

Balance training: its influence on pulmonary rehabilitation

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Received 9 July 2018

Accepted 1 November 18

Bulletin of Faculty of Physical Therapy 2019, 24:8–13

Background

Balance disorders are one of the most important complications for patients with chronic obstructive pulmonary disease (COPD).

Objective

To investigate the effect of adding balance training to pulmonary rehabilitation program in improving balance in patients with COPD.

Patients and methods

A total of 48 male patients diagnosed as having COPD were selected from the outpatient clinic of Wadi El-Neel Hospital, Cairo, and their ages ranged from 60 to 65 years. Patients were assigned randomly into two equal groups. The study group received balance training with pulmonary rehabilitation program, and the control group received pulmonary rehabilitation program only. Exercise training was performed for both groups three times a week for 8 weeks. Balance assessment was performed by Berg Balance Scale, Balance Evaluation Systems Test, and 6-min walking test before and after training.

Results

The 2x2 mixed-model analysis of variance analysis demonstrated significant increase in the Berg Balance Scale and Balance Evaluation Systems Test after treatment in both groups, with a percentage of improvement in control group was 5.01 and 9.15%, respectively, whereas in the study group was 16.04 and 25.46%, respectively. However, the study group showed significant improvement than the control group after treatment in both tests. Regarding 6-min walking test, both groups showed significant increase after treatment, with a similar percentage of improvement in the control group (23.95%) and the study group (24.93%). There was no significant difference between the control and the study group after treatment.

Conclusion

Addition of balance training to pulmonary rehabilitation program was more effective in improving balance in elderly patients with COPD.

Keywords:

balance training, chronic obstructive pulmonary disease, fall risk, pulmonary rehabilitation

Bulletin of Faculty of Physical Therapy 24:8–13
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1110-6611

Introduction

Chronic obstructive pulmonary disease (COPD) is a prevalent, treatable, and preventable disease characterized by continual respiratory symptoms and limitation of airflow owing to the fact that changes in airways and alveoli are caused by inhalation of noxious particles suspended in the smoke [1]. Lower limb muscles appear to be more severely affected as there is reduction in both muscle strength and endurance, resulting from a reduction in physical activity, as well as a feebleness in the capacity of muscle metabolism, owing to the fact that lower limb muscles of patients with COPD consume more oxygen at any given workload and are characterized by an early fatigue and increased production of lactate [2]. Moreover, muscle mass reduction and a reduced percentage of oxidative fibers, fewer blood vessels and capillary contacts per fiber, a reduced myoglobin content, and a diminished enzyme capacity in the oxidative pathways result in reduced oxidative capacity of

lower limb muscles. Although the oxygen delivery is comparatively kept in COPD, there is an existence of an ineffectual intracellular use of oxygen [3].

In COPD, diminished exercise capacity, peripheral muscle performance, and functional mobility lead to a serious deficit in balance control that increases risk of falls, increasing the mortality rate among older patients [4]. Falls that do not lead to trauma frequently initiate a series of fearful assumptions that lead to stillness and decreased muscle strength, balance disorders, and often result in dependency in daily living activities [5].

Balance impairment was found in patients with varying COPD severity which happens as a result of peripheral

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muscle weakness, decreased physical activity level, changes in trunk muscle mechanics, and somatosensory deficits [6]. Individuals with COPD may have different fall risk factors such as usage of multiple medications, cognitive impairment, and comorbidities such as osteoarthritis and osteoporosis [7]. The prevalence of annual fall rate among COPD was five times higher than expected based on age alone [8].

Pulmonary rehabilitation should be incorporated into COPD treatment strategies as part of long-term disease management [9]. Pulmonary rehabilitation has valuable benefits for patients with COPD, as it improves health-related quality of life and improves functional exercise capacity across various COPD grades through application of supervised exercise protocols, including strength, endurance, and interval training for upper limbs, lower limbs, and respiratory muscles, for a period of 6–8 weeks [1].

International guidelines for pulmonary rehabilitation do not include fall prevention or balance training strategies, so it had minimal effect on fall risk and balance measures; therefore, to reduce falls, exercises that include targeted balance training are needed [10,11]. Thus, the aim of this study was to determine the value of adding balance training to conventional pulmonary rehabilitation on improving balance among elderly individuals with COPD on a short-term basis (after 8 weeks of training).

Patients and methods

Patients

A total of 48 patients with COPD, with age range from 60 to 65 years, were screened to be enrolled into this 8-week blinded randomized controlled trial. They were recruited from outpatient clinics of the Wadi El-Neel Hospital, Cairo, to participate in this study. This study was approved by the Ethics Committee for Scientific Research of the Faculty of Physical Therapy, Cairo University. Informed consent for participation and publication of the results of the study was provided. The participants underwent initial evaluation and completed the course of training.

