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Prevalence of Balance Impairment in People with Chronic Obstructive Pulmonary Disease

Kaviya M[1]* and Anandhi D[2]

[1]*College of Physiotherapy, Faculty of Medical and Health Sciences, SRM Institute of Science and Technology, Kattankullathur, India*

[2]*College of Physiotherapy, Faculty of Medical and Health Sciences, SRM Institute of Science and Technology, Kattankullathur, India*

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***Corresponding author:** Kaviya M, Department of Physiotherapy, Faculty of Medical and Health Sciences, SRM Institute of Science and Technology, Kattankullathur, India

Abstract

Background: Chronic obstructive pulmonary disease (COPD) is not reversible and progressive disease which occurs mainly due to lung infections. There are so many pulmonary and extra pulmonary factors that affect these patients; some of the extra pulmonary effects are musculoskeletal problems, cardiovascular problems and psychological problems. Among this balance impairment play a vital role due to peripheral muscle weakness. This peripheral muscle weakness significantly influences on muscle strength, endurance and balance.

Objective: The aim of the study is to find the prevalence of balance impairment among COPD patients.

Materials and Methods: 50 diagnosed mild and moderate COPD patients, both men and women of age ranging from 35 to 55 years were included in this study. Patients with any neurological conditions, lower limb fracture, soft tissue injuries, musculoskeletal pain and vertigo were excluded in this study. Stork balance test and y balance test.

Results: Among 33 males and 17 females, males have poor static balance when compared to females and both male and female have poor posterolateral and posteromedial reach in Y balance test.

Conclusion: There is an increased prevalence of static and dynamic balance impairment in COPD patients. These impairments can significantly impact their quality of life and increase the risk of falls, which can lead to serious injuries and further reduce their mobility and independence.

Keywords: COPD; Stork Balance Test; Y Balance

Abbreviations: COPD: Chronic Obstructive Pulmonary Disease; FVC: Forced Vital Capacity; FEV1: Forced Expiratory Volume in 1 Second; BOLD: Burden of Obstructive Lung Disease; α1-antiproteinase: Alpha-1 Antiproteinase; GOLD: Global Initiative for Chronic Obstructive Lung Disease

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a disease characterized by irreversible and ever-increasing airflow obstruction that is associated with lung inflammation. [1,2] Emphysema and chronic bronchitis are the two common conditions that are associated with COPD. In COPD due to airway obstruction the air gets trapped inside the lung. Because of this air trapping the total lung capacity will be raised but FVC (amount of air expelled out forcefully after taking deep breathe) and FEV1(amount of air expelled out forcefully in one second) ratio will be reduced.

Main cause for COPD is cigarette smoking. It includes the number of packs and duration, environmental exposure to dust particles and air pollutants such as allergens, bacterial and viral spores which get settled in the lungs, occupational hazards such as coal, crop residues, wood, cadmium etc, the genetic factors such as α1 – antiprotease deficiency. Estimated disease burden of COPD was about 210 million people worldwide and causes 3.15 million deaths per year. The 4th leading reason for mortality globally is COPD (5.1%) in 2004 and it is expected to occupy the 3rd position (8.6%) in 2030. [3] The BOLD (Burden of Obstructive Lung Disease) estimates the prevalence of COPD have ranged from 2 % to 22% in male and from 1.2% to 19% in female [4].

In chronic bronchitis infiltration of inflammatory cells causes hypertrophy of mucus secreting glands and the number of goblet cells increases which results in increased sputum production.

In emphysema the airspaces which are present distal to the terminal bronchioles will be enlarged permanently, accompanied by destruction of their walls [5]. The clinical features will be productive cough and copious sputum on almost all the days for at least 3 consecutive months and for at least 2 successive years.

Exposure to irritants and chemicals leads to hypertrophy and hyperplasia of bronchi and goblet cells in bronchioles causes increased mucus production hence the slight increase in mucus causes obstruction in bronchioles. Smoking causes reduced ciliary function and softens the cilia and makes the mucociliary escalation to be reduced. The excessive mucus secretion pooling and dysfunctional cilia in these patients results in cough with mucus plugs. The chronic bronchitis can be treated by avoiding smoking, managing the associated illness by supplementing with oxygen, bronchodilators, inhaled steroids [6,7].

