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Original Research Article

Assessment of Components of Functional Balance in Individuals Suffering From Chronic Obstructive Pulmonary Disease and to Compare It with Age and Gender Matched Individuals

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ABSTRACT

Evidence suggests that balance deficits are an important secondary impairment in individuals with chronic obstructive pulmonary disease (COPD). Not much is known with respect to the disordered sub-components underlying the control of balance. We aimed to determine the specific components of balance that are impaired in COPD as compared to healthy age and gender matched individuals.

Methods: The postural balance was assessed in35 subjects with COPD and 35 age and gender matched healthy control subjects using the Balance Evaluation Systems Test (BESTest).

Results: Subjects with COPD showed significantly lower scores than did control subjects on all the BESTest subscales ($p = 0.01$). All the sub-components of balance which are Biomechanical Constraint Score Percent ($p = 0.044$); Stability Limits Score Percent ($p = 0.045$); Anticipatory Control Score Percent ($p=0.045$); Reactive Postural Control Score Percent ($p = 0.040$); Sensory Orientation Score Percent ($p = 0.04$) and Gait Score Percent ($p = 0.045$) were statistically reduced in COPD patients as compared to the control group. On comparing the score percent within the group, it was found that the sensory orientation score was affected more compared to other components of the BESTest in both the groups.

Conclusion: This suggested that functional balance assessment and treatment should be included in the treatment plan of the COPD patients. The treatment of functional balance should concentrate more on the sensory orientation component as compared to the other components. Thus, helping the patients to improve their functional balance and hence their quality of life.

Key Words: Chronic obstructive pulmonary disease (COPD), Balance evaluation systems test (BESTest), Postural balance.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a respiratory condition characterized by progressive, partially reversible airflow limitation, which results from an emphysematous destruction of the lung parenchyma and increased airway resistance due to inflammation, fibrosis, bronchospasm and increased mucous production. [(1)]

COPD is the second most common lung disorder after pulmonary tuberculosis in India. [(2)] Prevalence of COPD in Mumbai was reported to be 8% in one of the studies. [(3)] It has been estimated that by the year 2030, COPD will become the third biggest cause of death and the 5th leading cause of loss of 'Disability Adjusted Life Years' (DALYs) as per projection of the Global Burden of Disease Study (GBDS). [(3)]

The assessment of COPD has conventionally focused on lung function but systemic effects of the disease such as reductions in peripheral muscle performance, functional mobility and exercise capacity are also gaining attention. [4,5] Emerging evidences suggest that there are deficits in functional balance control in individuals with COPD. [6]

Good functional balance is an imperative skill for daily life. Functional balance does not work in isolation. It is a component of all movements, whether that movement is dominated by strength, speed, flexibility or stamina. Impairment in any component of balance control system can lead to instability and falls. [7]

A large cross-sectional study done by Lawlor D.A. et al. reported that COPD was second only to osteoarthritis in its correlation with the number of falls in elderly women. [8] In a recent study it was found that individuals with COPD had a projected yearly fall rate of 1.2 falls per person as compared to older adults who had fall incidence rate of 0.24 per person. [6] Another study done by Beauchamp M.K. et al. remarked that 46% (n = 18) of subjects reported at least one fall in the earlier year. [9] Risk of falls can be multifactorial and decreased functional balance is one of the chief contributors. Impairment in functional balance may seem less important than other life-threatening effects of COPD but falls are associated with increased mortality, more injuries, higher chances of depression, decreased independence, poor quality of life and reduced physical activity participation of a person. [10] Fear of falls or falls can further decline the already limited functional mobility and independence in the COPD population, thus, further deteriorating the condition of the patient. So, examination of functional balance in individuals with COPD is important in physical therapy to predict their safety in variety of environment. Also, many times the patients avoid lot of movement and perform movements slowly due to the fear of becoming dyspnoeic. This overlaps the underlying balance deficits which come into foreground only when this problem (i.e. of impaired balance) increases. The Balance Evaluation Systems Test (BESTest) is one test which comprehensively evaluates functional balance by dividing it into six components. The six components of BESTest are biomechanical constraints, stability limits, anticipatory control, reactive postural control, sensory orientation & stability in gait. [11]

Functional balance in COPD was assessed by a few researchers. [6] They assessed functional balance using clinical assessment tools like Bergs Balance Scale, Functional Reach Test, Time Up and Go test, posturography etc. and they found that balance was impaired in patients suffering from COPD. However, they have not found which components of balance will be affected the most in COPD as these balance assessment tools are directed at screening for balance problems and predicting fall risk. [12] These tools identify which patients may benefit from balance training exercises, but they do not help the therapists to decide how to treat the underlying balance problems.

