study was to evaluate the effect of practicing respiratory muscles training program on the level of maximal respiratory pressures, exercise tolerance and dyspnea perception in stable COPD patients.

SUBJECTS, MATERIAL AND METHODS

Subjects

Twenty-eight male patients with mean age 62.25 ± 1.79 years participated in the study. Patients had moderate COPD ($FEV_1/FVC<0.70$ and $50\%\leq FEV_1<80\%$ predicted) according to Global Initiative for Chronic Obstructive Lung Disease[3], patients were recruited from the outpatient pulmonary clinics.

All patients were smokers or ex-smokers, and their mean body weight was 65.89 ± 3.80 kilogram (kg), the mean height was 1.68 ± 0.07 meter (m) and the mean body mass index (BMI) was 23.56 ± 2.34 kg/m^2. BMI was computed as the ratio between body weight in kilogram and square height in meter[17].

Inclusion criteria were; non-smokers during the study, clinical stability for at least one month before engaging in the study program, the ability to use facial muscles in measuring respiratory pressure and practicing breathing exercises. Patients' physical activity had to be limited by pulmonary dyspnea only. Exclusion criteria included; myocardial disorders, respiratory infections and patients with neuromuscular diseases characterized by facial or buccal muscles weakness. Patients, who met the study criteria and agreed to participate in the study, had signed the informed consent form.

Material

Instruments used to measure maximal static inspiratory and expiratory pressures were:

- Maximum Inspiratory Pressure Gauge (55-0120 negative pressure gauge, 0 to -120 cm H_2O, Smith Medical ASD, Inc. USA).
- Maximum Expiratory Pressure Gauge (55-6065 pressure gauge, +60 to -60 cm H_2O, Smith Medical ASD, Inc. USA).

- Disposable mouth pieces.

Methods

Physical Examination and Laboratory Investigations:

Patients were screened thoroughly by the pulmonologist for reviewing their charts and history taking including medications history. Physical examination and chest radiograph were conducted to confirm COPD diagnosis and to exclude other causes of dyspnea. Laboratory investigations were conducted as required.

Medical Intervention:

All patients were clinically stable and were instructed to contact the pulmonologist immediately when there is any disturbance in their clinical state. During the study program, patients did not take any medications that might interfere with the results of the study. Patients were instructed to use short-acting inhaled bronchodilator $ß_2$-agonists (Salbutamol) as presented by severe exertional dyspnea.

Patients' Education:

Patients of both groups received a simple medical cultural lecture to demonstrate the general scope of the disease and its relation to smoking and air pollution. Patients were trained how to use optimally the short-acting $ß_2$-agonists inhaler when needed. All patients were instructed to immediately contact the treating physician if there was any change in the medical condition of the disease.

Physical Therapy Procedures:

Patients were referred to outpatient physical therapy department to be enrolled in a supervised exercise program aimed to strength respiratory muscles. The following measurements were conducted to all patients.

Respiratory Pressure Measurements:

The strength of respiratory muscles was determined from sitting position by measuring the pressures developed against an occluded airway[6]. The pressure gauge device was connected to the mouth piece through a rubber tube. A standardized air leak hole of 2-millimeter diameter was present in the distal end of the rubber tube in the measurement system to eliminate erroneously high respiratory muscles pressure readings resulting from the use of cheek muscles. MIP was measured by asking the patient to exhale to residual volume, placed the mouth piece against the lips, and sucked as hard as possible to make a maximum inspiratory effort. While MEP was measured by asking the patient to inhale maximally almost to peak pulmonary capacity; held the mouth piece firmly against the lips, and exhaled as hard as possible. Several reproducible efforts were obtained, and the highest negative and positive pressure values for MIP and MEP respectively which were maintained for three seconds were recorded.

Prior to each maneuver, patients were oriented about the technique, and had to remain seated for at least 10 minutes. Both tests were dependent on patient cooperation and effort. Good instruction, vigorous coaching and adequate rest between efforts were applied. The gauge devices were calibrated before applying pre- and post-measures respiratory pressure measurements. The gauge device was connected to a three-way stopcock in line with a calibrated mercury U-tube of known accuracy. A vacuum was produced and subsequent readings were compared and adjusted. Measures of maximal inspiratory pressure (negative values) were considered as absolute values.

