Effectiveness of pulmonary rehabilitation on pulmonary function parameters and dyspnea in patients with stable chronic obstructive pulmonary disease

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Background Chronic obstructive pulmonary disease (COPD) is a common preventable and treatable disease characterized by persistent airflow limitation that is usually progressive. The characteristic symptoms of COPD are chronic and progressive dyspnea, cough, and sputum production. Breathing exercises aim to reduce hyperinflation, improve respiratory muscle performance, and reduce dyspnea.

Aim The aim of the study was to assess the effectiveness of breathing exercises among patients with stable COPD in improvement of pulmonary function parameters, 6-min walk distance, and dyspnea score.

Patients and methods Randomized controlled design was used in this study. Patients recruited for this study were enrolled from the outpatient clinic of Department of Chest Diseases and Tuberculosis. Overall, 15 patients with stable COPD were enrolled in pulmonary rehabilitation group and underwent breathing exercises for 12 weeks. Moreover, 15 patients were enrolled in the control group. Statistical package for the social sciences (SPSS version 20) software was used for statistical analysis.

Results In the breathing exercise group, there was a significant increase in the mean forced expiratory volume in first second ($P=0.001$), forced vital capacity ($P=0.001$), and inspiratory capacity ($P=0.015$). There was a significant decrease in the mean functional residual capacity ($P=0.005$), residual volume ($P=0.001$), and total lung capacity ($P=0.001$). There was no significant difference between the values of the previous parameters in the control group.

Conclusion In stable COPD, breathing exercises improved pulmonary function parameters, 6-min walk distance, and dyspnea score.

Egypt J Bronchol 2018 12:149–153

Egyptian Journal of Bronchology 2018 12:149–153

Keywords: chronic obstructive pulmonary disease, dyspnea, pulmonary rehabilitation

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Received 26 May 2016 **Accepted** 28 February 2017

Introduction

Chronic obstructive pulmonary disease (COPD) is a common preventable and treatable disease characterized by airflow limitation that is usually progressive [1]. Airflow limitation is usually associated with air trapping and hyperinflation. Lung hyperinflation results in disruption of neuroventilatory coupling, increased work of breathing, and the perception of dyspnea. Breathing exercises are designed to retain the breathing pattern, reduce breathlessness, increase exercise capacity, alter respiratory muscle recruitment, improve respiratory muscle performance, reduce dyspnea, and improve well-being for patients with COPD [2].

The aim of the study was to evaluate the effect of breathing exercises on hyperinflation in patients with stable COPD. Exertional dyspnea, pulmonary function tests parameters, and 6-min walk distance were the main outcome measures.

Patients and methods

This prospective cross-sectional randomized controlled study was carried out in Chest Outpatient Clinic. The total duration the study was 12 weeks from January 2014 to March 2015. All patients provided written consent, and the study was approved by the respective ethics committees and institutional review boards.

The inclusion criteria were diagnosis as stable COPD 'moderate, severe, and very severe' according to Global Initiative for Obstructive Lung Disease guidelines 2015 [1] [post bronchodilator forced expiratory volume in first second (FEV1)/forced vital capacity (FVC) <70%], age more than 40 years, male sex, and hyperinflation [total lung capacity (TLC) >120% predicted by plethysmography].

The main exclusion criteria were bronchial asthma, heart diseases, musculoskeletal disorders, peripheral vascular diseases, respiratory failure, decompensated corpulmonale, acute pulmonary embolism, uncontrolled cardiac arrhythmia, and any disabling conditions that would interfere with the tests.

 DOI: 10.4103/ejb.ejb_43_16

Following an initial screening visit at the outpatient clinic to assess eligibility, patients who fulfilled the inclusion criteria were asked to return after 2 weeks for the baseline visit. Patients were kept on their current treatment (such as inhaled corticosteroids and long-acting B2 agonist). Patients were randomized at the baseline visit through the closed envelop method to allocate each of them either into breathing exercises group, which underwent exercises to mobilize one side of the chest, mobilize the upper chest, stretch the pectoralis muscles, and mobilize the upper chest and shoulders and pursed lip breathing, or into the control group. Patients in the control group were kept only on their current treatment. Clinic visits were scheduled after 4, 8, and 12 weeks following randomization. Assessment of dyspnea by modified Medical Research Council (mMRC), 6-min walk distance, and performing pulmonary function testing including spirometry and body plethysmography (D 97723; Zan 300, Oberthulba, Germany) were done at baseline and at all clinic visits. Measurements were performed according to American Thoracic Society criteria·[3].

Statistical analysis

All results were tabulated and statistically analyzed using the statistical package for the social sciences (SPSS version 20; SPSS Inc., Chicago, Illinois, USA) software. Data were expressed as mean±SD or frequencies. The *t*-test was used for comparison of continuous variables between the two groups. Wilcoxon's sign rank test was used for comparing the results in the same group before and after the therapy.

Results

A total of 30 patients were selected for this study, with 15 patients in each group.

Patient demographics

Age, weight, height, BMI, smoking status, and pack per year index were determined in all patients (Table 1).

