

## Correlation of Chester Step Test and Six Minute Walk Test in COPD Patients

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### Abstract

**Background:** A cross sectional study was done to use Chester step test, a graded submaximal test that mimics stair climbing, for assessing functional capacity in COPD patients.

**Purpose:** To correlate Chester step test (CST) and six minute walk test (6MWT) in COPD patients.

**Methods:** Sixty five COPD patients performed a 6MWT on a 30 m hallway and CST on a 15-20 cm high step, randomly on the same day after giving a rest interval between the tests. The distance walked and the number of steps performed, during the 6MWT and CST were recorded respectively. Data analysis was done using SPSS 16 software. Spearman correlation was used to correlate between six minute walk distance and number of steps.

**Conclusion:** The mean 6MWD was  $344.68 \text{ m} \pm 106.47 \text{ m}$  and the mean number of steps performed during CST was  $76.50 \pm 65.08$ . A significant positive linear correlation ( $\rho = 0.713$ ,  $p = 0.000$ ) between 6MWD and a number of Steps was seen, therefore number of steps in CST showed a strong correlation with the distance walked in the 6MWT in patients with COPD, which confirms the applicability of CST to assess the functional capacity of patients with COPD.

**Keywords:** Chronic obstructive pulmonary disease (COPD), Six minute walk test (6MWT), Six minute walk distance (6MWD), Chester step test (CST).

### Introduction

“Chronic obstructive pulmonary disease (COPD) is a common, preventable and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities, usually caused by significant exposure to noxious particles or gasses.” It is the fourth leading cause of death in the world currently. COPD is said to be considered in any patients having

dyspnoea, chronic cough or sputum production, history of recurrent lower respiratory tract infection and has a history of exposure to various risk factors for the disease<sup>(1,2)</sup>. Peripheral muscle dysfunction is considered one of the main systemic changes in COPD that contributes to the loss of exercise capacity, which in turn interferes with the activities of daily living (ADL) of the patients. 6MWT and the shuttle test are the commonly used tests to assess functional capacity in COPD patients, but these tests require a large space, making clinical practice difficult<sup>(3)</sup>.

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Chester step test (CST) was developed by Kevin Sykes et al.<sup>(4)</sup> in order to assess aerobic capacity of healthy individuals and hence prescribe physical activity<sup>(3,5)</sup>. It is a submaximal, multistage fitness test which measures heart rate (HR) and rate of perceived exertion (RPE) continuously during exercise<sup>(4)</sup>, while requiring the participants to step onto and off a low step at a rate set by metronome beat<sup>(6)</sup>. It is highly applicable to a wide variety of ages, conditions of people and their abilities and also highly adaptable. Being inexpensive, easy to standardize, portable, and safe it is therefore applicable for use by exercise and health professionals in different workplaces and community settings<sup>(4,5,7,8,9,10,11)</sup>. Patients with COPD find the task of going up and down the stairs difficult on account of breathlessness<sup>(12)</sup>.

Six minute walk test (6MWT) is the most common among the field walking test, originally developed to assess patients with pulmonary diseases<sup>(13)</sup>. It is a self-paced submaximal test employed to determine the functional capacity, intensity of the disease and its progression in COPD patients. It is well standardized by the American Thoracic Society (ATS) and the American Association for Respiratory Care. It is administered in the 30 m hallway, where the patients are instructed to cover the maximal distance in 6 min<sup>(14,15,16)</sup>.

## Material and Methods

This is a cross sectional study design in which sixty-five COPD patients coming to the Pulmonary Medicine OPD were included. The study was done as a postgraduate research thesis during a period of 6 Months (January 2021-June 2021). Figure 1 shows the Study Design Flowchart which includes Inclusion (clinically diagnosed COPD patients) and exclusion criteria (Difficulty in climbing stairs, Quadriceps muscle strength <4 as per MRC scale,

Acute exacerbation in last month, Resting RR>35, spo2 <90, Subjects with heart disease, Subjects with uncontrolled systemic diseases, Neurological deficit in lower extremity, Musculoskeletal pain >2 on NPRS, Subjects unwilling to participate.) Figure 2 shows the study material required. Demographic data (Age in years, Gender, Weight in kg, height in m, FEV1/FVC in percentage) of patients was recorded. Simple randomization by the chit picking method was done, where group A patients performed 6MWT first followed by rest and CST and vice versa for group B patients. Lower limb stretching exercises (figure 3) were given for 5-10 minutes as warm up and cool down before and after the tests, to prevent delayed onset muscle soreness<sup>(17,18,19)</sup>. Instructions for the tests were given to the patients and if they reported symptoms during the exercise tests, the tests would be terminated (figure 4)<sup>(16, 13, 20)</sup>. Demonstration of CST test was given, a trial was given for the patients to get accustomed to the test. After a rest interval of 15 minutes, final CST was performed (figure 5). CST is a 5 stage test, each of 2 minutes, which gives a total test time of 10 minutes. The step test is set with a metronome starting at 15 steps/min and increases by 5 steps/min every 2 min (each stage), till it reaches 35 steps/min at stage 5. The test will be performed on a 15-20cm bench or step. 8" (20cm) Step is generally suitable for those under 40 years of age who take little or no regular physical exercise and for those under-40's who are moderately overweight. 6" (15cm) Step is generally suitable for those over 40 years of age who take little or no regular physical exercise and for those under-40's who are moderately overweight. Heart rate, rate of perceived exertion was recorded after each stage for all patients<sup>(6)</sup>. 6MWT was performed according to American Thoracic Society (ATS) guidelines (figure 6)<sup>(14,16)</sup>. Adequate rest intervals were given between the two tests.