Inclusion criteria were as follows: moderate COPD [forced expiratory volume in 1 s/(FEV1)/forced vital capacity <70% predicted and FEV1 <80% predicted] [1] according to physician diagnosis, smoking history of more than 10 packs/year, age between 60 and 65 years, good cognition level, and fall history in the past 5 years.

Exclusion criteria were as follows: severe COPD (FEV1<50% predicted) [1], oxygen-dependent or mechanically ventilated patients, decrease cognition level, limited balance and mobility owing musculoskeletal or neurological condition, and presence of visual or hearing disorders.

Each patient underwent an initial medical screening by the physician. Documentation of clinical history was done, and explanation of the study protocol and objectives was done for all the participants who were asked to maintain their pharmacological treatment and normal daily activities and lifestyle throughout the study.

Patients were randomly assigned using opaque envelop into two groups by an investigator who was not implicated in this study.

Group A, the study group, received balance training in addition to pulmonary rehabilitation program, and group B, the control group, received pulmonary rehabilitation program only.

The exercise program was based on pulmonary rehabilitation program present in the global initiative for Chronic Obstructive Lung Disease (GOLD) 2017 guidelines [1] and was conducted in the period from June 2017 to March 2018.

Initial measures

The two groups were subjected to the same initial tests: baseline measures before training and after 8 weeks at the end of exercise training program.

- (1) The evaluated parameter included pulmonary function test measurement.
- (2) Weight and height were measured with the participant standing in an erect position against a vertical scale of a portable stadiometer to calculate BMI (kg/m^2).

Outcome measures

The outcome measures were assessed using the following:

- (1) Berg Balance Scale (BBS): it is used to objectively determine a patient's ability (or inability) to safely balance during a series of predetermined tasks. It elucidates inter-rater and inter-rater reliability and predictive validity for detecting fall risk in elderly. It is a 14-item list, with each item consisting of a five-point ordinal scale, ranging from 0 to 4, with 0 indicating the lowest level of function and 4 the highest level of function [12].

- (2) The Balance Evaluation Systems Test (BESTest): it is an excellent inter-rater reliability and validity and allows for detecting balance deficiency. It consists of 36 items that evaluate six subsystems of balance control; each item is graded on a four-level ordinal scale from 0 (unable to perform) to 3 (normal performance) as sentenced by performance time. Each subsystem category comprises 20% of the total balance score. The BESTest total score is a sum of all the individual items, with a maximum of 100 (higher numbers indicate better balance) [13].
- (3) The 6-minute walk test (6MWT): it is an easy method to measure individual's exercise capacity. The distance covered is used to compare changes in performance capacity.
- (3) Transition exercise [e.g. sit to stand from chair with arms (10 repetitions) and then without arms support (five repetitions)], sit on floor and stand up with assistance and then without assistance.
- (4) Gait training (e.g. walking tandem, sideway and backward with arm support and without arm support, and walking over obstacles).

Materials

The following materials were used:

- (1) Weight and height scale.
- (2) Stopwatch to adjust the time for each exercise phase.
- (3) Measuring tape mounted on wall.
- (4) Approximately 60 cm×60 cm block of 4 inches, medium density, Tempur foam.
- (5) 10-degree incline ramp (at least 2×0.6 m).
- (6) Stair step, 15 cm (6 inches) in height
- (7) Two stacked shoe boxes (for 9-inch obstacle height).
- (8) 2.5-kg free weight.
- (9) Firm chair with arms with 3 m in front marked with tape.
- (10) Masking tape to mark 3-m and 6-m lengths on the floor.

Procedures

Exercise training protocols

Group A (study group) underwent balance training and pulmonary rehabilitation program for a duration of 25–30 min (total session) at a frequency of three times/week (every other day). The balance training was as follows:

- (1) Functional strength exercise [e.g. heel raise, toe raise, walking on toes, step ups in all directions (forward, backward, and sideway), squats, and core strength on ball] with arm support, and then without arm support (each exercise two sets eight times each).
- (2) Stance exercise (e.g. tandem, narrow, one leg stance, and stand on uneven surfaces) with open eyes (each exercise 30 s) and then with eyes closed (each exercise 15 s).