The emphysema is mainly due to structural changes in alveoli which become permanently enlarged and lose its elasticity. Usually, these patients have difficulty in expiration due to inability of the lung to recoil. The oxygen goes out of the alveoli into the blood and carbon dioxide from the blood enter into alveoli but when the lung tissue is exposed to irritants such as cigarette smoking it will stimulate some inflammatory reaction that affects the gas exchange and alveolar wall.

This inflammatory reaction attracts some immune cells such as leukotriene B4, IL-8, TNF-α and also proteases such as elastases and collagenases which break down the structural proteins' collagen and elastin (which provide tissue elasticity). Thus, this loss of elasticity leads to less compliance of lung and surface area for gas exchange will be reduced. All these processes take place in acinus i.e. end of airways [8]. The overall symptoms of the COPD include persistent cough, excessive production of sputum, breathlessness, wheezing and in more severe cases it leads to cyanosis, tachypnea, peripheral muscle weakness, oedema, hyperinflation abnormal lung sound, elevated jugular venous pulse. The patient with emphysema has barrel chest due to hyperinflation of the lungs [9].

The GOLD (Global initiative for chronic obstructive lung disease) document (2011) has classified the airflow limitation severity in COPD. The pulmonary function test is used to diagnose the COPD, post bronchodilator FEV1/FVC ratio of < 0.70 is commonly considered as a diagnostic tool for COPD (mild: FEV1 ≥ 80% predicted, moderate: 50% ≤ FEV1< 80% predicted, severe: 30%≤ FEV1 <50% predicted and very severe: FEV1 < 30% predicted. [10] It also advices proper attention not only to respiratory problems but also for the non-respiratory problems in COPD patients.

One of the main extra pulmonary problems among COPD patients is peripheral muscle dysfunction which is due to reduction in their physical activity, steroid induced myopathy, hypoxia, hypercapnia, nutrition depletion and oxidative stress. These causes reduction in their muscle mass, strength, endurance and easy fatigability [11,12]. There are studies which state that people with COPD have more weakness in the lower limb than the upper limb. This is mainly due to greater reduction in the lower limb activity. Particularly strength of quadriceps muscle is reduced by 20% - 30% in patients with moderate to severe COPD. Thus, this muscle dysfunction leads to reduced exercise tolerance, balance impairment and poor quality of life [13].

There are 2 types of balance, static and dynamic balance. The static balance is the ability of the individual to maintain the body in stable posture and also accommodate with the centre of mass over the base of support at rest. The dynamic balance is the ability of the individual to maintain the body in stable posture and also accommodate with the centre of mass over the base of support during movement. The static balance among COPD patients is tested by stork balance test and the dependence of reliability is based upon the individual's level of motivation to perform the test and how strict the test is conducted. The dynamic balance is tested by Y balance test which is the component of SEBT (Star Excursion Balance Test) and it has the high inter-rater reliability of 0.99-1.00 and intra-rater reliability of 0.85-0.91 [14].

Materials and Methods

The study was granted ethical approval by the ethical committee (IEC:0021). This was a cross-sectional study on COPD patients. Subjects were recruited by convenient sampling method; COPD patients who come under the inclusion criteria were included in the study after obtaining informed consent. The inclusion criteria were both male and female COPD patients, Age: 35 to 55 years with the diagnosed case of mild and moderate COPD based on Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines. Patients with acute respiratory distress, major neurological conditions that affect balance or gait (eg: prior stroke, Parkinson's disease), Any cognitive impairment that interferes with the ability to provide informed consent or to complete the study, Previous lower limb surgeries, soft tissue injuries in the lower limb, Vertigo, Musculoskeletal pain on the day of assessment were excluded from the study. Study setting: Patients seeking SRM medical college hospital and research center for pulmonologist.

