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# Effect of Proprioceptive Training with Muscle Strengthening on Postural Instability in Patients with Chronic Obstructive Pulmonary Disease

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## Abstract

*Background:* Chronic obstructive pulmonary disease (COPD) is preventableand treatablelung disease characterized by narrowing airways and inflammation. However, it is accompanied by several extrapulmonary problems as balance problems and decrease in postural control combined with muscle weakness and proprioception deficits.

*Aim of Study:* Todetermine the effect of proprioceptive training with muscle strengthening on postural instability in patients with COPD.

*Patients and Methods:* Sixty COPD male patients with postural balance problems their age ranged between 55 to 65 years were randomly chosen and assigned into study and control groups. Both the groups practiced pulmonary rehabilitation program with medications, study group in addition to pulmonary rehabilitation applied proprioceptive training with muscle strengthening exercises for 12 weeks. Balance was evaluated by using Berg Balance Scale (BBS) and Activities-specific Balance Confidence Scale (ABC), and muscle strength was assessed using handheld dynamometer.

*Results:* At the end of the study, there were a significant increase in BBS, ABC, quadriceps and calf muscles' strength scale in both groups post treatment compared with that pre-treatment. The percent of change of BBS, ABC scale, right and left quadriceps strength and right and left calf muscle strength in the study group was (28.77, 29.69%, 15.53, 15.21, 26.77 and 27.74%) respectively, and (5.61, 4.2%, 0.36 and 1.63%)respectively for control group, there was no significant change in calf muscle strength in the control group ($p$<0.05). In comparison between groups there was significantincrease in BBS, ABC, quadricepsand calf muscles' strength in the study group more than the control group ($p$>0.001).

*Conclusion:* It was concluded that adding proprioceptive training with muscle strengthening exercises to pulmonary rehabilitation program was more effective in improving postural balance control inpatients with COPD.

***Key Words:*** *Postural control – Proprioception – Balance – COPD.*

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## Introduction

**CHRONIC** obstructive pulmonary disease (COPD) is a preventable and treatable illness with effects on the whole body that can contribute to loss of functional capacity for the patient. The Global Initiative for Chronic Obstructive Lung Disease (GOLD) document advises proper attention to not only respiratory treatment but also to extra respiratory consequences in COPD patients. According to some studies, impaired balance may be one of important extra respiratory morbidity leading to loss of functional independence and falls **[1]**. Postural instability is the inability to maintain equilibrium under dynamic and static conditions such as preparation of movements, perturbations, and quiet stance **[2]**. Postural control (i.e., postural stability) is critical in preventing older people from falling,people with COPD experience deficits in postural stability and an increased risk of falling **[3]**. Proprioception was defined as “the perception of joint and body movement as well as position of the body, or body segments, in space”, and it is considered as the most important sensory system in the maintenance of postural stability in the elderly people **[4]**. COPD patients show a reduction in proprioception, which condition results in less body control during daily movement. Thus, inserting exercises to improve proprioception in COPD patients should be a usual procedure, through balance training **[5]**. Muscle dysfunction often occurs in patients with COPD and may involve both respiratory and locomotor (peripheral) muscles, the loss of strength and/or endurance in the former can lead to ventilatory insufficiency, whereas in the latter it limits exercise capacity and activities of daily life. Muscle dysfunction is the

consequence of complex interactions between local and systemic factors, frequently coexisting in COPD patients **[6]**. Muscle strength is a key contributor to balance in both healthy populations and in people with COPD **[7]**. In our study, we intend to evaluate balance control using Berg Balance Scale **[8]**. Furthermore, to assess confidence on balance control Activities-specific Balance Confidence Scale (ABC) was used **[9]**. Lafayette handheld dynamometer was used for assessment of isometric muscle strength **[10]**. Therefore, that study may contribute to illustrate the role of proprioceptive training and muscle strength on postural instability and control of balance in COPD patients.