In addition to balance exercises, the pulmonary rehabilitation program is a key part of exercise training for group A which consists of (a) individualized endurance exercise training based on 60–80% of 6MWT speed achieved; (b) strength exercise for large muscle groups in upper and lower extremities using Thera band and weights (three sets eight repetition each with rest between sets about 1.30 min), where workload is based on 50–75% of 1 RM, repeated at week 4; and (c) daily breathing exercises (e.g. diaphragmatic, pursed lip breathing, and stretch exercise for major respiratory muscles).

Group B (control group) underwent pulmonary rehabilitation program only for a duration of 25–30 min (total session) at a frequency of three times/week (day after day). The pulmonary rehabilitation program was applied as aforementioned.

In addition, both groups received 30 min of breathing exercise on daily basis as home-program exercise [6].

Data collection

First, data were compiled from all participants in both groups concerning age, weight, and height (to measure BMI), smoking history, used walking aids, fall history, and pulmonary function parameters.

Second, data on balance tests (BBS, BESTest, and 6MWT) (were collected before and after training).

Statistical analysis

To eliminate type II error, a prefatory power analysis [effect size=0.8, $\alpha=0.01$, power (1- α error) $P=0.85$] specified a sample size of 48 for this study, as it yielded a realistic sample size [14].

Data were analyzed for this study using descriptively and with a 2×2 mixed-model analysis of variance with the treatment groups (study vs. control) serving as the between-subjects factor and time of assessment (before treatment and after treatment) serving as the within-subjects factor using the IBM SPSS, version 22 software (IBM), with P value set at 0.05. The dependent variables were BBS, BESTest, and 6MWT. Before data analysis, Shapiro–Wilk test and

Levene's test were used to test the normality of the data and the equality of variances, respectively. The differences in demographic characteristics for both groups were assessed using unpaired *t* tests. Furthermore, unpaired *t* tests were also used to assess if there was a difference between the two groups in before-treatment dependent variables. A preliminary power analysis (power=0.8) determined a sample size of 24 patients in each group.

Results

Demographic data of the participant are presented in Table 1. No significant differences were found between both the groups in age, BMI, FEV1 predicted, and FEV1/forced vital capacity predicted. Statistical diagnostic tests revealed no violations of the assumptions of normality and homogeneity of variance for any of the dependent variables. There was no significant difference between the two groups in all pretreatment dependent variables ($P > 0.05$).

Descriptive statistics of BBS, BESTest, and 6MWT are presented in Table 2. The 2x2 mixed-model analysis of variance analysis demonstrated significant increase in the BBS after treatment in both groups as the main effect of time was statistically significant (0.0001) with a percentage of improvement in the control group (5.01%) and in the study group (16.04%). However, the study group showed significant improvement than the control group after treatment as the main effect of group was statistically significant (0.006) and time×group interaction effect was also significant (0.0001), as shown in Table 3.

Table 1 Demographic characteristics of the participants

Characteristics	Study group	Control group	<i>P</i> value
Age (years)	63.08±1.69	62.37±1.58	0.14
BMI (kg/m ²)	24.85±2.22	24.95±2.38	0.88
FEV1 predicted (%)	63.62±5.64	61.58±8.51	0.33
FEV1/FVC predicted	49.25±5.56	48.87±5.2	0.81

FEV1/FVC, forced expiratory volume in 1 s/forced vital capacity.

Table 2 The mean values for Berg Balance Scale, Balance Evaluation Systems Test, and 6-min walking test for both groups before and after treatment

Variables	Group	Before treatment	After treatment
BBS	Control group	45.65±3.9	47.94±3.87
	Study group	45.99±3.76	53.37±2.55
BESTest	Control group	64.91±6.33	70.85±6.03
	Study group	65.55±6.28	82.24±6.49
6MWT	Control group	289.32±40.31 m	358.62±57.37 m
	Study group	296.27±41.96 m	370.14±51.1 m

6MWT, 6-min walk test; BBS, Berg Balance Scale; BESTest, Balance Evaluation Systems Test.

BESTest was significantly increased after treatment in both groups as the main effect of time was statistically significant (0.0001) with a percentage of improvement in control group (9.15%) and in study group (25.46%). Moreover, the study group showed significant improvement in the BESTest than the control group after treatment, as the main effect of group was statistically significant (0.002), and time×group interaction effect was also significant (0.0001) as shown in Table 3.

Regarding 6MWT, both groups showed significant increase after treatment, as the main effect of time was statistically significant ($P < 0.0001$) with a percentage of improvement in the control group (23.95%) and in the study group (24.93%). However, there was no significant difference between the control and the study groups after treatment in 6MWT, where the main effect of group was nonstatistically significant (0.5) and time×group interaction effect was also nonsignificant (0.4), as shown in Table 3.