Marla K. Beauchamp in their study Effect of Pulmonary Rehabilitation on Balance in Persons with Chronic Obstructive Pulmonary Disease found that a conventional pulmonary exercise rehabilitation program, in the absence of any specific balance training, resulted in only minor improvements in balance and no effect on balance confidence. But balance training and fall prevention strategies are not included in international guidelines for pulmonary rehabilitation and very few programs include any standardized balance assessment. Thus, the researchers who assessed balance in COPD patients recommended balance training as one of the aspects of treatment of patients suffering from COPD.

But to treat a complex issue like balance, it is necessary that we find which component of balance is affected the most such that the treatment will be more specific and concise.

The aim of this study was to compare the components of functional balance using Balance Evaluation Systems Test (BESTest) in individuals suffering from COPD with healthy (age and gender matched) controls.

The objectives of the study were:

- To assess the components of functional balance using the BESTest in individuals suffering from COPD and in healthy (age and gender matched) controls.
- To compare each component of the functional balance of both the groups.
- To determine which component of functional balance was affected the most in individuals suffering from COPD as compared with healthy (age and gender matched) controls.

The null hypothesis for the study was that there was no significant impairment in any component of functional balance in individuals suffering from COPD. The alternate hypothesis for the study was that there was significant impairment in components of functional balance in individuals suffering from COPD.

Thus, the intent of this study was to assess the components of balance using BESTest and to decide which component of balance is affected the most in COPD patients. This will help the therapist to identify the problematic underlying postural control system, which then can be used to formulate and include a specific balance training programme in the treatment. As the programme will be more specific towards the affected components, it will be more effective and faster results in improvement of affected balance may be expected. Hence, improving the functional activities, independence in moving around, overall confidence and their quality of life.

MAERIALS AND METHODS

Approval from Ethics Committee was sought for this comparative cross-sectional study. Appropriate permission for using the BESTest was taken.Sample population taken was patients suffering from COPD andhealthy age and gender matched individuals were taken as controls.

58 subjects suffering from COPD were screened, out of which 35subjects meeting the inclusion - exclusion criteria were selected to be a part of the COPD group.

Inclusion criteria were:

- Individuals aged 40 years or above.
- Patients with mild, moderate, and severe airway obstruction based on the GOLD-stage classification of COPD.
- No exacerbation of symptoms in the last 1 month.
- Subjects who can stand unsupported.
- Voluntary consent to participate.

Exclusion criteria were:

- If the individual suffers from any other lung condition, lower limb injury, neurological injury/disease, or any vestibular problems.
- Major vision/auditory problem.
- If the individual uses any walking aids.
- Fever or worsening of respiratory symptoms.
- Unstable coronary artery disease.
- Participation in any physical training activities.

The COPD subjects were divided into several age bands and then controls were recruited in equal numbers as the COPD subjects.

60 healthy subjects were screened out of which 35 subjects meeting the inclusion - exclusion criteria were selected to be a part of the control group.

Individuals of the control group were age and gender matched on the basis of frequency matching. [13] (As such a matching, could include a very wide range of ages in one group but a very narrow range in the other group yet still be matched for (mean) age. To avoid this problem 'frequency-matching' was used.)

A written consent was taken from the participants after explaining the study and its procedure in the language best understood. The basic personal and demographic data were recorded. Participants were then tested for functional balance without shoes and socks using Balance Evaluation Systems Test (BESTest) which was used as the outcome measure for the study.