## Patients and Methods

*Patients:*

This study was conducted on Sixty COPD male patients having postural control problems with age ranged from 55 to 65 years, were screened to be enrolled into this 12-week randomized controlled trial. They had been recruited from Menoufia University Hospital (chest department), to participate in this study through a period of 3 months (from March 2022 to June 2022). All patients received a complete explanation about procedures of the program of treatment and measurement devices. This study was approved by the Ethics Committee for Scientific Research of the Faculty of Physical Therapy, Cairo University, Egypt [NoP.T.REC/012/003655]. The participants underwent initial evaluation and completed the course of training.

*Inclusion criteria:*

were as follows: Sixty male mild to moderate COPD patients, Age ranged from 55 to 65 years, BMI ranged from 25 to 29.9 $Kg/m^2$, clinically and medically stable when attending the study, patients with good cognition to understand the requirements of the study, conscious patient and respond to verbal command, patients with grade 3 muscle test, patients with the following features:

- Failure to maintain 45 seconds Timed Unipedal Stance Test.
- <45 scores on Berg Balance Scale.
- Below 50% functioning level on Activities-specific Balance Confidence Scale.

*Exclusion criteria:*

Neurological conditions that might affect postural sway (e.g., stroke history, Parkinson's disease), Presence of an acute illness, metabolically unstable chronic illness, Pre-existent untreated metabolic or renal disease, Malignancy, Recent surgery, Endocrine disorders.

Patients were randomly assigned into two groups, the study group, received pulmonary rehabilitation program in addition to proprioceptive training with muscle strengthening exercises and medical treatment, and the control group, received traditional pulmonary rehabilitation program with medical treatment only.

Instrumentation:

*Evaluating tools of muscle strength:*

Handheld Dynamometer: Lafayette muscle tester was used to assess muscle strength of lower limb muscles, model (01163). Handheld dynamometer has its digital screen that shows force generated by each muscle measured pre- & post-intervention.

*Therapeutic equipment and tools:*

- Swiss Balls (Yanre, Model NO. YB01, HS Code.9506919000, Wuhu, China) was used to exercise the patients to Sit on the ball while balancing their weight and maintaining posture thus improve overall balance and proprioception.
- BOSU Ball (BOSU Ball Nex Gen Home Balance Trainer)was used for building strength and stability. The hemisphere is half-filled with air, which provides enough instability that prompts the recruitment of all muscles.
- Whole-Body Vibration machine (Pinty 2000W Whole Body Vibration Platform Exercise Machine. LCF-H001-BK. China) was used to improve joint stability and to reduce the risk of falling by activation of cutaneous mechanoreceptors in the soles of the feet.
- Free weights were used to provide isotonic resistance and strength lower limb muscles.

Procedure:

A- *Evaluating procedures for balance:*

1- *Berg Balance Scale (BBS):*

The BBS is a 14-item scale was used to assess balance and risk for falls in older community-dwelling adults through direct observation of their performance. The scale required 10 to 20 minutes to complete and measured the patient's ability to maintain balance-either statically or while performing various functional movements-for a specified duration of time. The items were scored from 0 to 4, with a score of 0 representing an inability to complete the task and a score of 4 representing independent item completion. A global score is calculated out of 56 possible points. A score of 56 indicates functional balance and score <45 indicates

greater risk of falling. The BBS measured both static and dynamic aspects of balance **[11]**.

2- *Activities-specific Balance Confidence Scale (ABC):*

The ABC scale is used to assess balance confidence and comprises 16 situation-specific items related to indoor and outdoor activities (Appendix). The respondent indicates their level of self-efficacy at performing specific itemized activities without losing balance or becoming unsteady by choosing a corresponding number from 0% (no confidence) to 100% (completely confident) **[9]**.