## Tables and Figures

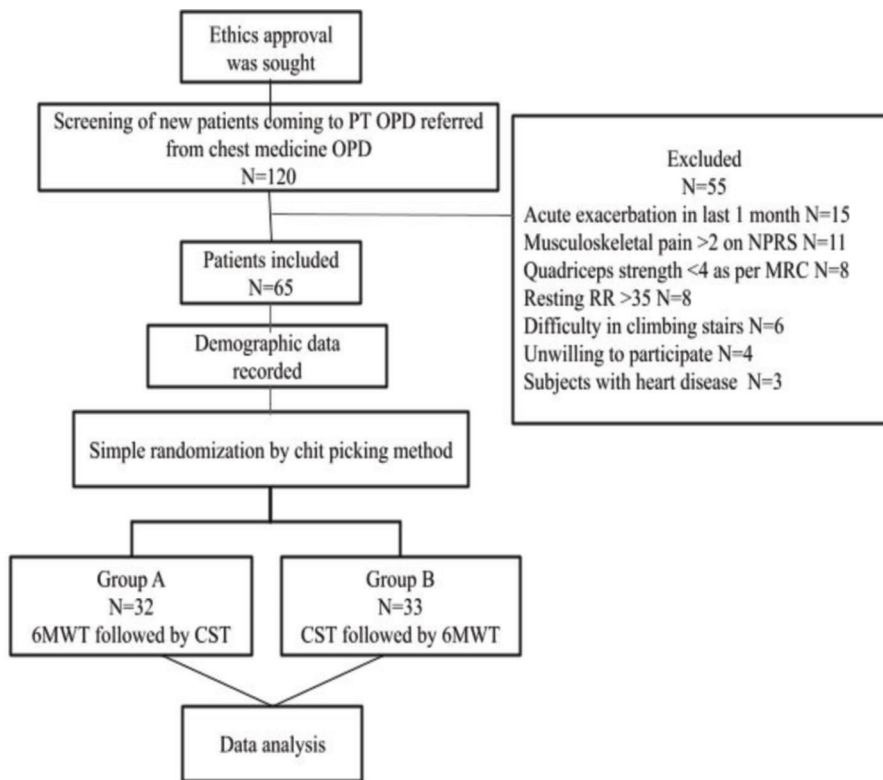


Figure 1: Study Design Flowchart



Figure 2: Study material



Figure 3: Lower limb stretching

Termination criteria for the tests:

- Perception of any limiting symptom (dizziness, strong dyspnoea, headache, chest pain, staggering, diaphoresis, and pale or ashen appearance.) by the participant.
- Pain and fatigue in lower limbs.
- The applicant reaches 80% of maximum heart rate at any point during the test.
- O<sub>2</sub> saturation in blood <88%
- Rate of perceived exertion (RPE) >7.
- Unable to maintain metronome set pace.
- Applicant reports needing to stop.

Figure 4



Figure 5: Performance of CST

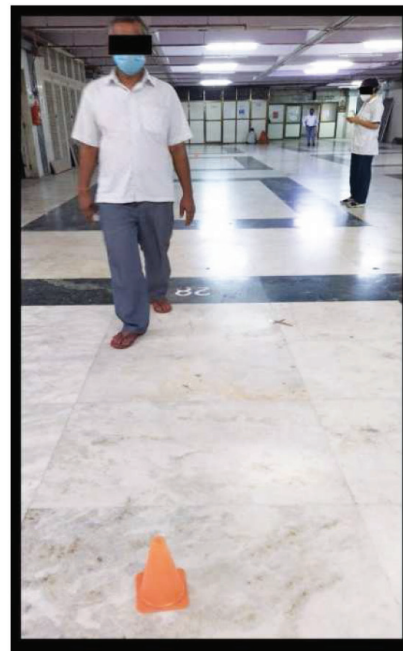
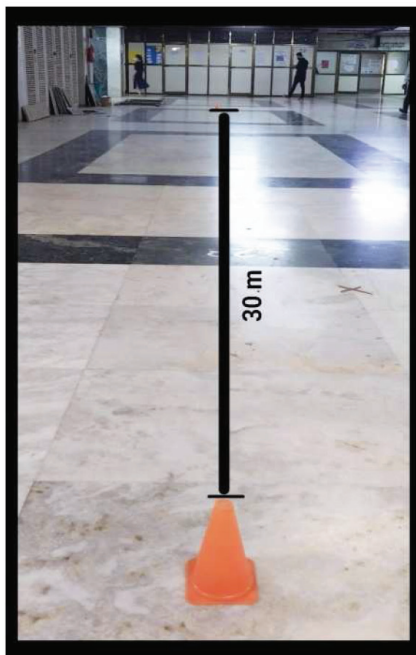