Participants and Recruitment

Based on the inclusion and exclusion criteria, participants were chosen. 50 male and female subjects between the age group of 35 to 55 years diagnosed with mild and moderate COPD by the pulmonologist were selected. The subjects were invited to participate, and after being informed about the goal, methodology, risks, rewards, opportunity to withdraw, and guarantee that the study would remain anonymous, their permission was obtained. The static and dynamic balance was tested among these patients.

Stork Balance Test:

The static balance was tested by stork balance test. The patients were instructed to stand comfortably with their hands

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on the hip. Then the patients were instructed to lift their right leg and place the sole of the foot over the left knee cap, the time was noted using the stopwatch when the patients lifted the heel of the left foot to stand on their toes. The patients were asked to hold this position and the time was stopped when the patients left heel touched the ground or the right foot moved away from the left knee cap. The same procedure was done with left leg. The test was done in 3 trials on each leg and the average duration was noted (Table 1).

Table 1: Normative values of stork balance test [17].

Rating	Male Score in Seconds	Female Score in Seconds
Excellent	>50	>27
Above average	37-50	23-27
Average	15-36	8-22
Below average	5-14	3-7
Poor	<5	<3

Y-BALANCE TEST:

The dynamic balance is the ability of the person to balance in motion or switching between the positions. Here the patient's dynamic balance was checked by using the y-balance test. This test was done by using y-balance kit which consist of PVC pipes arranged in y manner with reach indicator or else it can also be done by sticking the tapes on the floor in y manner in three directions i.e. anterior, posteromedial and posterolateral. The anterior reach line should be 135° from the posterior reach line and there should be 90° between the posterior reach line. The patients were allowed to perform each direction with 6 practice trails and the 3 best scores for each direction was taken and average was calculated. Then the distance reached by the patients was measured by using the inch tape at the point where the most distal part of the foot was reached. The reached distance is divided by the limb length (i.e. distance between the anterior superior illac spine and the medial malleolus) then multiplied by hundred to calculate the normal value.

Results

(Table 2) shows that the mean age of the patients (n=50) is 48.48±5.87 years, the mean height is 157.82±5.12cm, the mean weight is 62.80±6.32kg and the mean BMI is 25.21±2.60. (Figure 1) shows that among 50 COPD patients, 33 males (66%) and 17 females (34%) participated in this study.

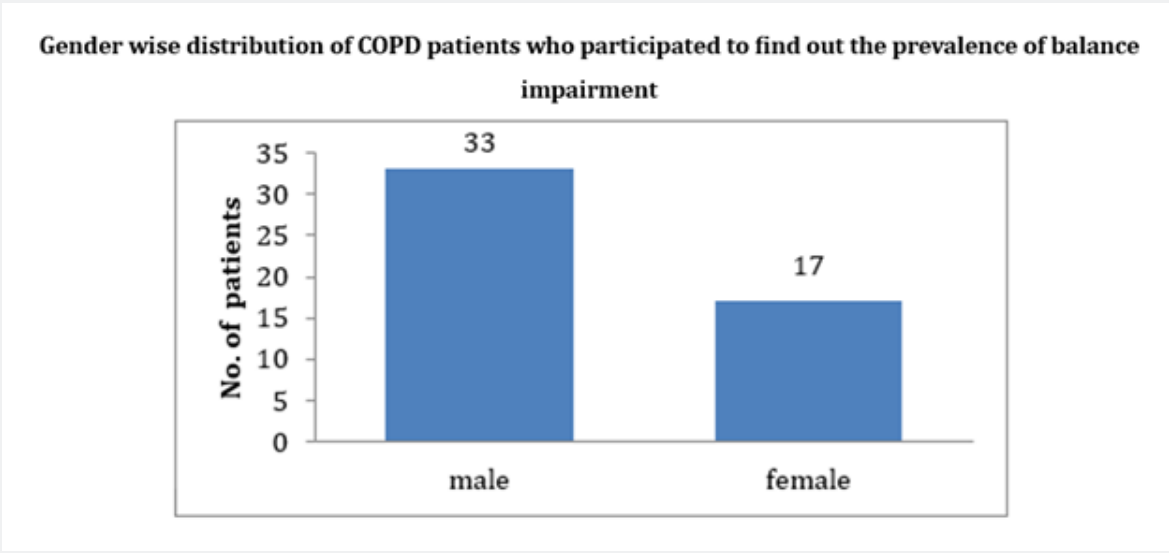

Figure 1: Shows the predominanace of male subjects in the study sample compared to females.