*B- Evaluating Procedures for muscle strength:*

*Handheld dynamometer:*

Lafayette Manual Muscle Testing System Model (01163) was used for assessment of isometric muscle strength. The HHD pad was placed perpendicular to the limb, instructions for the participant were to hold the position, trying to exert as much force as possible against the pad. Each participant performed 3 trials for each leg and average was taken **[10]**. In our study quadriceps and calf muscles were assessed for lower limb muscles strength measurements, Quadriceps muscle assessment Was done from sitting position. The examiner sat in front of the participant and the dynamometer was placed on the anterior surface of the distal tibia just proximal to the ankle joint. The participants exerted a 5-s isometric maximum quadriceps voluntary contraction and extend the knee against the dynamometer fixated by the examiner **[12]**. Calf assessment was done from supine position. The ankle was then placed in a neutral position by the examiner. Flat, comfortable, and easily reproducible contact points were chosen for dynamometer placement. The handheld dynamometer was placed on the plantar aspect of the foot. Participants were asked to plantar flex the foot against the dynamometer fixated by the examiner **[13]**.

*C- Treatment procedures:*

*The study group:*

The program was conducted over 12 weeks (3 sessions/week).

1- *Proprioceptive training:*

This program training consisted of proprioceptive exercises using Swiss ball and BOSU ball, which were conducted in static and dynamic positions for a period of 30 minutes. The exercise consisted of 2 sets of 10-15 repetitions with 1 minute of rest between sets and include alternate knee flexion-extension with extended trunk posture, Hip and knee flexion-extension with the Swiss ball between back and wall, hip raises lying their back on the floor with both legs on the Swiss ball and standing on the BOSU ball **[4]**.

2- *Muscle strengthening exercises:*

Resistance training: Resistance training was performed using Free weights with Intensity 70% of 1-RM, participants performed 3 sets with a 2 min rest between sets for 12 repetitions **[14]**. Quadriceps muscles trengthening exercises include Isotonic quadriceps strengthening exercises **[15],** Wall squat **[16]**. Calf muscle strengthening exercises include Double Calf Raise **[17]**.

*The control group:*

This group underwent traditional pulmonary rehabilitation program only with medications 3 sessions per week for consequent 12 weeks.

*Statistical analysis:*

Unpaired *t*-test were conducted for comparison of subject characteristics between groups. Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to ensure the homogeneity between groups. Mixed MANOVA was conducted to compare the effect of time and the effect of treatment, as well as the interaction between time and treatment on mean values of BBS, SLS, ABC scale, quadriceps and calf muscles' strength. The level of significance for all statistical tests was set at $p<0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

## Results

*Subject characteristics:*

Table (1) showed the subject characteristics of the study and control groups. There was no significant difference between groups in age, weight, height and BMI ($p>0.05$).

Table (1): Comparison of subject characteristics between study and control groups.

| | Study group | Control group | MD | *t*-value | *p*-value |
|---|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | | |
| Age (years) | 60.6±3.32 | 59.83±3.25 | 0.77 | 0.9 | 0.37 |
| Weight (kg) | 83.33±4.37 | 82.04±3.22 | 1.29 | 1.3 | 0.19 |
| Height (cm) | 173.31±4.94 | 173.13±2.8 | 0.18 | 0.17 | 0.86 |
| BMI ($kg/m^2$) | 27.75±1.29 | 27.37±1.13 | 0.38 | 1.19 | 0.23 |

SD: Standard deviation.
MD.: Mean difference.
*p*-value: Probability value.

*Effect of treatment on BBS, ABC scale, quadriceps and calf muscles' strength:*

Mixed MANOVA was conducted to investigate the effect of treatment on BBS, ABC scale, gluteus maximus, quadriceps strength and calf muscles' strength. There was a significant interaction effect of treatment and time ($p$=0.001). There was a significant main effect of treatment ($p$=0.001). There was a significant main effect time ($p$=0.001).

*Within group comparison:*

There was a significant increase in BBS and ABC scale in the study and control groups post treatment compared with that pretreatment ($p$>0.001). The percent of change of BBS, and ABC scale in the study group was 28.77 and 29.69% respectively; and that in the control group was 5.61 and 4.2% respectively (Table 2).