Balance Evaluation Systems Test (BESTest)

Table 1- Description of Subcomponents and Outline of Items from the BESTest

Subcomponent	Description	Items (Numbers)	Score Calculation of each component
Biomechanical constraints	Evaluates constraints on standing balance, including strength, ROM, and posture	Quality of BOS, COM alignment, ankle strength and ROM, hip strength, sit on floor and stand up (1-5)	Biomechanical Constraints = ___ / 15 Points. Biomechanical Constraints score percent = ___ / 15 x 100
Stability limits/verticality	Includes items for an internal representation of how far the body can move over its BOS, as well as an internal perception of vertical	Verticality and lateral leans, forward and lateral reach (6-8)	Stability Limits = ___ / 21 Points. Stability Limits score percent = ___ / 21 x 100
Anticipatory adjustments/transitions	Includes tasks that require active movement of the body's COM in expectation of a transition from one body position to another	Sit to stand, rise to toes, one-legged stance, stair task, standing arm raise (9-13)	Anticipatory postural adjustment = ___ / 18 Points. Anticipatory postural adjustment score percent = ___ / 18 x 100
Postural responses	Includes both in-place and compensatory stepping responses to an external perturbation induced by the examiner's hands	In-place, forward, backward, and lateral "push and release" (14-18)	Reactive Postural Response= ___ / 18 Points. Reactive Postural Response score percent = ___ / 18 x 100
Sensory orientation	Identifies any increase in postural sway during stance associated with altering visual or somatosensory information	Stance on firm surface and foam surface with eyes open and closed, stance on incline with eyes closed (19-20)	Sensory Orientation= ___ / 15 Points. Sensory Orientation score percent = ___ / 15 x 100
Stability in gait	Assesses stability during walking when balance is challenged	Usual gait speed, change in gait speed, walk with head turns, step over obstacle, TUG, TUG with dual task (21-27)	Stability in Gait = ___/21 Points. Sensory Orientation score percent = ___/21 x 100.
Total			TOTAL: ___ / 108 x 100 = ___ Percent Total Score

BESTest= Balance Evaluation Systems Test; BOS = base of support; COM = center of mass; ROM = range of motion; TUG = Timed Up and Go

Each of these components was tested and data was collected. After the completion data summary sheet was prepared and statistical analysis was done.

STATISTICAL ANALYSIS

The data was collected and statistically analysed using SPSS 22. The data was tested for normality using the Shapiro-Wilk test. The means and standard deviation of the age of the COPD group and control group were compared using the unpaired t-test to statistically show that the two groups were age matched. Comparison of the components within the group was carried using Kruskal-Wallis test. Comparison of the components of Balance Evaluation Systems test between COPD group and control group was done using Mann-Whitney U test (non-parametric test for independent samples) as the components did not pass the normalitytest. Comparison of Percent Total Score between COPD group and control group was done using Unpaired-t test (parametric test for unpaired samples) as percent total score of both the groups passed the normality test.At 95% Confidence interval, the level of significance was set as 0.05.