Six-minute Walk Test (6-MWT):

The 6-MWT was performed according to the guidelines of the American Thoracic Society[10]. Patients were instructed to walk from end to end at the corridor of the hospital which is 40 meters long at their own pace, while attempting to cover as much distance as possible in the allowed 6 minutes. Verbal encouragement was given to each patient. At the end of the walk test, 6-MWD was recorded to the nearest meter.

Dyspnea Assessment:

Dyspnea severity was measured by using Modified Borg Scale[8] which consisting of 11-point scale, in which patients were instructed to indicate the level of their dyspnea as graded from 0 (nothing at all) to 10 (maximum). Patient's score of dyspnea was recorded initially after 10 minutes of rest before practicing the 6-MWT (pre-measurement), and were asked to practice the walking test and finally dyspnea level was recorded immediately after completing the 6-MWT (post-measurement).

The study Program:

Patients were categorized randomly into two groups (training and control); by matching closed envelops each one included a name of a patient. Patients of the control group were instructed to practice their usual daily activities and to keep in contact with the researches. Patients of the training group were engaged in a supervised exercise program for strengthening respiratory muscles. The program lasted for 8-weeks (thrice weekly sessions) of total 24 sessions[11].

Post-measures:

MIP, MEP, 6-MWT and dyspnea assessment were performed to all patients in a standardized manner and sequence before starting the study program and after its completion.

The session included the following procedures:

Pursed lips breathing:

From sitting position, the patient inhaled through the nose over several seconds with the mouth closed and then exhaled slowly over 4 to 6 seconds through pursed lips held in a whistling or kissing position without contraction of the abdominal muscles. Each exercise was repeated for 8 to 10 times and took 30 to 45 seconds to complete, for a total exercise time of about 15 minutes. With short rest periods between the exercises, the pursed lips breathing exercise duration was approximately 20 minutes. Patients were instructed to practice pursed lips breathing during or following any daily living activity that might lead to tachypnea or dyspnea[18].

Diaphragmatic breathing:

From long setting position, the patient told to move the abdominal wall mainly during inspiration and to reduce upper rib cage motion. During expiration, the patient told to contract the abdominal muscles to help in displacing the diaphragm upward leading to increasing of abdominal pressure during active expiration. The contraction of the abdominal muscles results in an increased abdominal pressure during active expiration[18]. Diaphragmatic breathing exercise was repeated for 8 to 10 times and lasted for about 10 minutes including a brief rest periods in between the exercises. Home-based training program comprised twice daily of 15-minute sessions of pursed lips and diaphragmatic breathing exercises, in the non-exercising days.

Statistical analysis:

Data from pre- and post-measures including; MIP, MEP, 6-MWD and dyspnea sore were collected and entered into statistical program (SPSS version 13.0). Descriptive analysis was performed for both the baseline anthropometric and clinical characteristics of the patients. Values were expressed as means and standard deviations. Paired t-test was used to compare intra-group data (pre- and post-measures) to evaluate the effect of the study program at the end of the program, while unpaired t-test was used for comparisons between post-measures between training and control groups. Pearson's product moment correlation coefficient was used to determine the correlation between post-measures of the training group. Multiple linear regression analysis model was performed to predict the change in a dependent variable (6-MWD) for each independent variables (MIP, MEP and dyspnea score) for post-measures of the training group. The selected level of significance was set to be ($P<0.05$).

RESULTS

Twenty-eight male patients enrolled in the study, the mean age was 62.25 ± 1.79 years, the mean weight was 65.89 ± 3.80 (kg), the mean standing height was 1.68 ± 0.069 (m) and the mean BMI was 23.56 ± 2.34 (Kg/m^2).

Table (1) shows the baseline anthropometric and clinical characteristics measures for both training and control groups. There were no significant differences between both groups concerning mean; age, weight, height, BMI, MIP, MEP, 6-MWD and dyspnea score.

Table (1): Baseline Anthropometric and Measured Clinical Characteristics for Patients of Training and Control Groups.