There was a significant increase in quadriceps and calf muscles' strength in the study group post treatment compared with that pretreatment ($p$>0.001). The percent of change of right and left quadriceps strength and right and left calf muscle strength was 15.53, 15.21, 26.77 and 27.74% respectively. There was a significant increase in quadriceps in the control group post treatment compared with that pretreatment ($p$>0.05). The percent of change of right and left quadriceps strength was 0.36 and 1.63% respectively. There was no significant change in calf muscle strength of the control group ($p$<0.05) (Table 3).

*Between groups comparison:*

There was no significant difference between groups pre-treatment ($p$>0.05). Comparison between groups post treatment revealed a significant increase in BBS, ABC scale, quadriceps and calf muscles' strength of the study group compared with that of the control group ($p$>0.001) (Tables 2,3).

Table (2): Mean BBS and ABC scale pre and post treatment of the study and control groups.

| | Pre | Post | MD | % of change | $p$-value |
|---|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | | |
| *BBS:* | | | | | |
| Study group | 41.96±1.03 | 54.03±0.92 | –12.07 | 28.77 | 0.001 |
| Control group | 41.73±0.78 | 44.07±0.78 | –2.34 | 5.61 | 0.001 |
| MD | 0.23 | 9.96 | | | |
| | $p$=0.32 | $p$=0.001 | | | |
| *ABC scale:* | | | | | |
| Study group | 47.83±1.21 | 62.03±1.32 | –14.2 | 29.69 | 0.001 |
| Control group | 47.6±0.81 | 49.6±0.81 | –2 | 4.20 | 0.001 |
| MD | 0.23 | 12.43 | | | |
| | $p$=0.38 | $p$=0.001 | | | |

SD: Standard deviation.
MD.: Mean difference.
$p$-value: Probability value.

Table (3): Mean quadriceps and calf strength pre and post treatment of the study and control groups.

| Strength (lb) | Pre | Post | MD | % of change | $p$-value |
|---|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | | |
| *Right quadriceps:* | | | | | |
| Study group | 343.17±40.81 | 396.47±40.81 | –53.3 | 15.53 | 0.001 |
| Control group | 336.65±34.15 | 337.85±34.15 | –1.2 | 0.36 | 0.001 |
| MD | 6.52 | 58.62 | | | |
| | $p$=0.5 | $p$=0.001 | | | |
| *Left quadriceps:* | | | | | |
| Study group | 333.86±31.11 | 384.63±28.27 | –50.77 | 15.21 | 0.001 |
| Control group | 329.76±24.03 | 335.15±23.07 | –5.39 | 1.63 | 0.02 |
| MD | 4.1 | 49.48 | | | |
| | $p$=0.57 | $p$=0.001 | | | |
| *Right calf:* | | | | | |
| Study group | 264.98±25.28 | 335.92±27.32 | –70.94 | 26.77 | 0.001 |
| Control group | 256.31±23.09 | 259.38±23.45 | –3.07 | 1.20 | 0.24 |
| MD | 8.67 | 76.54 | | | |
| | $p$=0.17 | $p$=0.001 | | | |
| *Left calf:* | | | | | |
| Study group | 258.26±25.92 | 329.89±24.95 | –71.63 | 27.74 | 0.001 |
| Control group | 256.78±19.18 | 259.37±18.96 | –2.59 | 1.01 | 0.22 |
| MD | 1.48 | 70.52 | | | |
| | $p$=0.8 | $p$=0.001 | | | |

SD: Standard deviation. MD.: Mean difference. $p$-value: Probability value.

## Discussion

The purpose of this study was to determine the effect of proprioceptive training with muscle strengthening on postural instability in patients with COPD.

It was observed that there was a significant improvement in both groups with more improvement in study group compared with control group. showing that 12 weeks of proprioceptive training with muscle strengthening exercises yielded a positive result in improving postural balance control in patients with COPD.

Patients with COPD have systemic damage secondary to the primary pulmonary impairment, expressed in impaired peripheral musculature and a deficit in postural control compared to healthy subjects. It has been reported that the history of falls in people with COPD could range from 33 to 50%. Pulmonary rehabilitation protocols have been modified to provide more comprehensive and functional care to patients, focusing on increasing participation, minimizing health care costs, increasing exercise tolerance, improving quality of life, decreasing hospitalizations, and reducing mortality. In addition, balance training has been installed as a new treatment target in COPD patients to prevent falls **[18]**.