(Figure 2) and (Figure 3) shows that in stork balance test among 33 (66%) males, 23 males (46%) had below average balance on the right leg and10 males (20%) had poor balance on their right leg, then 22 males (44%) had below average balance on left leg and 11 males (22%) had poor balance on the left leg. Among 17 (34%) females, all females had below average balance on their right and left leg, none of the females had poor balance. (Figure 4) shows the distance reached by the COPD patients in each direction.

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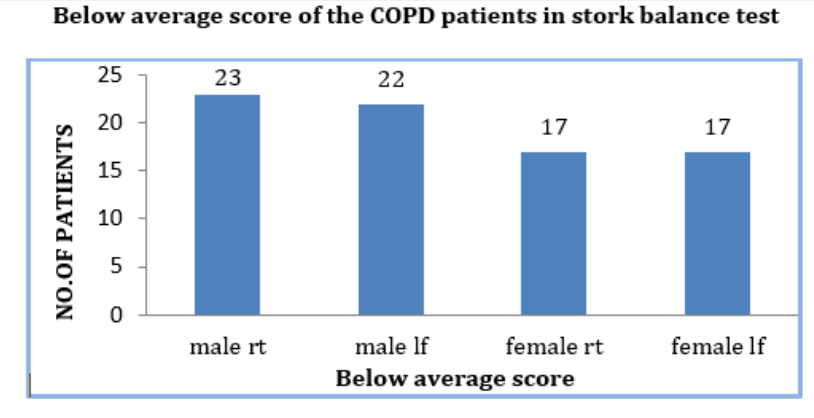
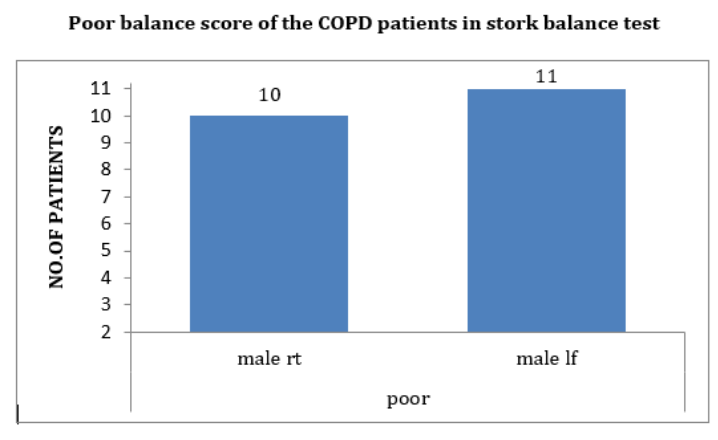
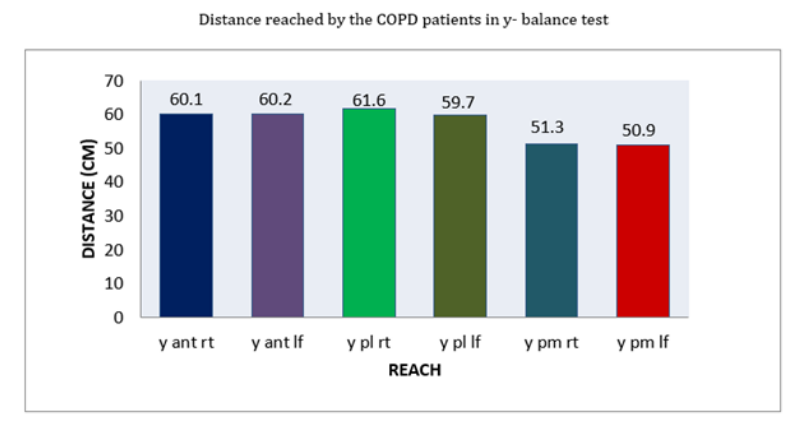


*Data expressed as rt-right leg and lf- left leg.
Figure 2: Shows the number of patients in the below average score category and there is no significant changes in number (n) on either legs.