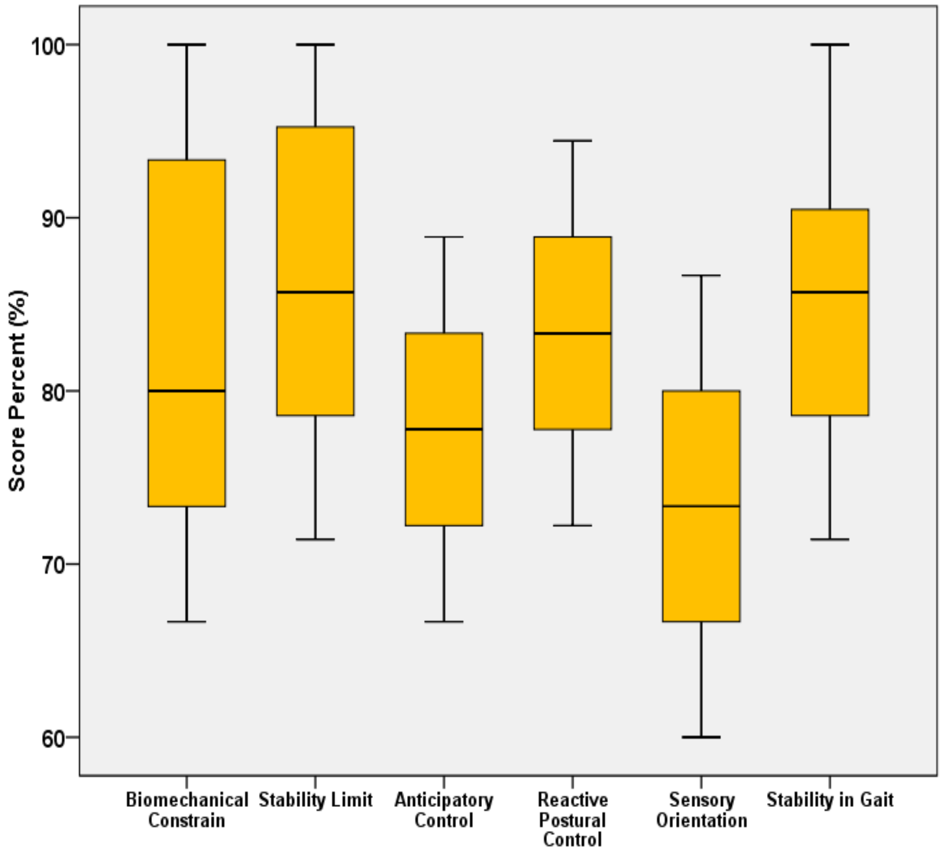
RESULTS

Table 2 - Characteristics of the subjects

	COPD Group	Control Group	P-Value (unpaired t-test)
	n=35	n=35	
Age	56.45±8.02	56.26±7.927	0.917
Gender M/F	18/17	18/17	

The data was matched based on gender and age.

Though the data is age and gender matched, the matching done is a frequency matching and not an individual paired matching. Thus, the two groups are considered as separate groups and hence Mann-Whitney U test is performed to compare the components of balance in both the groups.

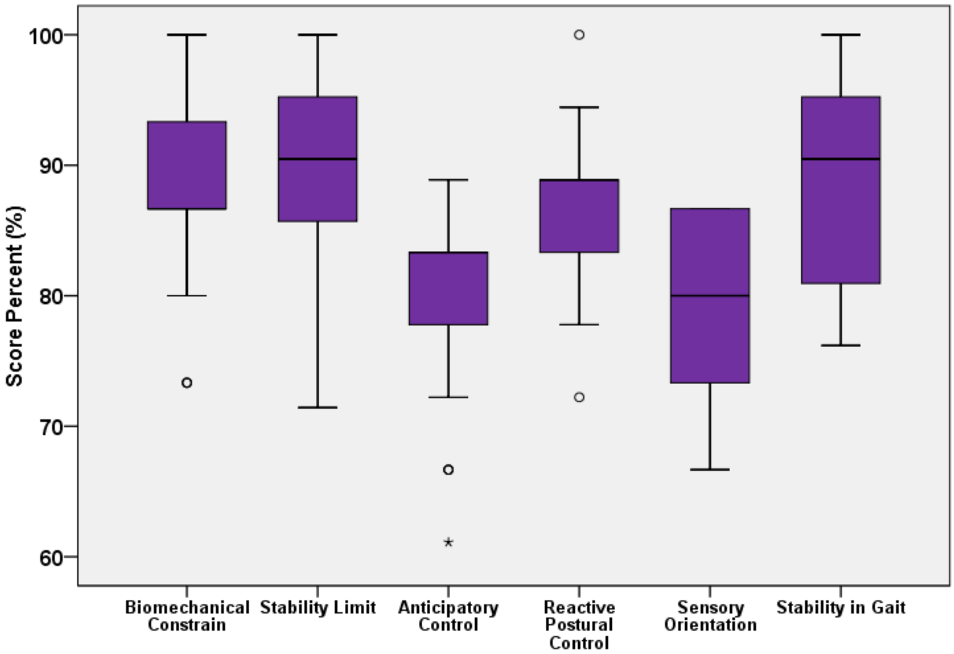


Graph 1 shows Distribution of components of BESTest in COPD group

On comparing the components of balance within the COPD group (table 3) the mean rank is the least for the sensory orientation score (63.27) followed by anticipatory control score (78.14), indicating these two components are the most affected. The mean rank is highest for Stability Limit Score Percent (131.74) followed by Stability in Gait Score Percent (128.46), indicating that these components are the least affected. The p value is 0.000 suggesting there is a significant difference between the groups.

Table 3 – Comparison of the components of balance within the COPD group.

