



Comparison of reaction time and functional balance in chronic obstructive pulmonary disease and healthy participants

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ABSTRACT

Background: Reaction time is one of the components of functional balance and could contribute to balance impairment. Information regarding this relationship is scant among Chronic Obstructive Pulmonary Disease (COPD) participants.

Objectives: To compare stepping reaction time between participants with COPD and age; gender-matched healthy individuals to find out whether reaction time in COPD population is affected.

Methods: This cross-sectional study included 41 COPD participants and 41 age and gender-matched healthy individuals. All the participants underwent measurements of stepping reaction time (SRT) and timed up and go test (TUG).

Results: SRT was significantly higher in COPD participants compared to healthy individuals [median of difference- 350 milliseconds (110, 830), $p < 0.001$]. TUG was significantly higher in COPD participants compared to healthy individuals [median of difference = 2.82 seconds (0.34 and 4.5), $p < 0.001$].

Conclusions: Participants with COPD exhibit marked increase in SRT and demonstrate a deficiency in functional balance compared to the healthy participants.

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Introduction

Chronic Obstructive Pulmonary Disease (COPD) is an airflow limiting respiratory disease characterized by chronic dyspnea and debilitating morbidity. COPD severity, its symptoms, and underlying comorbidities can result in morbidity.¹ The COPD morbidity in India is among the highest in the world. An average of 556,000 COPD cases are reported in India (>20%) out of the global total of 2,748,000 cases every year.² In the early stage, COPD involves extensive structural and functional remodeling of the lungs, causing shortness of breath, cough accompanied by excessive mucus production, and chest tightness. Disease progression is associated with increased systemic manifestations such as weight loss, nutritional abnormalities, and skeletal muscle dysfunction.^{3,4} Persistent hypoxemia and systemic inflammation lead to skeletal muscle dysfunction, neurological deficits and cognitive impairments, which in conjunction could affect the levels of physical activity, posture, balance and coordination. These deficits can result in increased risk of falls.^{4–6}

Postural control requires the synchronous activity of somatosensory, vestibular and visual schemes, thereby, maintaining the functional balance.^{7,8} All these schemes determine the body's response or reaction to the outside surroundings.⁸ The reaction to external stimuli is crucial in maintaining functional balance, and the time taken for this reaction is known as reaction time.^{9,10} Quick protective reactions such as stepping or reaching are prerequisites to avoid falls and minimize injuries. The time taken for the stepping response is known as the stepping reaction time, and this helps in maintaining functional balance.¹¹

Cognitive reaction time, which involves testing of working memory, cognitive manipulation of temporal information and processing speed using upper limbs, is reportedly impaired in COPD patients.¹² Since the stepping reaction time is poorly understood in COPD population, the comparison of stepping reaction time between COPD participants and healthy individuals may provide an insight into balance impairment and falls. In the present study, the following hypotheses are considered: (1) stepping reaction time is affected among COPD participants, and it worsens as the disease progresses; and (2) severe the balance impairment, longer is the reaction time. The purpose of the study was to compare the stepping reaction time and functional balance in COPD and healthy participants. The study also aimed to correlate (a) stepping reaction time and functional balance with disease severity, and (b) stepping reaction time and functional balance among COPD participants.

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Methods

Study design

This cross-sectional study was conducted from January 2017 to February 2018. Ethical clearance was obtained from the Institutional Ethics Committee, Kasturba Medical College and Hospital, Manipal (IEC 275/2017).

Human participants

Clinically stable COPD participants and age- and gender-matched healthy individuals were included in the study. For every COPD participant recruited, an age- and gender-matched healthy individual was recruited. Matching was achieved by recruiting a healthy individual of the same gender whose age was within five years of the COPD participant's age.

Setting and sample

The entire sample consisted of 82 participants: 41 participants with COPD and 41 healthy participants. The COPD participants were recruited from the outpatient and inpatient departments of pulmonary medicine of a tertiary care hospital, based on a diagnosis of COPD according to the Global Initiative for Obstructive Lung Disease (GOLD).¹ The healthy participants were recruited from the local neighborhood and were informally interviewed to identify any pre-existing disease. The selected participants with COPD were in the age group of 40–70 years and were medically stable, with self-reported functional vision. The participants were screened informally for functional vision by inquiring if they had visual impairment during activities of daily living. COPD participants were excluded if they had comorbidities that affected balance such as diabetes, vestibular disorders, cerebrovascular accidents, and musculoskeletal disorders. None of the participants had undergone surgery within a year. Patients on long-term oxygen therapy were also excluded.

The healthy participants had the same inclusion criteria except for the diagnosis of COPD. They also had no diagnosed health condition/s which could affect balance or reaction time.

Sample size: For an 80% probability of detecting the difference in reaction time, a total of 82 samples was required. We included 41 participants in each group based on the assumed difference between groups of 90 ms and a standard deviation of 113 ms for attention reaction time among COPD participants and 110 ms among healthy individuals.¹²

Procedure: The procedure for reaction time test and methods for data collection was explained to the participants, and informed consent was obtained. Participant characteristics, including age, gender, and anthropometric data, were recorded for both the groups. Forced vital capacity and forced expiratory volume in 1 (FEV1) second were obtained with a computerized spirometer (Koko® Px, nSpire Health, Inc. Longmont, Colorado, USA) according to a standardized procedure.¹³ The participants performed three trials of both the stepping reaction time test and the Timed Up and Go (TUG) test in a single session, and the best results were used for the analysis.