*Data expressed as rt-right leg and lf- left leg.
Figure 3: Shows the number of patients in poor balance score. It can be seen that no significant changes in numbers among male patients and no female patients in poor balance score.



*Data expressed as distance in cm, rt-right, lf-left, Ant-anterior, Pl-posterolateral, Pm-posteromedial direction.
Figure 4: Shows distance covered in Y balance test in different directions. It can be seen that distance achieved in Posteromedial direction was less compared to Posterolateral and anterior direction.

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(Table 3) shows that the mean value for the stork balance test conducted among the COPD patients on the right leg is 4.95±0.68 sec, left leg is 5.0±0.83sec and y balance test anterior reach mean value on right leg is 60.14±3.62 cm, left leg is 60.20±3.95cm, posterolateral reach on right leg is 61.68±7.99cm, left leg is 59.79±9.30cm, posteromedial reach on right leg is 51.31±10.59cm, left leg is 50.98±10.30cm.

Table 2: Demographic data of the COPD patients who participated to find out the prevalence of balance impairment.

Demographic data	Mean	N	STD. Deviation
Age	48.48	50	5.87
Height	157.82	50	5.12
Weight	62.8	50	6.32
BMI	25.21	50	2.6

*Data expressed as Age in years, Height in cm and Weight in kg. BMI=Body Mass Index.

Table 2 shows that the mean age of the patients (n=50) is 48.48±5.87 years, the mean height is 157.82±5.12cm,

the mean weight is 62.80±6.32kg and the mean BMI is 25.21±2.60.

Table 3: Mean values of stork balance test and y- balance test obtained from COPD patients.

	Mean	N	STD. Deviation
STORK RT (SEC)	4.95	50	0.68
STORK LF(SEC)	5	50	0.83
Y-ANT RT (CM)	60.14	50	3.62
Y-ANT LF(CM)	60.2	50	3.95
Y-PL RT(CM)	61.68	50	7.99
Y-PL LF(CM)	59.79	50	9.3
Y-PM RT(CM)	51.31	50	10.59
Y-PM LF(CM)	50.98	50	10.3

*Data expressed as time in sec, distance in cm, RT-right, LF-left, Ant-anterior, Pl-posterolateral, Pm-posteromedial direction.

Table 3 shows that the mean value for the stork balance test conducted among the COPD patients on the right leg is 4.95±0.68 sec, left leg is 5.0±0.83sec and y balance test anterior reach mean value on right leg is 60.14±3.62 cm, left leg is 60.20±3.95cm, posterolateral reach on right leg is 61.68±7.99cm, left leg is 59.79±9.30cm, posteromedial reach on right leg is 51.31±10.59cm, left leg is 50.98±10.30cm.

Discussion

In this study, the static and dynamic balance was assessed in mild and moderate cases of COPD patients in order to find out their prevalence of balance impairment. The quantitative data of static and dynamic balance determines that there is balance impairment in COPD patients. This balance impairment differs from person to person (i.e.) age, gender, bodyweight and also severity of the disease. There are various reasons for balance impairment in these patients compared to healthy individuals. The intake of high steroids, hypoxemia, oxidative stress, dyspnoea, because of fear of dyspnoea these patients do not involve in any physical activity [15,16]. Fewer physical activities, the existence of comorbidities, a history of exacerbations, and the utilization of oxygen treatment are all potential risk variables that are associated with these balance deficits. Additionally, tolerance, gait speed, muscular force, and lung capacity are also potential risk factors.

In this study the mean age group is 48.48±5.87 years, among this there were 33 males (66%) and 17 females (34%). The COPD is usually a male dominant disease because of smoking and also frequent occupational exposures. The disease progression is more severe in smokers when compared with the non-smokers. Due to this there is an increased mortality rate in males than females. Because of peripheral muscle weakness these patients had loss of both static and dynamic balance. In stork balance test among 66% males, 46% had below average balance on the right leg and 20% of male had poor balance on their right leg, then 44% of male had below average balance on left leg and 22% of male had poor balance on the left leg. Among 34% of females, all females had below average balance on their right and left leg, none of the females had poor balance.