	Mean Rank	Kruskal Wallis Test		
		Chi square	Df	p value
Biomechanical Constraint Score Percent (Component 1)	110.53	38.164	5	0.000
Stability Limit Score Percent (Component 2)	131.74			
Anticipatory Control Score Percent (Component 3)	78.14			
Reactive Postural Control Score Percent (Component 4)	120.86	Thus, signifying there is a statistical difference between the groups		
Sensory Orientation Score Percent (Component 5)	63.27			
Stability in Gait Score Percent (Component 6)	128.46			



Graph 2 shows the distribution of components of BESTest in Control group

On comparing the components of balance within the control group (table 4) the mean rank is the least for the sensory orientation score (56.53) followed by anticipatory control score (67.96), indicating these two components are the most affected. The mean rank is highest for Stability Limit Score Percent (137.21) followed by Stability in Gait Score Percent (129.44), indicating that these components are the least affected. The p value is 0.000 suggesting there is a significant difference between the groups.

Table 4 – Comparison of the components of balance within the control group.

	Mean Rank	Kruskal Wallis Test		
		Chi square	df	p value
Biomechanical Constraint Score Percent(Component 1)	128.23	56.923	5	0.000
Stability Limit Score Percent (Component 2)	137.21			
Anticipatory Control Score Percent (Component 3)	67.96			
Reactive Postural Control Score Percent(Component 4)	113.63	Thus signifying there is a statistical difference between the groups		
Sensory Orientation Score Percent (Component 5)	56.53			
Stability in Gait Score Percent (Component 6)	129.44			

Since in both the groups'sensory orientation and anticipatory control are the most affected and Stability Limit and Stability in Gait are least affected we compared the total BESTest score and their individual components between COPD group and the control group.

Subjects with COPD demonstrated reduced Total BESTest score when compared to the control group as shown in table 5.

Table 5 – Comparison of total BESTest score between COPD and Control group.

	Mean	SD	Min.	Max.	Percentiles			Mann-Whitney U	p Value
					25th	Median	75th		
COPD Group	81.43	6.87	70.37	93.52	75.93	81.48	87.96	833	0.01
Control Group	85.71	6.73	73.15	95.37	81.48	86.11	91.67	Difference is Significant	

Subjects with COPD demonstrated reduced balance scores on each component of the BESTest when compared to the control group as shown in table 6.

Table 6 – Comparison of each component of BESTest between COPD and Control group.

	Mean	SD	Min	Max	Percentiles			Mann-Whitney U	p Value
					25th	Median	75th		
Component 1									
COPD Group	83.05	10.0	66.6	100	73.33	80	93.33	782.5	.044
Control Group	86.18	8.07	73.3	100	86.67	86.67	93.33	Difference is Significant	
Component 2									
COPD Group	85.44	9.45	71.43	100	78.57	85.71	95.24	781	.045
Control Group	89.93	8.39	71.43	100	85.71	90.48	95.24	Difference is Significant	
Component 3									
COPD Group	77.14	5.99	66.67	88.89	72.22	77.78	83.33	777.5	.045
Control Group	79.84	7.27	61.11	88.89	77.78	83.33	83.33	Difference is Significant	
Component 4									
COPD Group	83.17	6.93	72.22	94.44	77.78	83.33	88.89	777.5	.040
Control Group	86.67	6.20	72.22	100	83.33	88.89	88.89	Difference is Significant	
Component 5									
COPD Group	73.91	8.14	60	86.67	66.67	73.33	80	782.5	.040
Control Group	77.91	7.19	66.67	86.67	73.33	80	86.67	Difference is Significant	
Component 6									
COPD Group	84.76	8.70	71.43	100	78.57	85.71	90.48	782.5	.045
Control Group	89.11	8.45	76.19	100	80.95	90.48	95.24	Difference is Significant	

DISCUSSION

In previous studies, Bergs Balance Scale (BBS) and Short Physical Performance Battery (SPPB) were the most frequently used clinical instruments to assess postural control, followed by the Functional Reach Test (FRT) and One Leg Stance (OLS). [14] But these assessment tools did not help the therapists to identify which component of balance was affected the most. Therefore, in this study, we had assessed various components of balance using BESTest.

The aim of this study was to compare the components of functional balance using BESTest in individuals suffering from COPD with healthy (age and gender matched) controls.

Table 2 showed that subjects in both the groups were age and gender matched. This was done to decrease the confounding factor of age which affects postural balance.