Discussion

The purpose of this study was to measure the effect of addition of balance exercises to pulmonary rehabilitation program to improve the overall body balance in patients with COPD.

COPD would be considered universally as the third major cause of death by the year 2020 [1]. The most earnest manifestation of COPD is dysfunction of skeletal muscle, and this is clearly shown in early dyspnea and fatigue after minimal exertion [15]. Although pulmonary rehabilitation is primarily concerned with strengthening muscles and improving respiratory function, it does not take into account the problem of imbalance in patients with

Table 3 Results of a 2x2 mixed-model analysis of variance

Source of variance	<i>F</i> value	<i>P</i> value
BBS		
Between subjects (group)	8.17	0.006*
Within subjects (time)	535.9	0.0001*
Time×group	147.82	0.0001*
BESTest		
Between subjects (group)	11.22	0.002*
Within subjects (time)	1803.64	0.0001*
Time×group	407.18	0.0001*
6MWT		
Between subjects (group)	0.45	0.5
Within subjects (time)	710.26	0.0001*
Time×group	0.72	0.4

6MWT, 6-min walk test; BBS, Berg Balance Scale; BESTest, Balance Evaluation Systems Test. *Significant at $\alpha = 0.05$.

COPD. Balance deterioration usually develops in elderly and individuals with COPD, leading to an increased risk of falling [16]. Patients with COPD usually develop higher rates of osteoporosis [17], which raises the incidence of risk to fall-related fractures and its deleterious effects on respiratory system of patients with COPD owing to reduction of physical activity level [10]. Moreover, Butcher *et al.* [18] proposed that coordination and balance shortfall corresponds to seriousness of FEV1 and subsequent diminished degree of activities in patients with COPD, whereas Eisner *et al.* [19] reported that there is a significant decrease in balance functional tests in patients with moderate COPD compared with healthy people.

However, attention to balance deficit is not taken into consideration during pulmonary rehabilitation programs [15] with high incidence of morbidity and mortality among these patients resulting from fractures owing to falls [10].

Studies of pulmonary rehabilitation use endurance, strength, and breathing intervention. More novel intervention such as balance exercise can be used that could provide a more appropriate and effective exercise modality when added to pulmonary rehabilitation program to reduce risk of fall. In the current study, there was significant improvement in the results of BBS and BESTest in the study group more than the control group after 8 weeks of combined exercises. However, in 6MWT, there was a significant improvement in both the groups, whereas between-group difference was not significant.

Howe *et al.* [20] reported that balance and coordination exercises reduce risk of fall among elderly people as it has definite enhancement on BBS when performed three times per week for 3 months, and this corresponds to the results of this study.

In a group of elderly people having a number of factors that increase fall risk, Gillespie *et al.* [21] found that balance exercise employed as home-program exercise and Tai Chi exercise was found to be efficacious in reducing falls, whereas Sherrington *et al.* [22] noticed that high dose of balance challenging exercise without adding walking program results in greater opportunity for reducing fall risk among elderly patients with COPD. This could be elucidated by increasing time spent in specified balance training program rather than walking exercise. So the American Geriatrics Society recommended combining exercise with balance training as a strategy to reduce risk of falling in older adults [23].

In a study by Chang *et al.* [24], it was reported that after 6MWT, there is static postural control impairment as a result of diminished strength of peripheral skeletal muscles and excess of work of breathing after exertion.

A study by Beauchamp *et al.* [25] measuring the effect of balance training during pulmonary rehabilitation found that there was a significant improvement in balance confidence gained during this program, which is consistent with the findings in this study.

Pulmonary rehabilitation guidelines advocate strength exercises for lower limb muscles to improve daily activities such as climbing stairs or walking [26]. The importance of using resistance exercise to ameliorate balance and reduce the risk of fall for this population was reported [27]. However, Sherrington *et al.* [28] postulated that the small percentage of improvement in balance in pulmonary rehabilitation program attributed to strength exercises, and this come in line with the results of this study concerning the control group.

Many pulmonary rehabilitation studies concentrate on strengthening of lower limb muscles rather than balance training and fall prevention strategies. It also showed that less than 10% use balance assessment tools, so it should be necessary to use this tools while assessing patients with COPD with balance deficiencies [29].

Conclusion

There was a significant improvement in balance and reduction in fall risk in patients with COPD who underwent pulmonary rehabilitation program in addition to balance exercises. So, we therefore advice the addition of balance exercises to the pulmonary rehabilitation program as an essential part, especially for elderly patients with COPD.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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