The stepping reaction time device was indigenously developed and calibrated using previously published methods.^{9,11,14,15} The stepping reaction time apparatus had a board and a visual stimulus. Reaction time was measured with the participant standing with feet shoulder-width apart, five centimeters behind the simple reaction time apparatus board placed in front of the participant on the floor. Guidelines for measuring reaction time were followed during the procedure. Participants were instructed to press a switch as soon as they see a visual stimulus and the time was recorded in milliseconds. The lower limb that was most preferred for any lower limb activity was chosen for the stepping reaction time test.

Functional balance was assessed by the TUG test, which is a reliable and valid tool to measure the risk of falls in this population.^{16–18} The time taken in completing the test was recorded in seconds.

Data analysis

Statistical analysis was performed using SPSS (SPSS for Windows, Version 15, SPSS Inc., Chicago, IL, USA). The level of significance was set at $p \leq 0.05$ for all statistical analyses. Non-parametric tests were used for the data which did not follow normal distributions. Data are presented as medians and interquartile ranges. The Wilcoxon signed rank test was performed for between group comparisons with respect to stepping reaction time. Paired t tests were computed for between groups comparison of functional balance test results. Spearman's rank correlation coefficient test was performed to identify the correlation between the following: (a) stepping reaction time and TUG, and (b) FEV1 and stepping reaction time. Pearson's correlation coefficients were computed for (a) age and TUG time and (b) FEV1 and TUG as they followed normal distribution.

Results

Two hundred and fifty-nine participants were screened, and 82 participants were recruited. All participants completed the tests, and there were no adverse events. The flow diagram of recruitment of participants into the study is shown in Fig. 1. The age of the participants ranged from 46 to 70 years, and the majority of them were males ($n = 76$, 92.7%). The demographic and clinical characteristics of the participants and distribution of disease severity of COPD participants (FEV1) are presented in Table 1. Comparisons between reaction time and the TUG test are presented in Table 2.

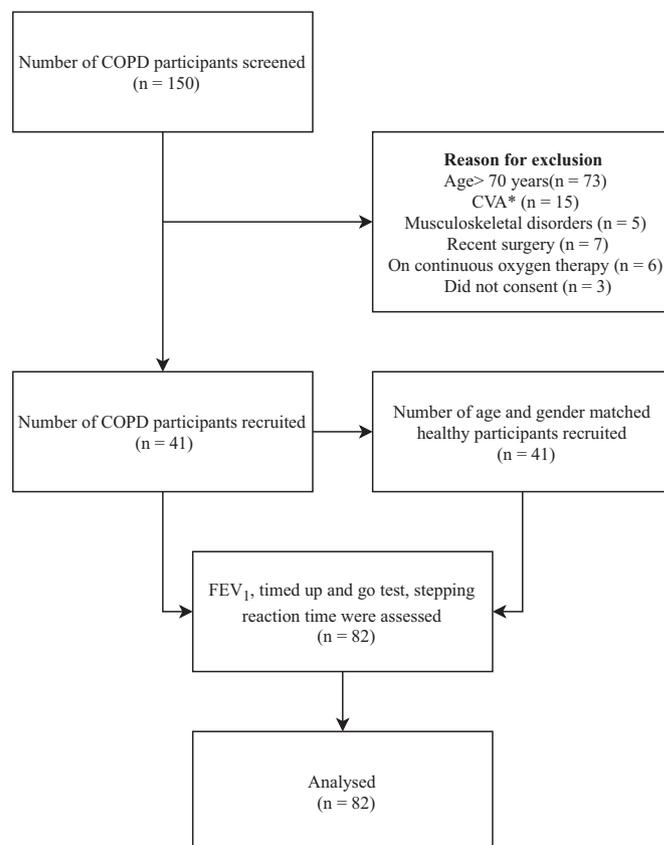


Fig. 1. Flow diagram of recruitment. Abbreviations: COPD, Chronic Obstructive Pulmonary Disease; CVA, Cerebro Vascular Accident; FEV1, Forced Expiratory Volume in 1 s.

Table 1
Demographic characteristics of participants

Characteristics	COPD participants (n = 41)	Healthy participants (n = 41)
Age (years) [Median (IQR)]	61 (54,67)	61 (54,67)
Gender (male/female)	38/3	38/3
Height (cm) [Median (IQR)]	162 (156,167)	163 (160.5, 165)
Weight (kg) [Median (IQR)]	63 (61, 70)	68 (62,73)
Weight (Pounds) [Median (IQR)]	139.07 (134.65, 154.52)	149.91 (136.69, 160.937)
FEV ₁ (%) (Mean ± SD)	47.6 ± 17.9	
FVC (%) (Mean + SD)	59.4 + 15.3	
FEV ₁ /FVC (%) (Mean ± SD)	64.1 ± 16.2	
GOLD severity stage		
Stage 1 (%)	51	
Stage 2 (%)	26	
Stage 3 (%)	18	
Stage 4 (%)	5	

Abbreviations: COPD, Chronic Obstructive Pulmonary Disease; IQR, Interquartile range; FEV₁, Forced Expiratory Volume in 1 s; FVC, Forced Vital Capacity; GOLD, Global Initiative for Obstructive Lung Disease.

