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Original Research Article

Functional Balance in Chronic Obstructive Pulmonary Disease: A Case Control Study

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ABSTRACT

Objective: The objective of this study is to compare functional balance in subjects with COPD and normal healthy individuals and to find association between functional balance and lower extremity muscle strength.
Materials and Methods: 30 subjects were selected through convenient method of sampling. 19 subjects with COPD and 11 were normal healthy individuals with age range from 55 – 70 years. Patients with moderate COPD were only included. Functional balance was assessed with the help of short physical performance battery (SPPB), single leg stance time and functional reach test. Muscle strength was measured with the help of push pull dynamometer. Correlation between functional balance and muscle strength was determined.
Result: We found that patients with COPD were associated with substantially decreased performance in Short physical performance battery score, single leg stance time and functional reach test ($p<0.001$).Subjects with COPD were also having significantly lower values of all muscle strength measures. There was a positive correlation seen between functional balance and muscle strength.
Conclusion: Results of the study shows that subjects with COPD had reduced functional balance in comparison to normal healthy individuals of same age group. So it should be considered as important component of assessment during pulmonary rehabilitation.
Key words: COPD. Balance assessment, pulmonary rehabilitation, functional balance, short physical performance battery,

INTRODUCTION

"Chronic Obstructive Pulmonary Disease (COPD) is a preventable and treatable disease with some significant extra pulmonary effects that may contribute to severity in individual patients. Its pulmonary component is characterized by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and associated with an abnormal inflammatory response of the lung to noxious particles or gases." [(1)]

Chronic obstructive pulmonary disease is one of the most important causes of death worldwide and is projected to rank 3rd in 2020 in global burden of disease. [(2)] In India chronic obstructive pulmonary disease (COPD) constitutes nearly 25-30 % of cases data according to chest clinics. [(3)]

The common symptoms of COPD include cough, mucus production, wheezing and shortness of breath typically on exertion. Dyspnea is slow but progressive in onset and occurs late in the course of the disease. [(4)]

Despite being formerly considered a disease affecting the lungs, it is now well recognized that people living with COPD also suffer from many non-respiratory manifestations including peripheral muscle dysfunction, systemic inflammation, nutrition depletion and malnutrition. [(5)] Numerous factors have been identified to contribute to peripheral muscle changes including airflow obstruction, disuse, hypoxia, malnutrition, oxidative stress, systemic inflammation and medication. [(6)]

Detriments in the peripheral muscle performance are seen with COPD which is exhibited by reduced muscle mass and strength [(7)] that occurs when balance of protein synthesis and degradation shifts to net protein breakdown. In these patients, reduction in proportion of type I fibers accompanied by increase in that of type IIb fibers was found. A 50% decrease in the capillary to fibre ratio and capillary density was also found. However, studies have reported that a disproportionate loss of capillaries may occur during COPD. [(8)]

Muscle strength is thought to be an essential factor in maintaining postural control and minimizing postural sway. Muscle strength and endurance are reduced in people with COPD compared to healthy control subjects. [(5)]

Balance and mobility are important elements of most of the activities of daily living and recent studies have shown that reduced muscle strength and hypoxia have an impairing effect on static as well as dynamic balance in patients with COPD. [(7, 9)]

Functional balance focuses on maintenance of posture while doing activities and it can be measured by various tests like time up and go test, fast speed test. These tests have shown reduced functional balance in COPD patients. However, reliability and validity of these tests is not yet established for people with cardiovascular and pulmonary disease. [(7)]

Short physical performance battery (SPPB) is a simple test to measure functional balance using tasks that mimic daily activities. SPPB examines 3 areas of lower extremity function: static balance, gait speed and getting in and out of a chair. These areas represent essential tasks important for independent living and thus make it an important outcome measure for patients with Cardiovascular and Pulmonary disease. Reliability and validity of this measure has been established and it was found to be suitable for COPD patients as well. [(10)]

Recent studies on western population have also shown that there is reduction in the functional balance and mobility in individuals with COPD relative to healthy controls. This reduction may be because of

the combined effect of various systemic factors in COPD. [7]

The exercise component of pulmonary rehabilitation is considered as the cornerstone of rehabilitation including upper limb, lower limb, and respiratory muscle training but balance assessment and training is not considered in the standard guidelines of pulmonary rehabilitation. [11] Therefore, There is paucity of studies for comparing functional balance performance in subjects with COPD and normal healthy individuals in Indian population. The objective of this study is to compare functional balance among subjects with COPD and normal healthy individuals.