Variables	Training Group	Control Group	P-value
Age, y	62.14 ± 1.83	62.36 ± 1.82	0.76
Weight, kg	66.50 ± 4.26	65.29 ± 3.33	0.41
Height, m	1.67 ± 0.074	1.68 ± 0.068	0.68
BMI, Kg/m^2	23.94 ± 2.37	23.19 ± 2.35	0.41
MIP, cm H_2O	63.86 ± 8.19	65.79 ± 7.80	0.53
MEP, cm H_2O	72.21 ± 8.98	72.36 ± 8.59	0.97
6-MWD, m	513.57 ± 37.86	515.21 ± 42.63	0.91
Dyspnea Score, 0-10	7.21 ± 0.70	7.14 ± 0.66	0.78

Values are expressed as mean ± standard deviation. y; year, kg; kilogram, m; meter, BMI; body mass index, m^2; meter square, MIP; maximum inspiratory pressure, cm; centimeter, H_2O; water, MEP; maximum expiratory pressure, 6-MWD; 6-minute walk distance, Dyspnea Score; modified Borg dyspnea scale.

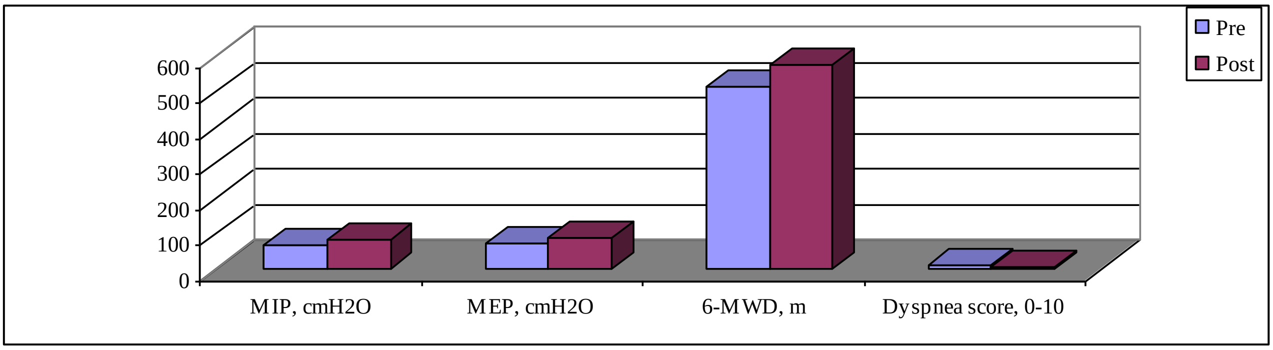
Table 2 and figure 1 show comparison of the mean pre- and post-measures of MIP, MEP, 6-MWD and dyspnea score for the training group, the results showed a highly significant ($P<0.001$) increase of mean MIP, MEP and 6-MWD, where it was 63.86 ± 8.19 vs. 82.36 ± 8.29 (cm H_2O) for MIP, 72.21 ± 8.20 vs. 88.36 ± 7.14 (cm H_2O) for MEP and was 513.57 ± 37.86 vs. 575.93 ± 36.16 (m) for 6-MWD for pre- and post-measures respectively. The mean values of dyspnea score of the training group showed a highly significant ($P<0.001$) reduction, where it was 7.21 ± 0.70 vs. 4.57 ± 1.09 for pre- and post-measures respectively. The table shows also that there were positive correlations between pre- and post-measures among the training group, where it was for

MIP (r=0.81), MEP (r=0.23), 6-MWD (r=0.79) and dyspnea score (r=0.33).

Table 2 shows the mean differences and percentage changes of pre- and post-measures of the studied parameters for training group. The results showed that the mean difference of MIP was 18.5 (cm H_2O) with a percentage increase of 29%, the mean difference of MEP was 16.15 (cm H_2O) with a percentage increase of 22.4% and the mean difference of 6-MWD was 62.36 (m) with a percentage increase of 12.14%. The mean difference of dyspnea score was −2.64 showed a percentage reduction of −36.62%.

Table (2): Comparison, Correlation, Mean Difference and percentage Change between Pre- and Post-measures of Training Group.

