Original Article

Effect Of Biodex Training On Balance Impairment In Patients With Chronic Obstructive Pulmonary Disease

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Abstract

Background individuals with chronic obstructive pulmonary diseases (COPD) showed balance control deficits with a suggested relevance to increased fall risk. So, studies suggest balance training to be a complementary component of COPD rehabilitation program. **Aim** this study aimed to examine the effects of balance training using Biodex balance system on balance control in COPD patients. **Methods** thirty patients with COPD from the October 6 University Hospital outpatient clinic and University employees were recruited. Patients ranged between 50 to 60 years in age. After their recruitment, patients had been assigned at random into Biodex training group (BTG) and control group (CG). Patients in BTG (n= 15) participated in a 8 weeks program implementing balance training using Biodex balance system, conventional balance training, and breathing exercise for 3 times/week. Patients in CG (n=15) applied conventional balance training and breathing exercise only. Postural stability test (PST) and fall risk test (FRT) using Biodex balance system, in addition to Berg Balance score (BBS) were used for pre- and post- experimental testing. **Result** Outcomes of comparisons demonstrated statistically significant improvements in all measured variables within both BTG and CG ($P < 0.05$). Meanwhile, between groups comparisons showed significantly higher improvements has been reported in favour of BTG in all outcomes. **Conclusion** Balance training using Biodex balance system is recommended for balance training in patients with COPD to correct deficits in balance control and reduce fall risk.

Key words: Balance training, Biodex balance system, Balance impairment, Fall risk, Chronic Obstructive Pulmonary Disease.

Introduction

Balance function is complex in nature, and entails interplay of visual, vestibular, somatosensory systems, besides proper musculoskeletal system function. The interplay of these sensory input systems and musculoskeletal output provides adequate movements planning and performance while centre of gravity displacement is controlled at both static and dynamic situations [1]

Patients with COPD Show impaired respiratory function, besides well- recognized impaired skeletal muscles function, mobility, decreased exercises capacity, and lower quality of life related to health status.[2, 3] Furthermore, evidence suggests that COPD patients suffer significant balance deficits and an increased falls risk. [4]
Deficits in the sensory systems involved in balance function cause deficits in balance control due to deficits in sensory accuracy and integration of sensory input that guides balance control [4]. Several studies reported that different balance measures showed impaired balance in patients with COPD of different severity.[5-9]

Different contributing factors were attributed to balance impairment in COPD including muscles weakness and general decrease in level of function [6], altered trunk muscle mechanics [10], hypoxemia, and somatosensory deficits. [3] Due to skeletal muscle weakness and its relation to balance impairments, Beauchamp, Brooks,[11] suggested that objective method of balance training is required for COPD patients to reduce balance deficit and fall risk.

Biodex balance system, is a sophisticated balance evaluation and training system, which objectively report balance in a quantitative form, provide reliable and valid data regarding balance. Both dynamic and static balance testing and training are available using Biodex balance system. [12] Therefore, predictively, this device may contribute to the improvement of balance impairments compared to conventional balance training alone. Accordingly, this study was conducted in attempt to find out training effects on balance impairment in COPD patients when using balance training using Biodex balance system.

Methods

Study Design

Pretest–posttest control group design was used. Thirty patients with COPD diagnosed based on criteria of the Global initiative for Obstructive Lung Disease (GOLD), participated in this 8-weeks single-blinded study. Patients were selected from the October 6 University hospital outpatient clinics and University employees. Initially, patients were medically screened and their clinical history was documented. Inclusion/exclusion criteria were checked. Patients who participated were moderate cases of COPD, 50 to 60 years old, and BMI ranged from 25 to 29.9 kg\m^2. Exclusion criteria were severe cases of COPD, if their balance disorders were due to neurological, or other organic causes, if they had postural orthostatic hypotension, audio-visual and communication disorders, cardiovascular disorders of acute onset or serious in nature, previous fractures, or lower limbs arthroplasties, use of any medications which affects balance of the patient (e.g. Antidepressant drugs), or intake of systemic corticosteroids within the previous three months.

Patients eligible for inclusion got explanation of the study objectives, and signed consent forms upon agreement to participate. Study received ethical approval (**P.T.REC/012/003889**) from ethical committee at Faculty of Physical Therapy, Cairo University.