Table 1 Demographic characteristics of the study patients at the baseline visit (*n* = 30)

Variables	Control (*N* = 15) (mean±SD)	Breathing exercise (*N*=15) (mean±SD)	*P* value
Age (years)	64.47±6.99	64.87±8.56	0.976
Height (cm)	162.87±7.21	166.47±6.13	0.170
Weight (kg)	65.53±14.29	65.20±6.95	0.935
BMI (kg/m^2)	24.62±4.65	23.49±1.73	0.524
Smoking status [*n* (%)]			
Current smoker	1 (6.7)	2 (13.3)	0.697
Ex-smoker	14 (93.3)	13 (86.7)	
Pack per year	22.40±7.94	22.80±4.71	0.943

There was no statistical significant difference regarding the baseline pulmonary function tests parameters at baseline visit among the study groups (Table 2).

In the control group, there was a nonsignificant difference between the baseline values and the values obtained after 12 weeks regarding spirometric parameters such as FEV1 (*P*=0.107), FVC (*P*=0.089), and inspiratory capacity (IC) (*P*=0.239); plethysmographic parameters such as functional residual capacity (FRC) (*P*=0.148), residual volume (RV) (*P*=0.116), and TLC (*P*=0.840); dyspnea score (*P*=0.115); and 6-min walking distance (*P*=0.327) (Table 3).

In the breathing exercise group, there was a significant improvement in FEV1 (*P*=0.001), FVC (*P*=0.001), IC (*P*=0.015), FRC (*P*=0.005), RV (*P*=0.001), TLC (*P*=0.001), RV/TLC (*P*=0.010), dyspnea score (*P*=0.005), and 6-min walking distance (*P*=0.001) whereas there was a nonsignificant difference regarding baseline and 12-week values for FEV1/FVC (*P*=0.637) (Table 4).

Discussion

The present study was designed to evaluate pulmonary functions, dyspnea score, and 6-min walking distance following 12 weeks course of breathing exercises that aim to decrease hyperinflation in patients with stable COPD.

Regarding the characteristics of the study participants, the present study showed that the mean age of study

Table 2 Pulmonary function test parameters at the baseline visit (*n*=30)

Variables	Control group (*N*=15) (mean±SD)	Breathing exercises group (*N*=15) (mean±SD)	*P* value
FEV_1% predicted	35.07±13.20	40.93±19.83	0.305
FVC% predicted	51.53±7.25	57.00±21.91	0.092
FEV_1/FVC% predicted	65.73±12.12	70.73±12.20	0.399
IC% predicted	42.27±10.20	47.87±16.78	0.093
FRC% predicted	158.20±39.23	156.13±37.99	0.097
RV % predicted	141.27±11.75	136.00±4.46	0.154
TLC% predicted	143.67±30.81	141.27±10.38	0.168
RV/TLC % predicted	160.93±29.09	152.07±29.02	0.112
Dyspnea score (mMRC)	3.27±0.46	3.43±0.46	0.028
6-min walking distance (m)	50.87±9.46	51.73±7.06	0.660

FEV1, forced expiratory volume in 1 s; FRC, functional residual capacity; FVC, forced vital capacity; IC, inspiratory capacity; mMRC, modified Medical Research Council; RV, residual volume; TLC, total lung capacity.

Table 3 Pulmonary function test parameters before and after 12 weeks in the control group (n=15)

Variables	Baseline	After 12 weeks	*P* value
FEV_1% predicted	35.07±13.20	35.13±9.55	0.107
FVC% predicted	51.53±7.25	53.27±9.08	0.089
FEV_1/FVC% predicted	65.73±12.12	64.47±10.70	0.181
IC% predicted	42.27±10.20	42.73±9.48	0.239
FRC% predicted	158.20±39.23	157.07±39.11	0.148
RV% predicted	141.27±11.75	142.93±11.41	0.116
TLC% predicted	143.67±30.81	147.53±28.96	0.840
RV/TLC% predicted	160.93±29.09	158.20±25.43	0.092
Dyspnea score (mMRC)	3.27±0.46	3.18±0.41	0.115
6-min walking distance (m)	50.87±9.46	49.87±9.43	0.327

FEV1, forced expiratory volume in 1 s; FRC, functional residual capacity; FVC, forced vital capacity; IC, inspiratory capacity; mMRC, modified Medical Research Council; RV, residual volume; TLC, total lung capacity.

Table 4 Pulmonary function test parameters before and after 12 weeks in the pulmonary rehabilitation group

Variables	Baseline	After 12 weeks	*P* value
FEV_1% predicted	40.93±19.83	47.00±19.98	0.001*
FVC% predicted	57.00±21.91	63.60±22.45	0.001*
FEV_1/FVC% predicted	70.73±12.20	68.87±11.58	0.637
IC% predicted	47.87±16.78	59.13±16.42	0.015*
FRC% predicted	156.13±37.99	140.60±37.77	0.005*
RV% predicted	136.00±4.46	124.60±4.24	0.001*
TLC% predicted	141.27±10.38	130.87±10.08	0.001*
RV/TLC% predicted	152.07±29.02	142.53±33.95	0.010*
Dyspnea score (mMRC)	3.43±0.46	3.10±0.00	0.005*
6 min walking distance(m)	51.73±7.06	63.80±10.06	0.001*

FEV1, forced expiratory volume in 1 s; FRC, functional residual capacity; FVC, forced vital capacity; IC, inspiratory capacity; mMRC, modified Medical Research Council; RV, residual volume; TLC, total lung capacity.

groups was 64 years. These patients are appropriate candidates for the study and were not to be excluded based on age alone.