METHODOLOGY

The present study was conducted in the department of physiotherapy Kasturba medical college, Mangalore. Thirty subjects (19 COPD patient and 11 normal subjects) was included in study. Each subject underwent a formal evaluation program; including pulmonary function testing was performed as per the standards outlined by American thoracic society. The inclusion criteria were ,both COPD patient and healthy subjects should be in the age group of 55-70 years,FEV1 <80% of the predicated value for COPD patient , The COPD patient were not included if they had acute exacerbation ,neuromuscular and musculoskeletal conditions that may affect the performance . The healthy Subjects should not suffer from any medical problem that could affect their performance.

Procedure

A written approval was obtained from the scientific committee and time bound Research Ethics committee of KMC, Mangalore Manipal University. Following which subjects were selected from KMC hospital Mangalore Patients referred by the Pulmonologist or Physician diagnosed with COPD was included in the study. Age matched subjects for normal group were recruited from the community. Purpose of the study was explained and informed consent was obtained.

Screening was done on the basis of inclusion and exclusion criteria for both the groups. The eligible patients were allotted into group A included subjects with COPD and B included normal healthy individuals. Functional balance was assessed by using: Short physical performance battery, Single leg stance time, and Functional reach test. Lower extremity muscle strength was assessed using Push Pull dynamometer.

ASSESSMENT OF FUNCTIONAL BALANCE AND LOWER EXTREMITY FUNCTION BY SHORT PHYSICAL PERFORMANCE BATTERY (SPPB)

Before starting the test the activities were demonstrated to the subjects. The SPPB is a simple test to measure lower extremity function using tasks that mimic daily activities.

The SPPB examines 3 areas of lower extremity function:

1. Static balance
2. Gait speed
3. Getting in and out of a chair.

These areas represent essential tasks important for independent living and are thus an important outcome measure with the reliability and validity score for patients with Cardiovascular and Pulmonary Disease.

1. To assess static balance:

The subjects were asked to maintain up to 3 hierarchical standing postures for up to 10 seconds.

Side to side stand

First, the subject stands with feet together. If subject was able to maintain this posture for 10 seconds. Then progression for the next part was done.

Semi tandem stance

Then he/she performs a semi-tandem stance position for 10 sec.

Tandem stance

If semi-tandem stance was held for 10 second, it was followed by a tandem stance.

2. **Walk test (4 meter):**

For the 4 meter walk test, the subjects were asked to walk at his or her comfortable speed across a 4 meter distance. Timing starts on the "begin" command and ceases when one foot crosses the end of the course. The test was conducted twice and the best of the two results were recorded.

3. **Repeated chair stand:**

The subjects were asked to stand from a standard chair without upper extremity assistance. If they are able to stand once, then he or she was instructed to complete 5 sit to stands as quickly as possible without upper extremity assistance. The time taken to complete the 5 sit to stands was recorded.

Each subscale is scored 0-4 with 0 being "unable to complete the task" and 4 being the "highest level of performance." Scores from each subscale are added to create a summary score between 0 and 12. [(10)]

SINGLE LEG STANCE TEST

Demonstration of the activity had been given to the patient before starting the test. Performed with eyes open and arms on the hips, the subjects must stand unassisted on one leg and then the time was measured in seconds from the time one foot is flexed off the floor to the time when it touches the ground, the standing leg or an arm leaves the hips. [(12)]

FUNCTIONAL REACH TEST

This test measures how far the subject can reach forward beyond the arm's length while maintaining the fixed base of support in the standing position, without losing balance. The test uses a level scale mounted on the wall and positioned at the height of the subject' sacromian. The patient stands sideward next to the wall (without touching), feet normal stance width and weight equally distributed on both feet. Shoulder is flexed to 90° and elbow is extended with hand fisted. An initial measurement was made at 3rd metacarpal along the scale.