Included patients were, then randomly assigned to Biodex training group (BTG) and control group (CG). Patients in BTG used Biodex balance system for balance training, besides, conventional balance training and breathing exercises. Meanwhile, patients in CG applied conventional exercises for balance training and breathing exercise. Randomization was done using draw of patients groups placed in closed opaque envelopes, and drawn from a dark container Sessions were done over 8-weeks period (3 sessions/week). The study was conducted from March 2022 to November 2022. Patients maintained pharmacological treatment as prescribed. Besides, they were asked to follow their regular daily routine during the study.

Procedures

Evaluation procedures

Patients' ages, heights, weights, were measures and body mass indexes were calculated during initial interview for patients in BTG and CG.

Balance was evaluated using Postural Stability Test (PST), and fall-risk test (FRT) as evaluation parameters in Biodex balance system device. [12] (Biodex Medical Systems, Inc., NY, USA). Further, balance evaluation was, also, applied using Berg balance score (BBS). Outcomes evaluation was performed twice; pre and post-experimental.

During PST patients' data and test parameters were inserted. Test parameters including trial time (20 seconds), number of trials (3 trials), and in between trials rest (10 seconds. Initial and end stability levels were set from more to less stable (8-1) respectively. Patient stood bare- feet on the platform and patient feet position were recorded. Patients were asked to maintain their eyes open and directed towards the screen to assist in controlling balance as indicated by onscreen cursor at the center of the software grid. Outcomes were three stability indices; overall stability index (OASI), anterior posterior stability index (APSI), and mediolateral stability index (MLSI) [13]. Average stability indices were reported. Fall-risk test (FRT) was also carried out using Biodex balance system. Outcome was fall-risk overall stability index (FR-OASI). Setting the test parameters were in the same way as PST, except for initial platform stability that was set to 12 and end at 8. Likewise, during testing patients were instructed to maintain cursor centered during testing. [13, 14]

Berg balance score is a widely used for assessing balance and fall risk. It is a 14 items score, each of which is assessed from least (0) to highest (4), summing a total of 56 points with higher scores indicating less fall risk.[4]

Exercise training protocols

Both groups receive conventional balance training, and breathing exercises (3 sessions/ week), for 8 weeks. Sessions included warm-up and cool-down period consisting of flexibility exercise that was included stretching exercises of quadriceps, hamstrings calf muscles, and active free movements exercises for the neck, shoulders and trunk. These exercises were done at a slow pace without any resistive loads.[15]

Conventional balance training included functional strengthening exercises in form of toe raise, toes walking, stepping up (forward, backward, and sideway). Exercises were carried out for 2 sets, each of which consisted of 8 repetitions). Tandem, narrow and single leg stances were assumed with eye open (30 seconds each, and eye-closed for 15 seconds each. Further, patients performed sit to stand as form of transition exercise. Transition exercise was repeated for 10 reps using arm support, and for 5 reps without arm support. [16]

Breathing exercise in form of pursed lip breathing was applied aiming to improve function of respiratory muscles and exercises tolerance. Patients sat with their necks and shoulders in relaxed position. They were asked to inhale from their noses till chest expanded then exhale through their mouths with their lips pursed. Exercises were done in 3 sets of 2 minutes each. [17, 18]

In addition, BTG underwent balance training using Biodex balance training. Training phase on Biodex balance system continued for 10 minutes with equal duration for the two forms of training included; postural stability (5 minutes), and weight shift (5 minutes). With 2 minutes rest duration between both forms of training.

For postural stability training mode, patients name, weight, and height were input to the software. In addition, training parameters including training time, levels of stability to change throughout training time graduated from most stable level 8 to the least one 1, target setup, and on- screen tracing were set. Patients stood on the platform bare-feet, in the best way they felt comfort and confident of well platform control, and they were asked to maintain their feet position throughout the session. Patients kept their eyes open and looking to the display screen. The screen height and position were adjusted to provide best visual to the patient. The handles were set for safety purpose. The training session was started and patient was asked to control the movement of the platform moving the cursor to the screen set target, then move to the start position and repeat the trials. For weight shift-training mode**,** the same setup steps were done as in postural stability training. During training the patient was asked to move and maintain the centre of gravity within two parallel lines, in medial/lateral, anterior/posterior and diagonal planes of movements. The more balanced the patient was the wider the space was set between the parallel lines to challenge further the skill of controlled weight shifting.[13]

Statistical Analysis

Subjects' demographic data have been compared between both groups using independent t- test. Mixed ANOVA with post hoc multiple comparisons were used to declare what effect did balance training on Biodex balance system might have on PST stability indices (OASI, APSI, and MLSI), FR-OASI, and BBS. Statistical significance level was tested at $P<0.05$.