Some pulmonary rehabilitation studies have excluded patients older than 70 years, and rationale for age exclusion was not given in these studies; however, all three also excluded patients with other disabling conditions, including arthritis, ischemic heart disease, and heart failure [4]. Thus, elderly patients may have been considered inappropriate for pulmonary rehabilitation because it was believed that they were ‘too old’, that they would not tolerate aggressive treatment, or that the physiologic effects of aging and comorbid illness would limit their ability to improve exercise capacity [5].

Regarding outcome measures after rehabilitation, the present study showed that there was an improvement in baseline dyspnea score grade in breathing exercise training group compared with the control group.

The findings by Wedzicha *et al.* [6] were fully consistent with this; they showed that the effect of exercise training in patients with COPD might depend on the initial level of dyspnea. Patients with moderate dyspnea (MRC grade 2/3), who were regularly mobile outside the home, showed quite large improvements in exercise capacity after physical training. In contrast, patients with severe disability (MRC grade 4), who were largely housebound owing to dyspnea, showed no improvement in exercise performance following individualized physical training [6].

The present study also reported improvement in dyspnea score within the respiratory training group than the control group.

Harver *et al.* [7] were fully consistent with this; they found that targeted inspiratory muscle training results in significant increases in respiratory muscle function and significant reductions in dyspnea. This supports the concept that an increase in the strength of inspiratory muscles can ameliorate dyspnea [7].

Another study by Lisboa *et al.* [8] found that the trained patients were able to make greater efforts and perform harder tasks than they were before inspiratory muscle training and were able to carry out activities faster without dyspnea.

Exercise tolerance was measured using the 6-min walking distance. Timed walking tests such as the 6-min walking test have gained popularity for use in clinical practice and research setting to assess changes in functional capacity following pulmonary rehabilitation intervention [9,10].

The present study showed that 6-min walking distance increased to 63 m after 12 weeks of respiratory training program. This improvement was statistically significant.

Redelmeier *et al*. [11] suggested that the minimal clinically meaningful increase in the 6-min walking distance is ~54 m.

The improvement in exercise capacity after aerobic training program may be because of the following: (a) improving ventilatory muscle function and (b) desensitization to dyspnea.

This finding correlated with a meta-analysis done by Bendtrup *et al*. [12], where in a controlled 12-week study of outpatient pulmonary rehabilitation, the 6-min walking distance increased by 80 m at 6 weeks (half-way in the program), 113 m at the end of the program, and 96 m 12 weeks after the program ended. Another study demonstrated that 6-min walking distance increased by 71.75 m after 6 weeks of outpatient pulmonary rehabilitation [12,13].

However, De-Torres *et al*. [14] demonstrated that the mean improvement in 6-min walking distance was 65 m after 6–8 weeks of pulmonary rehabilitation. Another study by Seals *et al*. [15] noted an increase of 78.41 m in 6-min walking distance after 6 months of outpatient and home-based program.

Significant spirometric and plethysmographic improvements were observed in patient who were subjected to 12 weeks course of breathing exercise training, where significant increases in FEV1 (P=0.001), FVC (P=0.001), and IC (P=0.015) were observed in addition to significant reduction in RV (P=0.001), TLC (P=0.001), FRC (P=0.005), and RV/TLC (P=0.010) in comparison with control group. These results were in concordance with the results of Liu *et al*. [16].

Results of Tout *et al*. [17] were in agreement with the results of this study; spirometric and plethysmographic outcomes were similar across all the breathing exercises examined (diaphragmatic breathing, pursed lip breathing, exercise to mobilize one side of the chest, exercise to mobilize the upper chest and stretch the pectoralis muscles, exercise to mobilize the upper chest and shoulders, and to increase expiration during deep breathing).

In contrast, in other studies, no significant modification of pulmonary functions was marked after a training program. Pulmonary rehabilitation causes modification in peripheral myopathy but not ventilatory limitation. The airflow limitation in most cases is both progressive and associated with an abnormal inflammatory response of the lungs to noxious particles or gases [18,19].

Other studies have shown some improvement in FVC, which may have been because of the improved respiratory muscle function and a reduction in small airways disease; the improvement in FEV1 in those cases was small and not statistically significant [14]. Stav *et al*. [20] demonstrated that outpatient prolonged pulmonary rehabilitation program (3 years) did not improve FEV1, but has an important beneficial effect on the rate of FEV1 decline. In addition, it increased endurance time and work, so pulmonary rehabilitation should be considered as a disease modifier.

Estève *et al*. [21] found that breathing pattern training, enhanced with visual feedback, increased the FEV1 and FVC in patients with COPD.

However, another study by Singh *et al*. [22] reported no improvement following pulmonary rehabilitation having breathing exercises as a component.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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