Graph 1, Graph 2, table 3 and table 4 showed Sensory Orientation Score Percent (Component 5) was affected the most and Stability Limit Score Percent (Component 2) was affected the least in both the groups.

But table 5 a showed significant reduction in total percent score of BESTest (p=0.01) in the COPD group as compared to the age and gender matched control group. This suggests that COPD could hasten the rate of balance deterioration due to age.

Impairment of postural control in the elderly has been well established. [15-17] However, postural control had only been studied in COPD patients in the past few years. [10,18]

Table 6 showed a significant reduction (p =0.044) in the score percent of biomechanical constraints of COPD group when compared to the control group.

Biomechanical Constraints tests the alignment of the body. In COPD, excessive respiratory muscle recruitment causes mechanical abnormality in the thoracic cage. As the body is a closed kinematic chain, this influences the overall body mechanics and functional balance. [19]

The postural attitude of the hyper inflated thorax can lead to a series of the spinal column, shoulder, and pelvic girdle compensations. [20] Spinal column deformities, such as increased thoracic kyphosis and lumbar lordosis, are common in adults with COPD. [21]

Thus, COPD could have affected the postural alignment which could then negatively affect the score of biomechanical constraints, therefore, affecting balance. [22]

Biomechanical constraint also tests the overall functioning of the lower limb muscles. In COPD, there is greater reduction in muscle mass, intramuscular fat, muscle fibre atrophy (most notably in fast twitch type II fibres). Capillary density decreases, mitochondrial dysfunction can be seen and there is a lower proportion of oxidative enzymes. These abnormalities, when taken together, indicate an overall decline in both, the contractile and oxidative capacity of lower limb muscles. [23-27] Lower limb muscles are important for maintaining balance. In COPD, the functioning of these muscles is affected therefore affecting the score of biomechanical constraint.

Corticosteroids which is given as a part of treatment to most of the subjects with COPD leads to peripheral muscle weakness. This affects the production of contractile proteins and down regulates insulin like growth hormone factor 1 (IGF-1). This, in turn, decreases protein synthesis and increases intracellular proteolysis which results in reduced muscle strength and muscle mass in these subjects. [28,29] Low levels of vitamin D are observed in individuals with COPD which may impair bone strength and muscle strength. [30]

All these factors too could be probable reasons for the negative affection of biomechanical constraint component in COPD group as compared to age and gender matched control group.

Table 6 also showed a significant reduction (p =0.045) in the score percent of stability limits of COPD group when compared to the control group.

This component tests for limits of stability in all the directions. Stability in the anterior-posterior direction could be more affected in COPD individuals because of decreased flexibility of the muscles of the back and lower limb and decreased range of motion at the spine. [31]

For lateral reach outs, the body is more dependent on trunk movement due to poor efficiency of the ankle muscles. There is increased mediolateral displacement of the centre of gravity in people with COPD as the stability provided by the trunk muscles is decreased. This is because the trunk muscles have to work to aid respiration in COPD patients which are likely to reduce the contribution of trunk muscles to control balance due to which, there will be a decreased lateral reach out. [10]

Thus this component is more affected in COPD group.

A significant reduction (p =0.045) in the score percent of Anticipatory Postural Adjustments of COPD group was noted when compared to the control group. This component aimed to create a stable postural base on which the intended movement could take place. This is difficult for individuals suffering from COPD. It could be due to the weak quadriceps muscle which occurs in COPD because of an increase in pro inflammatory cytokines which further increases the activity of the ubiquitin-proteasome pathway, a proteolytic pathway that causes muscle wasting. [5,32] Thus a stable postural base on which the intended movement can take place is not allowed.

Studies show quadriceps strength is decreased on average by 30 per cent in patients with moderate to severe COPD. [33]

The positions assessed challenged the person’s capacity to maintain its centre of mass (CoM) within the base of support. To maintain this CoM within the base of support, the muscle activation and contraction increases. Muscle endurance is reduced in people with COPD compared to healthy controls. This reduction in muscle endurance is important because it reflects increased muscle fatigability, [34] which has been associated with impaired postural control as assessed by single-leg stand and toe rise.

Hence comparatively more affection is seen in this component in COPD group.