For forward reach the patient, the subjects were instructed to lean as forward as possible without bending the trunk, lifting the heel or taking a step. Record the difference between the starting and the end position number. Two practice trials were given and the performance of additional three trials was recorded and averaged. If the feet move, that trial must be discarded or repeated. [(13)]

ASSESSMENT OF SKELETAL MUSCLE STRENGTH:

Isometric muscle strength was evaluated with the help of Push Pull Dynamometer

The subjects were instructed to produce a maximal isometric contraction of the muscle group tested by pushing against the plate of the dynamometer and holding in position for duration of 4 seconds to allow the participant to adjust and recruit the maximum number of muscle fibres.
Familiarization was given before the test began followed by adequate rest. 3 attempts were recorded and the highest performance score was taken for analysis. [14]

Strength of the following muscles was checked

1. Hip extensors
2. Knee extensors
3. Ankle plantar flexors

STATISTICAL ANALYSIS

Data analysis was performed using the SPSS package version 16. Mann Whitney test was used to compare functional balance and muscle strength between normal healthy individuals and subjects with COPD ($p< 0.001$).Spearman's coefficient of correlation was used to find the correlation between functional balance and skeletal muscle strength.

RESULTS

Thirty subjects participated in this study, out of which 19 were subjects with COPD with mean age of 63.47 (±4.41) and 11 were healthy subjects with mean age of 63.45 (± 5.04). Disparity between the groups in number of subjects could be due to the difficulty in getting normal healthy individuals without any medical problem affecting their performance in this age group. Demographic data and pulmonary function characteristic of all the subjects are presented in (Table 1)

Table 1: Demographic data of the study participants

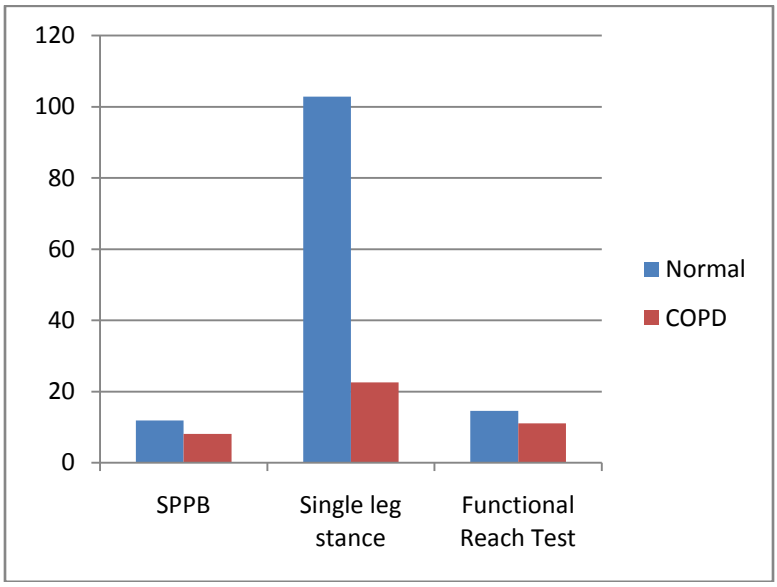
Characteristics	Subjects with COPD	Normal healthy individuals
N	19	11
Age	63.47 ± 4.41	63.45 ± 5.04
Height	163.74 ± 7.71	165.09 ± 5.68
Weight	58.68 ± 7.32	65.00 ± 10.64
BMI	22.04 ± 3.33	23.84 ± 3.82
FVC	2.61 ± 0.77	2.69 ± 0.52
FEV1	1.63 ± 0.56	2.37 ± 0.53
FEV1/FVC	613 ± 0.057	0.915 ± 0.12

Functional balance was compared between normal healthy individuals and subjects with COPD. Subjects with COPD were associated with substantially decreased performance in Short physical performance battery score, single leg stance time and functional reach test ($p<0.001$) (Table 2 and Graph 1)

Table 2 and graph 1: Comparison of functional balance between normal healthy individuals and subjects with COPD

Test	Subjects with COPD	Normal healthy individuals	Mean difference between the group	Percentage (%) reduction
Short physical performance battery(SPPB)	8.10 ± 1.24	11.90 ± .30	3.8	31%
Single leg stance time (sec)	22.52 ± 26.58	102.81± 55.25	80.29	78%
Functional reach test (inch)	11.10 ± 1.86	14.57 ± .86	3.47	23.81%