Variables	Pre-measures	Post-measures	P-value	r-value	Mean Difference	% Change
MIP, cm H_2O	63.86 ± 8.19	82.36 ± 8.29	<0.001	0.81	18.5	29.0
MEP, cm H_2O	72.21 ± 8.20	88.36 ± 7.14	<0.001	0.23	16.15	22.4
6-MWD, m	513.57 ± 37.86	575.93 ± 36.16	<0.001	0.79	62.36	12.14
Dyspnea Score, 0-10	7.21 ± 0.70	4.57 ± 1.09	<0.001	0.33	−2.64	−36.62
Values are expressed as mean ± standard deviation. MIP; maximum inspiratory pressure, cm; centimeter, H_2O; water, MEP; maximum expiratory pressure, 6-MWD; 6-minute walk distance, Dyspnea Score; modified Borg dyspnea scale, r; correlation coefficient, %; percentage.						



Values are expressed as mean ± standard deviation. MIP; maximum inspiratory pressure, cm; centimeter, H_2O; water, MEP; maximum expiratory pressure, 6-MWD; 6-minute walk distance, Dyspnea Score; modified Borg dyspnea scale.

Fig. (1): Pre- and Post-measures for Training Group.

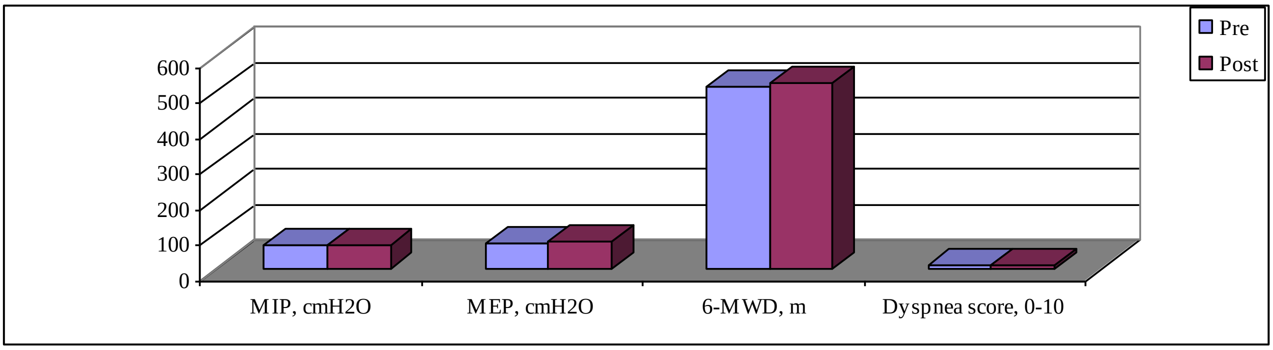
Table 3 and figure 2 show comparison of the mean pre- and post-measures of MIP, MEP, 6-MWD and dyspnea score for the control group, the results showed non significant differences of MEP and dyspnea scale; where it was 72.36 ± 8.59 vs. 74.14 ± 8.54 (cm H_2O) for MEP and was 7.14 ± 0.66 vs. 6.79 ± 0.89 for dyspnea score. While the mean MIP and 6-MWD showed a significant increase ($P<0.05$) where it was 65.79 ± 7.79 vs. 67.29 ± 6.56 (cm H_2O) for MIP and was 515.21 ± 42.15 vs. 523.86 ± 42.63 (m) for 6-MWD. The table shows also that there were positive correlations between pre- and post-measures among the training group, where for MIP (r=0.96), MEP (r=0.92), 6-MWD (r=0.99) and dyspnea score (r=0.45).

Table 3 shows the mean differences and percentage changes of pre- and post-measures of the studied parameters for control group. The results showed that the mean difference of MIP was 1.5 (cm H_2O) with a percentage increase of 2.3%, the mean difference of MEP was 1.78 (cm H_2O) with a percentage increase of 2.46% and the mean difference of 6-MWD was 8.65 (m) with a percentage increase of 1.68%. The mean difference of dyspnea score was −0.35 showed a percentage reduction of −4.9%.

Table (3): Comparison, Correlation, Mean Difference and percentage Change between Pre- and Post-measures of Control Group.