Statistical analysis was carried out using statistical package for social studies (SPSS) (IBM SPSS, Chicago, IL, USA) software. The version of software was v.25 for windows.

Results

Fifteen subjects (7 men and 8 women) were included in BTG. Likewise, CG was 15 patients including 8 men and 7 women. Demographic variables means (±SD) within both groups and their between groups comparisons are presented (table 1).

Table (1) Demographic data in patients with COPD in BTG and CG

	BTG	CG	t- value	p-value
	Mean ±SD	Mean ±SD		
Age (years)	53.47 ± 3.71	53.35 ± 3.67	-0.081	0.936
Weight (kg)	75.81 ± 7.92	73.11 ± 5.85	-1.250	0.221
Height (cm)	165.26 ± 8.01	161.85 ± 7.12	-1.073	0.292
BMI (kg/m²)	27.72 ± 1.64	28.08 ± 1.55	0.641	0.527

P<0.05

Effects of intervention on postural stability test parameters (OASI, APSI, MLSI)

As for OASI, Mixed ANOVA showed significant interaction effects of groups and evaluation occasions ($F_{(1,28)}$= 11.551, P=0.002), and main effects of evaluation occasions ($F_{(1,28)}$= 57.062, P<0.001). In APSI, mixed ANOVA showed non-significant interaction effects of groups and evaluation occasions ($F_{(1,28)}$= 1.572, P=0.220), however, evaluation occasions main effect was significant ($F_{(1,28)}$= 24.120, P<0.001). In MLSI, mixed ANOVA showed significant interaction of groups and evaluation occasions ($F_{(1,28)}$= 38.46, P<0.001), and main effects of evaluation occasions ($F_{(1,28)}$= 1.63, P<0.001).

Within groups analysis reported significantly decreased OASI at post- experimental evaluation in comparison to pre-experimental evaluation in BTG (P< 0.001), as well as CG (P= 0.007) respectively. Likewise, mean values of APSI significantly decreased in BTG (P < 0.001), and CG (P= 0.015) respectively at post-experimental evaluation. MLSI showed significant reduction post-experimental in BTG (P< 0.001), and CG (P<0.001) respectively.

Between groups analysis showed non-significant difference at pre-experimental evaluation in mean OASI values (P= 0.390). On the contrary, at post-experimental evaluation there was significantly lower mean OASI in BTG (P=0.02). Between groups APSI analysis showed non-significant difference at pre-experimental evaluation in mean APSI values (P=0.551). On the other hand, post-experimental evaluation showed significantly lower mean APSI in BTG (<0.001). For MLSI, pre-experimental comparison between groups was insignificant (P=0.956), in contrast to significant post-experimental lower mean values in favor of BTG(P=0.003) (Table 2).

Effects of intervention on Fall Risk

Mixed ANOVA showed significant interaction effects of groups and evaluation occasions ($F_{(1,28)}$= 41.646, P< 0.001), and main effects of evaluation occasions ($F_{(1,28)}$= 3.558, P< 0.001)

Within groups outcomes showed significantly higher post-experimental mean FR-OASI values in BTG (P< 0.001), and CG (P< 0.001) respectively compared to pre- experimental mean values. On the other hand between groups analysis at pre-experimental evaluation showed non-significant between groups difference (P=0.061), in contrast to a significantly lower FR-OASI means post-experimental in BTG compared to CG (P=0.003) (Table 2).

Effects of intervention on BBS

Mixed ANOVA showed significant interaction effects of groups and evaluation occasions ($F_{(1,28)}$= 32.712, P<0.001), and main effects of evaluation occasion ($F_{(1,28)}$= 1.971, P<0.001)

Within groups outcomes showed significantly higher mean BBS values post- experimental in BTG (P<0.001), and CG (P<0.001) respectively compared to pre- experimental mean values. On the other hand between groups analysis at pre-experimental evaluation showed non-significant between groups difference (P=0.196), in contrast to a significantly higher BBS means post-experimental in BTG versus CG (P< 0.001) (Table 2).