There was a significant reduction (p =0.04) in the score percent of Reactive Postural Responses of COPD group when compared to the control group.

Hamilton et al showed that the latency time for the Achilles and patellar tendon reflex was longer in COPD patients than in control subjects. The authors believe that this nerve conduction delay is secondary to peripheral muscle impairment in COPD patients, and this delay could affect the reaction time for correction of postural control. [35]

A significant reduction (p =0.04) in the score percent of Sensory Orientation of COPD group when compared to the control group.

In this component when the visual feedback is cut or when the individual is made to stand on foam or inclined slope, the feedback remains majorly from proprioception of the lower limbs and studies show that proprioception is affected in individuals suffering from COPD. This affection of proprioception can be one of the causes for postural affection in individuals suffering from COPD. [30]

Studies have also shown nerve conduction abnormalities and signs of peripheral neuropathy (i.e., smaller amplitude potentials, increased latency, decreased conduction velocity), especially in the sensory nerves, in people with COPD. [36,37]

In COPD subjects, the reliance on back muscle proprioception for maintaining postural balance is less compared to normal subjects because the diaphragm, which plays an important role in stabilizing the spine during balance and loading tasks in normal subjects, is not working efficiently. Thus, individuals with COPD utilize an ankle-steered postural control strategy. But when standing on an unstable support surface like foam, ankle proprioceptive signals become less reliable making them more vulnerable to falls on unstable surfaces. [30]

El-Kady and colleagues investigated audio-vestibular function in people with COPD having hypoxemia (Po2 < 75 mm Hg) compared with a control group; although they observed poorer general audio-vestibular function in the group with COPD, the differences were not significant. [38]

Lord SR et al. have indicated that postural deficits in older adults are associated with muscle weakness, especially during the more demanding balance tasks. [39] It is known that people with COPD have muscle weakness and these tests could have been a demanding task for them. This can be a possible explanation for the preferential deficits in this component.

Another reason for affection in this component could be the decreased tidal volume in COPD individuals as more the tidal volume in the lungs, lesser is the postural sway. [39]

A significant reduction (p =0.045) in the score percent of Stability in Gait of COPD group when compared to the control group was seen.

The reasons for affection in this component could be the weakness of the lower limb muscles, a lower functional capacity and independence and a lack of physical activity.

Butcher et al., reported that fast gait speeds measured over a 6 m walkway were significantly lower (~28%) in oxygen-dependent people with COPD (FEV1=29.9 ± 3.7% predicted) compared to a healthy control group. [40]

Therefore, through this study the alternate hypothesis, that there is significant impairment in components of functional balance in individuals suffering from COPD when compared to the healthy age and gender matched controls, is proved. Thus, rejecting our null hypothesis.

Limitation of this study was that the sample size was small and all the samples collected were taken from one geographical area. It is recommended to do this study with a larger population and it should be an interventional study so as to see the effect of a balance training program in COPD patients. This balance training program should be planned as per the components of balance affected in the study.

CONCLUSION

From this study, it was concluded that

Compared with age and gender matched control subjects, individuals with COPD have statistically significantly reduced performance in all sub-components of balance which was tested using the BEST scale (p=0.01, p<0.05)

On comparison of all the components of BESTest within the COPD group, it was found that Sensory Orientation Score Percent (mean rank = 63.27) was the most affected and Stability Limit Score Percent (mean rank = 131.74) was the least affected. (p=0.000)

On comparison of all the components of BESTest within the control group it was found that Sensory Orientation Score Percent (mean rank = 56.53) was the most affected and Stability Limit Score Percent and Stability in Gait Score Percent (mean rank = 137.21) were the least affected.

Good functional balance is an imperative skill for daily life. Impairment in any component of balance control system can lead to instability and falls. [9] Although current guidelines for pulmonary rehabilitation recommend progressive resistance exercises for improving peripheral muscle strength in patients with COPD along with the regular chest physiotherapy. But only strength training will not suffice to improve functional balance in COPD patients. Targeted balance training is required for the exercise program to have optimal effects on fall risk reduction and balance control. And as found from this study the component of sensory orientation should be more focused on, as compared to the other components when training the COPD patients for improvement in functional balance as it is comparatively more affected than other components of functional balance. Thus, helping the patients to gain more confidence in performing their daily tasks and thus improving their quality of life.

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