Variables	Pre-measures	Post-measures	P-value	r-value	Mean Difference	% Change
MIP, cm H_2O	65.79 ± 7.79	67.29 ± 6.56	0.03	0.96	1.5	2.3
MEP, cm H_2O	72.36 ± 8.59	74.14 ± 8.54	0.07	0.92	1.78	2.46
6-MWD, m	515.21 ± 42.15	523.86 ± 42.63	<0.01	0.99	8.65	1.68
Dyspnea Score, 0-10	7.14 ± 0.66	6.79 ± 0.89	0.14	0.45	−0.35	−4.9

Values are expressed as mean ± standard deviation. MIP; maximum inspiratory pressure, cm; centimeter, H_2O; water, MEP; maximum expiratory pressure, 6-MWD; 6-minute walk distance, Dyspnea Score; modified Borg dyspnea scale, r; correlation coefficient, %; percentage.



Values are expressed as mean ± standard deviation. MIP; maximum inspiratory pressure, cm; centimeter, H_2O; water, MEP; maximum expiratory pressure, 6-MWD; 6-minute walk distance, Dyspnea Score; modified Borg dyspnea scale.

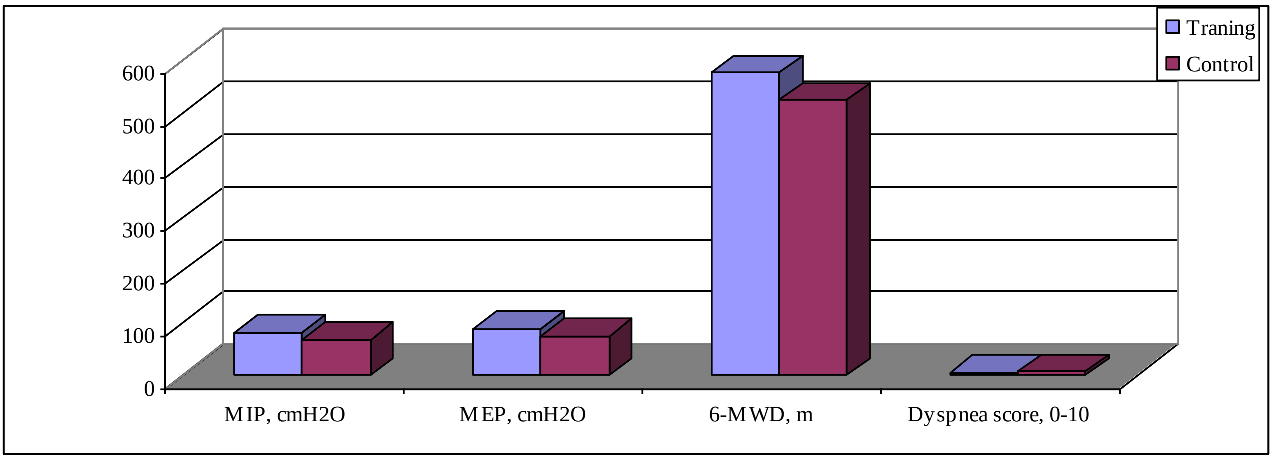
Fig. (2): Pre- and Post-measures for Control Group.

Comparing the mean post-measures of MIP, MEP, 6-MWD and dyspnea score between the training and control groups, the results showed highly significant differences (P<0.001), where it was 82.36 ± 8.29 vs. 67.29 ± 6.56 (cm H_2O) for MIP, 88.36 ± 7.14 vs. 74.14 ± 8.54 (cm H_2O) for MEP, 575.93 ± 36.16 vs. 523.86 ± 42.63 (m) for 6-MWD and 4.57 ± 1.09 vs. 6.79 ± 0.89 for dyspnea score for training and control groups respectively. (Table 4 and figure 3)

Table (4): Comparisons of Post-measures between Training and Control Groups.

Variables	MIP, cm H_2O	MEP, cm H_2O	6-MWD, m	Dyspnea Score, 0-10
Training Group	82.36 ± 8.29	88.36 ± 7.14	575.93 ± 36.16	4.57 ± 1.09
Control Group	67.29 ± 6.56	74.14 ± 8.54	523.86 ± 42.63	6.79 ± 0.89
P-value	<0.001	<0.001	0.002	<0.001

Values are expressed as mean ± standard deviation. MIP; maximum inspiratory pressure, cm; centimeter, H_2O; water, MEP; maximum expiratory pressure, 6-MWD; 6-minute walk distance, Dyspnea Score; modified Borg dyspnea scale.



Values are expressed as mean ± standard deviation. MIP; maximum inspiratory pressure, cm; centimeter, H_2O; water, MEP; maximum expiratory pressure, 6-MWD; 6-minute walk distance, Dyspnea Score; modified Borg dyspnea scale.