Graph 1

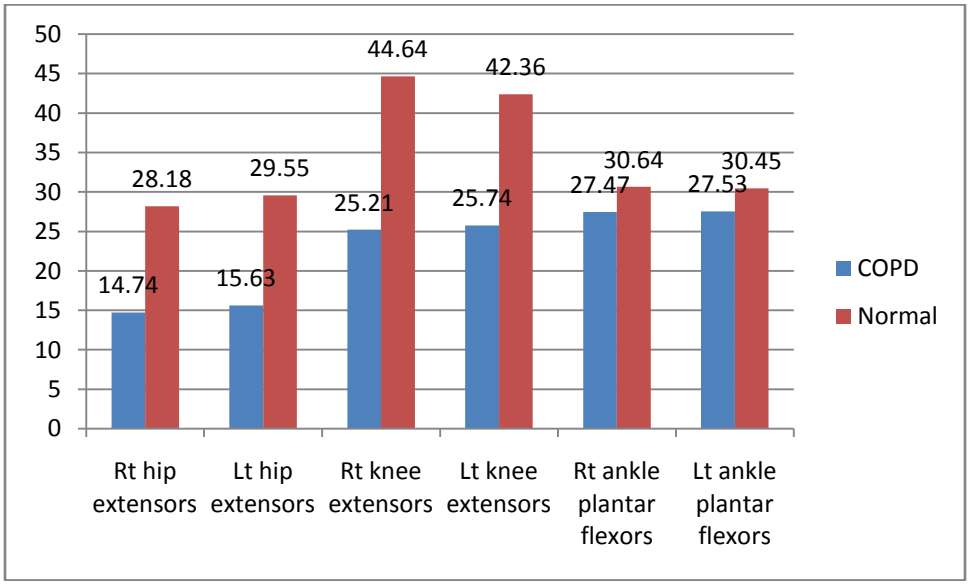


Muscle strength was compared between normal healthy individuals and subjects with COPD and it was found that subjects with COPD had significantly lower values for all muscle strength ($p<.001$) except for ankle plantar flexors (right and left) (Table 3 and Graph2)

Table 3 and graph 2: Comparison of muscle strength between Normal healthy individuals and subjects with COPD

Muscle		Subjects with COPD	Normal healthy individuals	Percentage reduction (%)
Hip extensor	Rt	14.74 ± 4.48	28.18 ± 10.32	47%
	Lt	15.63 ± 5.33	29.55 ± 12.23	47%
Knee extensor	Rt	25.21 ± 6.59	44.64 ± 7.47	43 %
	Lt	25.74 ± 7.43	42.36 ± 7.01	39 %
Ankle plantar flexor(right)	Rt	27.47 ± 5.17	30.64 ± 10.41	10%
	Lt	27.53 ± 5.12	30.45 ± 6.77	9.58%

Graph 2



All the three measures of functional balance show low to moderate positive correlation with muscle strength except ankle plantar flexor right which is showing low negative correlation. However the results were not statistically significant excepts for knee extensor left with functional reach test (p = .038).

Table 4: Correlation between functional balance and muscle strength for subjects with COPD

Group	HE Rt		HE Lt		KE Rt		KE Lt		APF Rt		APF Lt	
	r	p	r	p	r	p	r	p	r	p	r	p
SSPB	.0.219	00.36	00.217	00.37	00.317	00.186	00.367	00.122	00.216	00.37	00.428	.0.068
Single leg stance time (sec)	.0.074	00.76	00.209	00.39	00.057	00.81	00.092	00.70	-0.101	00.68	00.035	00.88
Functional reach test (inches)	.0.316	00.18	00.337	00.158	00.438	00.06	00.479	00.038	00.278	00.24	00.400	00.09

HE Rt = Hip extensor right, HE Lt = Hip extensor left, KE Rt = Knee extensor right, KE Lt = Knee extensor left, APF Rt = Ankle plantar flexor right, APF Lt = Ankle plantar flexor left.

DISCUSSION

The purpose of our study was to compare functional balance between subjects with COPD and normal healthy individuals. Results of our study shows compared to healthy individuals, moderate COPD subjects had reduced functional balance and lower extremity muscle strength. Administration of SPPB showed COPD subjects came under mild limitation category of this battery while the healthy subjects had minimal limitation.