Tymkew et al. **[19]** demonstrated that incorporating a balance training program into a pulmonary rehabilitation program may help to decrease fall risk and increase balance confidence in functional activities. Moreover, Marques et al. **[20]** reported that Pulmonary rehabilitation with a specific component of balance training had a large effect on functional balance in patients with COPD, highlighting the value of including balance training in PR programs.

The traditional approach to treating Chronic Obstructive Pulmonary disease has been based on alleviating and/or improving respiratory symptomatology. Nevertheless, in recent decades, pulmonary rehabilitation protocols have been modified to provide more comprehensive and functional care to patients, focusing on increasing participation, minimizing health care costs, increasing exercise tolerance, improving quality of life, decreasing hospitalizations, and reducing mortality. In addition, balance training has been installed as a new treatment target in COPD patients to prevent falls **[18]**.

McLay et al. **[7]** examined the role of muscle strength in the assessment and management of balance problems among individuals with chronic obstructive pulmonary disease (COPD), demonstrated that muscle strength is a key contributor to balance in both healthy populations and in people with COPD.

Pulmonary rehabilitation guidelines advocate strength exercises for lower limb muscles to improve daily activities such as climbing stairs or walking **[21]**. A study by Orr R. **[22]** reported the importance of using resistance exercise to ameliorate balance and reduce the risk of fall for this population.

Howe et al., **[23]** 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 our study.

*Conclusion:*

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

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# تأثير تدريب المستقبلات الحسية العميقة مع تقوية العضلات على عدم الثبات الجسدى فى مرضى الانسداد الرئوى المزمن

مقدمة : مرض الانسداد الرئوى المزمن (COPD) هو مرض رئوى يمكن الوقاية منه وعلاجه ويتميز بتضييق الشعب الهوائية والالتهاب. ومع ذلك، فإنه يترافق مع العديد من المشاكل خارج الرئة مثل مشاكل التوازن وانخفاض فى التحكم فى المستقبلات الحسية العميقة مع ضعف العضلات وعدم الثبات الجسدى.

المواد والأساليب : تم اختيار ستين ذكراً من مرضى الانسداد الرئوى المزمن الذين يعانون من مشاكل فى التوازن الوضعى تتراوح بين ٥٥ إلى ٦٥ عاماً بشكل عشوائى وتم تقسيمهم إلى مجموعات دراسة وتحكم.

النتائج : فى نهاية الدراسة، كانت هناك زيادة معنوية فى مقياس توازن بيرج، ومقياس الوقوف على ساق واحدة ومقياس ثقة التوازن الخاص بالأنشطة وقوة عضلات الألوية القصوى والعضلة الأمامية وعضلات الساق فى كلتا المجموعتين. كانت نسبة المئوية لمقياس بيرج، مقياس الوقوف على ساق واحدة ومقياس ثقة التوازن الخاص بالأنشطة وعضلة الألوية القصوى اليمنى واليسرى والعضلة الأمامية اليمنى واليسرى وعضلات الساق اليمنى واليسرى فى مجموعة الدراسة (٢٧.٧٤،٢٦.٧٧،٢١.٦،١٥.٥٣،١٥.٢١،٢٠.٢٠،٢٩.٦٩،١٣.٧١،٦٦.٦٥،٧٧.٢٨ فى المائة) على التوالى و(١.٦٣،٠.٣٦،١.٠٧،٠.٤٦،٤.٢،١٤.٣٥،١٤.٨٥،٥.٦١) على التوالى لمجموعة التحكم. لم يكن تغيير فى قوة عضلات الساق فى مجموعة التحكم ($p<0.05$). بالمقارنة بين المجموعات كانت هناك زيادة كبيرة فالمتغيرات فى مجموعة الدراسة أكثر من مجموعة التحكم ($p>0.001$).