Fig. (3): Comparisons of Post-measures between Training and Control Groups.

Table 5 shows the correlation between post-measures for the trained group. The results showed that there was negative correlation between MIP and MEP (r=−0.33), between MIP and 6-MWD (r=−0.28) and between MIP and dyspnea score (r=−0.04). The results showed also that there was positive correlation between MEP and 6-MWD (r=0.16), MEP and dyspnea score (r=0.36) and between 6-MWD and dyspnea score (r=0.50).

Table (5): Correlation Coefficient among the Post-measures for the Training Group.

Variables	MIP, cm H_2O	MEP, cm H_2O	6-MWD, m
MEP, cm H_2O	−0.33	----------	----------
6-MWD, m	−0.28	0.16	----------
Dyspnea Score, 0-10	−0.04	0.36	0.50

MIP; maximum inspiratory pressure, cm; centimeter, H_2O; water, MEP; maximum expiratory pressure, 6-MWD; 6-minute walk distance, Dyspnea Score; modified Borg dyspnea scale.

Table 6 shows the multiple linear regression analysis model to predict 6-MWD as a dependent variable from MIP, MEP and dyspnea score as independent variables (post-measures), the model is;

Post-measure 6-MWD = 663.34 – 1.33 Post MIP – 0.67 Post MEP + 17.72 Post Dyspnea Score.

Table (6): Multiple Linear Regression Analysis Model to predict 6-MWD from MIP, MEP and Dyspnea Score (Post-measures).

Independent Variables	B-Coefficient	Standard Error of the Coefficient	P-value
Constant	663.34	181.69	0.01
MIP, cm H_2O	−1.33	1.20	0.30
MEP, cm H_2O	−0.67	1.49	0.67
Dyspnea Score, 0-10	17.72	9.23	0.09
MIP; maximum inspiratory pressure, cm; centimeter, H_2O; water, MEP; maximum expiratory pressure, 6-MWD; 6-minute walk distance, Dyspnea Score; modified Borg dyspnea scale, β-Coefficient; regression coefficient.			

DISCUSSION

The present study demonstrates that a short term (8-weeks) supervised respiratory muscles training program significantly decrease dyspnea perception and improve exercise tolerance in moderate stable COPD patients. The main findings of this study were the significant increase in the mean MIP and MEP as the result of practicing a training program of pursed lips breathing technique and diaphragmatic breathing exercises. Previous studies[4,7,19-22] concerned with COPD patients demonstrated that respiratory muscles training program improves exercise tolerance and alleviate dyspnea.

The respiratory muscles are essential for sustaining ventilation, and therefore evaluation of respiratory muscle function is important when assessing COPD patients[23]. Measurement of maximal inspiratory and expiratory pressures is commonly used to evaluate respiratory muscle strength in COPD patients. Portable devices are useful for rapid and simple assessment of respiratory muscle strength in the clinic[20,24-26] which were used in this study.

The significant increase in MIP and MEP demonstrated in the present study following a strengthening exercise program for respiratory muscles in the training group was also revealed by the work of Martin et al[27]. They reported that high-intensity inspiratory muscle strength training protocol produces significant increases in respiratory pressure, which aids in weaning patients from mechanical ventilation in patients with respiratory failure. Soliman et al[28] added that measurement of inspiratory pressure is a valuable tool for monitoring the progression of respiratory muscle weakness.