Table (2) Mean values of OASI, APSI, MLSI, FR-OASI, and BBS within and between study and CG

	Pre-experimental	**Post-experimental**	**p-value**
	Mean ±SD	**Mean ±SD**	
OASI			
BTG	2.56 ± 0.72	1.04 ± 0.29	<0.001*
CG	2.37 ± 0.45	1.78 ± 1.18	0.007*
p-value	*p = 0.39*	*p = 0.02**	
APSI			
BTG	2.04 ± 1.11	1.15 ± 0.36	<0.001*
CG	2.24 ± 0.23	1.71 ± 0.33	0.015*
p-value	*p = 0.511*	*p <0.001**	
MLSI			
BTG	2.06 ± 0.89	1.11 ± 0.74	<0.001*
CG	2.08 ± 0.24	1.75 ± 0.22	<0.001*
p-value	*p = 0.956*	*p = 0.003**	
FR-OASI			
BTG	3.74 ± 0.59	1.97 ± 0.76	<0.001*
CG	3.45 ± 0.52	2.72 ± 0.48	<0.001*
p-value	*p = 0.176*	*p = 0.003**	
BBS			
BTG	39.26 ± 3.41	51.46 ± 2.69	<0.001*
CG	41.28 ± 2.19	47.28 ± 1.81	<0.001*
p-value	*p = 0.061*	*P= <0.001**	

*P<0.05

Discussion

The findings of the current study highlights the value of balance training in adjusting balance deficits in COPD patients. These findings conforms to previous studies examining effects of balance training programs on this patients' category. [8, 16] However, this study differs from previous studies in assessing the effect of balance training using Biodex balance system, rather than other forms of balance training, in managing patients with COPD.

This study revealed significant balance improvement within both groups comparing pre and post-experimental in PST indices (OASI, APSI, and MLSI), FR-OASI, and BBS. However, improvements in the BTG were more evident compared to CG. This shows that incorporating balance training using Biodex balance system, with conventional balance training and breathing exercises yielded better results in managing impaired balance, and fall risk in COPD patients than conventional balance training and breathing exercises alone.

Patients with COPD show an increased demands on respiration, a factor that might compromise trunk and respiratory muscles contribution to control the displacement of centre of gravity. In addition, as result of increased respiratory demands there is an increase in trunk stiffness, which might lead to abnormal postural control in patients with COPD. Moreover, in patients with COPD, deficit in contribution of thoracic region to postural sway can be attributed to increased trunk stiffness, and reduced flexibility of thoracic spine, rib cage and sternum. That is why patients with COPD relays in movement of lumbar region, hip, and ankle in attempt to control the displacement of centre of gravity.[19] However, relaying in these movements as strategies to control balance need lower limb muscle activity and somatosensory integration. [20] This cascade of changes in balance control strategies in COPD patients might be improved through use of balance training using Biodex balance system is likely due to enhanced sensory input required in balance control throw providing real-time feedback throughout the training sessions. Feedback during training might help patients to improve kinaesthetic awareness and restore proper body parts orientation, thus enhancing balance.

Another likely cause of balance deficit in COPD patients is impaired response time, and weakness of lower limbs muscles.[4] Reduced skeletal muscles performance in COPD patients might result in slow, inefficient muscles

contractions in case of perturbation.[21] Balance training combined with breathing exercises had been reported to improve balance and lower limbs muscles strength in COPD patients than breathing exercises alone.[8] In particular, balance training using Biodex balance system has been suggested to enhance balance and muscle strength probably due to overall improvement of neuromusculoskeletal performance. [22]

Patients with COPD showed prolonged anticipatory postural adjustment duration. [4] During balance training using Biodex balance system provides controlled and predictable perturbation of balance, through stepwise increase of platform instability. Therefore, balance training in Biodex balance system might have provided a more or less regular and gradual platform instability, a factor not available in conventional forms of balance training. Accordingly balance training on Biodex balance system might have enhanced anticipatory postural adjustment together with developing a better control over balance perturbations, improving overall balance and reducing risk of fall in BTG patients more efficiently than controls.

Effect in BTG due to using of balance training Biodex balance system as well as evaluation using Biodex balance system PST and FRT is a limitation of this study. However, additional evaluation of balance in both groups using BBS might have overcome this limitation, as significantly higher BBS mean values have been reported in BTG post-experimental. This confirms and reinforces the outcomes seen in PST and FRT which favour balance training using Biodex balance system over conventional balance training.

Conclusion

Whereas, incorporating balance training together with breathing exercises in treating COPD patients had been advised previously, the current study showed that it is recommended to apply balance training using Biodex balance system in treating COPD patients.

Conflict of Interest: non declared

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