Our findings showed that the stepping reaction time significantly correlated with TUG in both COPD participants and healthy individuals ($\rho = 0.443$, $p < 0.001$ versus $\rho = 0.774$, $p < 0.001$, respectively). The stepping reaction time showed a significant correlation with age in both COPD participants and healthy individuals ($\rho = 0.388$, $p < 0.012$ versus $\rho = 0.806$, $p < 0.001$, respectively). Stepping reaction time showed a moderate negative correlation with disease severity ($\rho = -0.446$, $p < 0.003$). The disease severity (FEV₁) showed negative, weak correlation with TUG time ($\rho = -0.185$, $p = 0.24$).

Discussion

The stepping reaction time was increased in COPD participants as compared to healthy participants. This could be due to the following reasons. (a) COPD often presents with chronic fatigue, chronic hypoxia, and hypercapnia that lead to muscle weakness and impaired cognition, contributing to the difference in reaction time. A previous study showed that upper limb cognitive reaction time was impaired in the COPD population.¹² (b) The proprioceptive changes in COPD patients affects the postural control. A study reported increased dependency on ankle for postural stability during anticipatory tasks.¹⁹ The stepping reaction time test, an anticipatory task involving lifting of the foot from the ground and placing it on the switch, challenges the postural stability. Therefore, this could have contributed to a delayed response. (c) A previous study demonstrated faster reaction time in individuals with active lifestyle compared to sedentary individuals.²⁰ Most of the COPD patients lead a sedentary lifestyle owing to dyspnea, weakness and fatigue. This could cause slower reaction time in COPD patients. However, we cannot ascertain this assumption as the study did not consider physical activity levels.

The TUG test results showed that the COPD participants took more time to complete the test compared to healthy participants. However, none of the participants had TUG score of > 13.5 s, which was considered as the cut-off for high fall risk. The findings of previous studies that examined functional balance in COPD population are in line with our results.^{5,6,17,21–24} This impairment has been attributed to muscle weakness, age, alteration of neurological function, limited mobility, and physical inactivity.²⁴

Logically, functional balance encompasses stepping reaction time. Healthy participants showed good correlation between reaction time and TUG, whereas a moderate correlation was seen in COPD participants. This could be attributed to the presence of neurocognitive and musculoskeletal impairments in COPD.^{25,26}

Further analysis showed that the majority of the COPD participants ($n = 32$, 77%) belonged to mild to moderate stage of disease severity according to GOLD criteria. The correlation between stepping reaction time and disease severity (FEV₁%) showed a moderate relationship. As the disease progresses, the time taken to respond to an external stimulus increased significantly. This neurocognitive impairment compounded by possible musculoskeletal involvement may provide a clue to falls in this population. The correlation between disease severity and TUG time was weak and negative as majority of the participants showed mild to moderate disease severity; this could have skewed the results. Previous studies have also reported similar relationship.^{21,27,28} On the contrary, Butcher et al. observed a significant positive correlation between TUG and FEV₁ values. However, this correlation requires further exploration to understand whether TUG time worsens with a decrease in FEV₁.⁴

The present study is the first research work to identify impairment in stepping reaction time in participants with COPD on controlling the confounders such as age and gender. The increased reaction time in COPD participants could be an important contributor to risk of falls. It is noteworthy to mention a few limitations of this study. (i) The stepping reaction time assessment was not performed in a controlled environment, and this might have affected attention span of the participants, although measures were taken to avoid distractions. (ii) We could not control the use of medications such as corticosteroids in our COPD group due to ethical reasons; this could also have influenced the reaction time.

The results of this study provided an insight into the changes in stepping reaction time, which is a part of functional balance. So, the assessment of a COPD patient for functional balance should also include the stepping reaction time. Further research is required considering leg dominance and lower limb strength in a larger sample size to find out the correlation between muscle strength and reaction time.

Conclusion

Participants with COPD exhibit a marked increase in stepping reaction time and a deficit in functional balance compared to the healthy participants. In addition, the stepping reaction time showed a moderate negative correlation with disease severity. Our findings indicate that the assessment of functional balance in COPD patients should also consider the stepping reaction time.

Table 2
Comparison of reaction time and functional balance among COPD participants and healthy individuals

Characteristics	COPD participants	Healthy participants	t-score/z score	p-value
Reaction time (ms) [Median (IQR)]	2200 (1830, 2400)	1830 (1540, 1960)	-3.502*	0.001
Timed up and go test (seconds) [Mean ± SD]	9.66 ± 1.83	7.23 ± 1.01	-6.55**	0.001

Abbreviations: COPD, Chronic Obstructive Pulmonary Disease.

* z-score.

** t-score.

Declaration of competing interest

None.

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