In the current study, pursed lips breathing technique and diaphragmatic breathing exercises were used for strengthening of respiratory muscles. Purse lipped breathing aims to improve expiration by actively expiring against partially closed lips. It is believed that this prolonging expiration technique is effective in preventing airway collapse[13]. Evidence for effectiveness of pursed lips breathing was demonstrated by Gosselink et al[16] study which was used for respiratory muscle training and to alleviate dyspnea. In addition Dechman and Wilson[18] revealed that the use of pursed lips breathing appears to be an effective way to improve gas exchange in people with moderate to severe, but stable, COPD. On the other hand, patients were able during diaphragmatic breathing to voluntarily change the breathing pattern to more abdominal movement and less thoracic excursion leading to normalization of breathing pattern. In addition, active expiration will increase elastic recoil pressure of the diaphragm and rib cage[15,16,29]. Diaphragmatic breathing appeared to be associated with slowing of respiratory rate without improving ventilation[16]. Slow and deep breathing techniques improves breathing efficiency and oxygen saturation at rest. Gosselink[16] and Geddes et al[22] recorded improvements in respiratory muscle strength, chest wall mobility, respiratory pattern, and respiratory endurance in patients with generalized myasthenia gravis as the result of practicing inspiratory muscle training and breathing retraining. The results of Dall'Ago et al[30] showed that a short-term, home-based program of inspiratory muscle training results in marked improvement in inspiratory muscle strength and endurance, which results in clinically relevant improvement in submaximal and maximal functional capacity, as well as in quality of life in chronic heart failure patients with inspiratory muscle weakness. Therefore inspiratory muscle training could be viewed as a relatively accessible, evidence-based component of rehabilitation programs that reduced dyspnea and improved exercise tolerance in patients with COPD[5,31].

Modified Borg Scale was used in this study to determine dyspnea score which is considered as an objective and reliable scale for dyspnea perception. von Leupoldt and Dahme[14] showed that inaccurate determination of perception of dyspnea in COPD was associated with poorer treatment outcome and reduced quality of life.

The improvement of maximal respiratory pressure demonstrated in the present study as the result of practicing respiratory muscle exercise program was associated with improvement of dyspnea perception during exercise. A significant reduction of dyspnea score was observed in the training group as the result of practicing the exercise program. This was supported by Ambrosino et al[15] who reported that the substantial improvements in dyspnea and exercise tolerance could be obtained as a result of programs of exercise training even in very severe COPD patients. Therefore, exercise training is a valuable adjunct to drug intervention for treating dyspnea in COPD patients. However, Hill et al[4] demonstrated that inspiratory muscle training alone, when optimized, was capable of yielding meaningful improvements in exercise capacity in COPD.

The present study also demonstrated that respiratory muscle training led to an improvement of exercise tolerance. This was demonstrated by the significant increase of 6-MWD, which is a sub-maximal exercise test used as a good predictor of functional status and more reflective of activities of daily life[32]. Weiner et al[21] proved that improvement in respiratory muscle performance was associated with an increase in the 6-MWD and in the sensation of dyspnea in daily activities. Our results also showed that there was a positive correlation between MEP and 6-MWD of the training group as indicated by the increased 6-MWD as the result of the improvement in MEP value. The regression equation presented in our results could be used as a tool to predict the 6-MWD using the measured MIP and MEP in moderate male COPD patients having similar criteria used in this study.

Inspiratory muscle training has also been applied successfully in a home-based setting[33]. This study used home routine respiratory muscle training program which is similar to program practiced by Scherer et al[7] and Koppers et al[19]. They found that home-based respiratory muscle endurance training improved respiratory muscle strength, exercise performance and dyspnea perception.

Geddes et al[22] emphasized that the training program protocol including sufficient frequency, intensity, duration and supervision of inspiratory muscle training produced effective outcomes. The American thoracic society and European respiratory society statement on pulmonary rehabilitation[11] recommended that a minimum of 20 supervised hospital sessions should be given for at least three times per week to achieve physiologic benefits; moreover, twice weekly supervised hospital sessions plus one unsupervised home session may also be acceptable. However, Weiner et al[21] added that the relatively brief (4-week) periods of training can provide beneficial effects. In the present study, we used 8 weeks supervised respiratory muscle training program with total 24 sessions which was effective enough for providing the significant improvements detected in the studied parameters for the training group.

Conclusion

Measurement of maximum respiratory pressure had gained importance due to its simplicity and great usefulness in the laboratory and in clinical and hospital settings to assess the strength of the respiratory muscles. Respiratory muscle training program could be useful in increasing maximal respiratory pressure, decreased dyspnea perception and improved exercise tolerance in stable moderate COPD patients.