There is a correlation between impaired balance and an increased risk of falling among people who have chronic obstructive pulmonary disease (COPD), and the recent studies found that females with COPD experienced more frequent falls in the last one and two years overall. Reduced trust in one's ability to maintain balance, advanced age, increased dyspnea, physical inactivity, decreased exercise tolerance, and muscular weakness are all potential contributors to the occurrence of recurrent falls

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in congestive pulmonary disease (COPD). Schell & Leelarthaepin describes about the normative value for stork balance test among men and women. In his study he states that physical flexibility of the individual is based on their age, physical activity and the muscle strength [17]. The main practical difficulty faced by the patients when performing the stork balance test was, they were not able to raise their heel of the static leg due to severe muscle weakness. These patients had fear of fall while performing this test, though they took so many trials to perform the task.

There will be significant risk of falls among COPD patients due to balance impairment. Both static and dynamic balance is reduced in these patients compared to healthy individuals of same age group. Beauchamp et al., concluded that 46% of patients with COPD experience a fall/year and the (BBS and TUG) is a standard clinical balance measures used to discriminate self-reported fallers from nonfallers [16-19].

Plisky et al. [20] describes about the normative values for each reach in Y-balance test, the normative values of anterior reach is 72.9±5.8cm (78.3%), posterolateral reach is 112.3±6.5cm (120.8%), posteromedial reach is 114.9±7.3cm (123.5%) [20]. But in COPD patients the anterior reach on the right leg was 60.1±3.6cm (71.2%) and 60.2±3.9cm (71.1%) on the left leg, posterolateral reach on the right leg was 61.6±7.9cm (73%) and 59.7±9.3cm (70%) on the left leg, posteromedial reach on the right leg was 51.3±10.5cm (60.2%) and 50.9±10.3cm (59.7%) on the left leg.

In the Y balance test, the patients felt easy to perform the anterior reach but felt very difficult to perform the posterolateral and posteromedial reach. In the anterior reach the patients were able to keep the trunk in the erect posture but in posterolateral and posteromedial reach due to weakness of the lower limb muscles they compensate this by rotating their trunk. After some trials they performed this test correctly but reached very minimal distance. So clear observation and proper instructions should be given when the patient performed this test.

Kim V et al., [19] stated that usually people with COPD have hypoxemia that contributes to exercise intolerance, decreased skeletal muscle function, reduced quality of life and ultimately increased risk of death. Due to reduced skeletal muscle function all the peripheral muscle goes for weakness and atrophy [19].

Bernard et al., [21] states that quadriceps muscle goes for weakness easily than the upper limb due to chronic inactivity. There will be severe exacerbations in COPD patients this leads to poor quality of life, the patients often feel very anxious and depressed. These two will obviously influence the prognosis of the disease [21].

Mohammed A. Zamzam et al., [22] reported that anxiety may appear earlier than the depression; the depression among these patients is mainly due to severity of the disease and also with the functional impairment. This will obviously increase the healthcare and economic costs and also decreases patient's quality of life [22].

Thus, furthermore importance should be given to this kind of extra pulmonary symptoms. More studies can be done to improve the balance among other lung pathology conditions by giving the balance exercises and it can be used as a tool for rehabilitation of the patients. This obviously reduces their fear of fall and also improves their quality of life (QOL).

Conclusion

This study highlights the significant static and dynamic balance impairments among patients with chronic obstructive pulmonary disease (COPD). The findings underscore the pronounced challenges in maintaining stability, particularly in the posterolateral and posteromedial directions. Such balance deficits, likely driven by peripheral muscle weakness and disease-related factors, place these individuals at heightened risk of falls, adversely impacting their quality of life. Therefore, integrating targeted balance and strength training exercises into rehabilitation programs for COPD patients is critical to addressing these limitations. Further research should explore broader demographic groups and evaluate the long-term benefits of tailored interventions on balance and functional outcomes.

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