The minimal limitation in normal healthy individuals could be due to age related detrimental changes in their muscle structure and function which includes: reduction in muscle mass, cross-sectional area, motor unit number, fibre number and size accompanied by increase in the noncontractile structures such as fat and connective tissues. Also the fast twitch fibre decreases with age whereas slow twitch type 1 fibre remains the same. While reverse occur in COPD where transition from slow to fast type fibres can be seen along with overall reduction in muscle fibre number. [8, 15, 16]

The categorization of subjects with COPD into mild limitation of SPPB would have been because of age related changes and disease process. It was observed that out of three subscale of the battery they were mostly limited in 4 m walk and repeated chair to stand sub-scale. The underlying mechanism for this finding could be the deconditioning which occurs as a result of long duration of the disease, with a mean duration of 7 years, present in these patients reducing their activity level. This is thought to be a consequence of the so called dyspnea spiral: (patients do not exert themselves in order to avoid the occurrence of dyspnea) thus causing atrophy of all fibres, affecting type I fibre the most. [8, 17] Corticosteroids being given as a part of treatment to most of

the subjects with COPD may lead to peripheral muscle weakness in them as they affect the production of contractile proteins and down regulation of insulin like growth hormone factor 1 (IGF-1), and thus may down regulate protein synthesis and increases intracellular proteolysis. All this may result into reduced muscle strength and muscle mass in these subjects. [6]

Other possible explanations for reduction in the performance of subjects are: low level of muscle aerobic enzymes which include citrate synthase and hydroxyacyl CoA dehydrogenase, decreased mitochondrial electron transport chain enzymes, capillary density, and fibre cross section area, along with early onset of lactic acidosis. [17, 18]

SPPB has proven to be is a very useful tool for assessing lower extremity function in the clinical settings. It has been shown that change in one point score in SPPB led to meaningful differences in risk of future morbidity and mortality. Previous studies had shown that subjects who scored 7 - 9 (mild limitation) in SPPB were at a relatively higher risk of developing ADL difficulties in comparison of subjects scoring 10–12 (minimal limitation). [10]

The balance subscale of short physical performance battery was found to have low reliability therefore we had also used single leg stance time test and functional reach test as an outcome measure for functional balance in our study. Single leg stance time was also significantly reduced in subjects with COPD (22.52 ± 26.58) but it was found that standard deviation in this group was higher than the mean which indicates a probable non uniform distribution and a wide variation in the individual performance.

Similarly functional reach test was also found to be reduced in subjects with COPD (mean difference of 3.47 inches).The probable reason for this reduction in performance may be attributed to reduced lower extremity and trunk muscle strength, alteration in postural control strategies, early fatigue and fear of falling. [2, 8, 18-20]

Compared to previous study our study has shown greater deficit in short physical performance battery score and the functional reach distance even in subjects moderately affect with COPD. The probable reason could be geographical variation, poor motivational status and higher age group of our participants.

It is known that patients with COPD have reduced lower extremity muscle strength; therefore, we have attempted to find correlation between muscle strength and functional balance in subjects with COPD. We found that there was low to moderate positive correlation between muscle strength and functional balance. However, the findings were not statistically significant. The probable reason could be the small sample size of our study which may be inadequate to find the interaction between muscle strength and functional balance. Also a probability of error may have been present during the measurement of muscle strength as the dynamometer requires to be properly stabilized while subjects perform the movement.

The sample size of our study was small consisting of only male subjects. Female subjects could not be included as they did not fall in the required age group or were in a severely debilitated condition. Accurate measurement of strength could have been obtained if an instrument of better reliability such as isokinetic dynamometer had been used instead of push pull dynamometer

Future research can be done with a larger sample size including both gender and with wide range of severity with use of more reliable tools. Future studies are required to examine the effect of balance training in pulmonary rehabilitation.

Clinical implication

The result of this study supports the use of assessing functional balance in male subjects with moderate COPD.

CONCLUSION

This study shows that male subjects with moderate COPD had reduced functional balance in comparison to healthy individuals; therefore the assessment of functional balance must be addressed during pulmonary rehabilitation.

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