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الملخص العربي

ممارسة برنامج تمرينات تقوية للعضلات التنفسية وعلاقته باقصى ضغط تنفسي لدى مرضى السدة الرئوية المزمن

يعتبر مرض السدة الرئوية المزمن خليط بين انتفاخ الرئة والتهاب شعبي مزمن هو حالة مرضية تتصف بقصور في تدفق الهواء الغير قابل إلى العودة إلى حالته الطبيعية ويكون عادة مصاحباً باستجابة التهابية في الرئتين . ان عامل الخطورة الأهم في مرض السدة الرئوية المزمن هو التدخين الايجابي والسلبي لجميع انواع التبغ والتعرض لتلوث الهواء . وتتضمن أعراض المرض صعوبة في التنفس المصاحب للمجهود البدني . ويعتبر نقص معدل الضغط الهوائي الشهيقي والزفيري داخل الرئتين الناتج عن قصور وضعف في العضلات التنفسية من اهم اسباب ضيق التنفس المصاحب المجهود البدني . تهدف هذة الدراسة الى تقييم اثر ممارسة برنامج تمرينات تقوية للعضلات التنفسية على مستوى اقصى ضغط شهيقي وزفيري ومستوى التحمل البدني والاحساس بصعوبة التنفس اثناء المجهود لدى مرضى السدة الرئوية المزمن . اجريت هذة الدراسة على ثمانية وعشرين رجلا ممن يعانون من مرض السدة الرئوية المزمن (الدرجة المتوسطة) وفي حالة مستقرة وكان متوسط اعمارهم 1.79 ± 62.25 عاما . تم قياس اقصى ضغط شهيقي واقصى ضغط زفيري باستخدام اجهزة القياس المحمولة وتم تحديد مستوى الاداء البدني عن طريق قياس اقصى مسافة يستطيع المريض تغطيتها من خلال اختبار المشي خلال 6 دقائق . وتم قياس مستوى الاحساس بصعوبة التنفس قبل وبعد اختبار المشى . تم القاء محاضرة تثقيفية طبية لجميع المرضى تساعد على التأقلم مع المرض وتوضيح الاضرار الصحية لممارسة التدخين ودورة كسبب رئيسي في حدوث وتدهور المرض ومساعدة المريض على الإقلاع عن التدخين . وتم تدريب المرضى على الطريقة المثلى لاستخدام البخاخة المحتوية على الدواء الموسع للشعب الهوائية لاستخدامها عند اللزوم . والتنبية على جميع المرضى بضرورة مراجعة الطبيب المعالج فورا فى حال حدوث اى تغير في الحالة الصحية . تم تقسيم المرضى عشوائيا الى مجموعتين (مجموعة التمرينات ومجموعة التحكم) كل مجموعة اشتملت على 14 مريضا . طلب من مرضى مجموعة التحكم ممارسة حياتهم بصورة طبيعية . اما مجموعة التمرينات فقد تلقوا برنامج تقوية للعضلات التنفسية تحت اشراف الباحث الاول لمدة شهرين بواقع ثلاث جلسات اسبوعيا (24 جلسة) . تتكون الجلسة من تمرينات تنفسية عن طريق تكوير الفم وتمرينات تنفسية للحجاب الحاجز . بعد انتهاء فترة التدريب تم قياس اقصى ضغط شهيقي واقصى ضغط زفيري وتم تحديد مستوى الاداء البدني عن طريق قياس اقصى مسافة يستطيع المريض تغطيتها من خلال اختبار المشي خلال 6 دقائق وكذلك تم قياس مستوى الاحساس بصعوبة التنفس قبل وبعد اختبار المشى لجميع المرضى . تم تجميع القياسات وعمل الإحصاءات الطبية اللازمة وبمقارنة متوسط القياسات بين قبل وبعد ممارسة برنامج التمرينات التنفسية وجد تحسن ذو دلالة إحصائية عالية في متوسط قياس اقصى ضغط شهيقي واقصى ضغط زفيري ومستوى الاداء البدني ومستوى الاحساس بصعوبة التنفس قبل وبعد اختبار المشى في مجموعة التمرينات. وبمقارنة متوسط القياسات بين المجموعتين في نهاية الدراسة وجد هناك تحسن ذو دلالة إحصائية في جميع القياسات في صالح مجموعة التمرينات . أثبتت هذة الدراسة اهمية ممارسة برنامج تقوية للعضلات التنفسية في زيادة مستوى اقصى ضغط شهيقي وزفيري ومستوى التحمل البدني وتقليل الاحساس بصعوبة التنفس اثناء المجهود لدى مرضى السدة الرئوية المزمن .