Figure 6: Performance of 6MWT

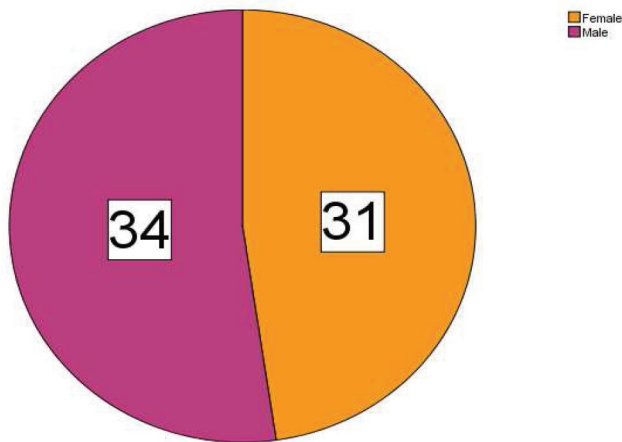


Figure 7: Gender distribution

The above graph is a pie chart which shows there were 31 female (47.7%) and 34 male (52.3%) subjects in the study.

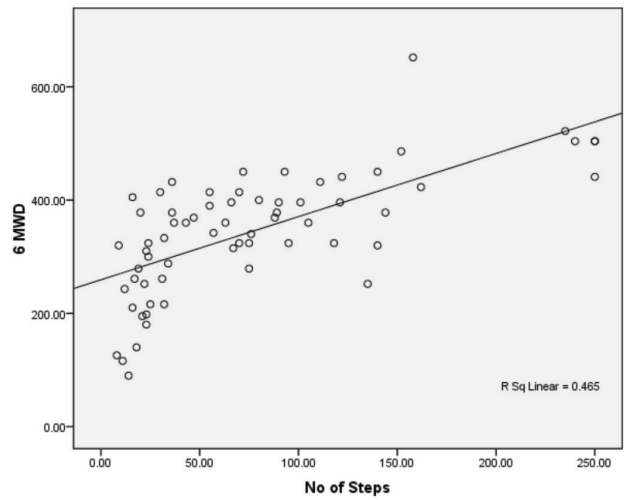


Figure 8: Correlation of 6 MWD and number of Steps during CST

The above graph is a scatterplot which shows a positive linear relation between 6 MWD and number of steps performed during CST. ( $\rho = .713, p = 0.000$ )

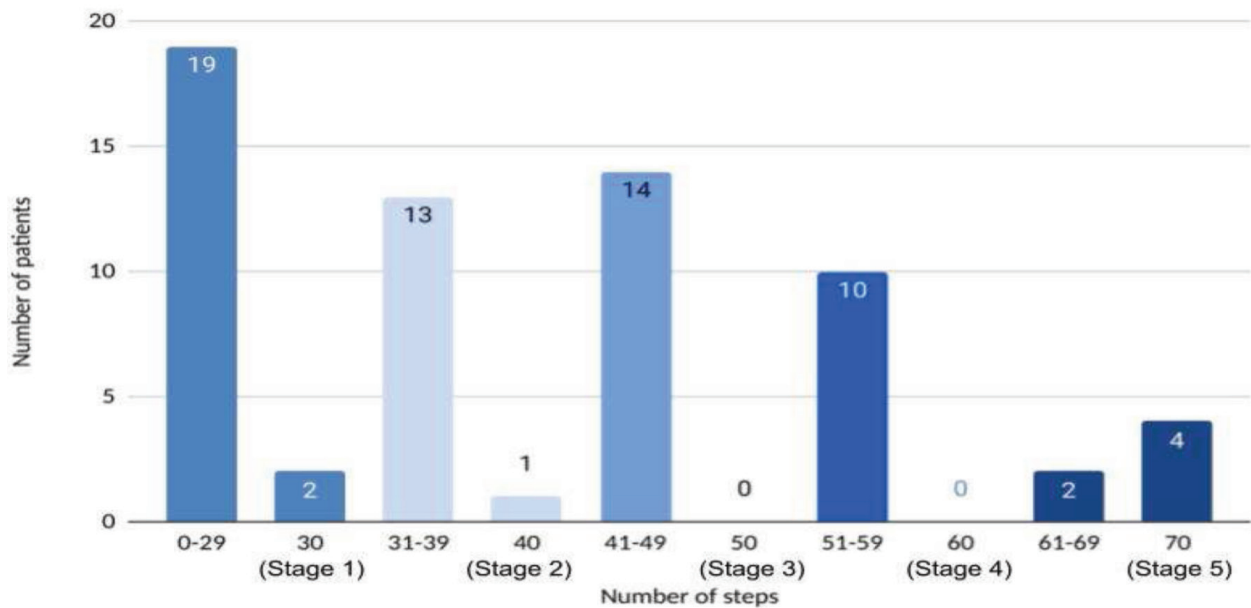


Figure 9: Distribution of number of patients in each stage of CST

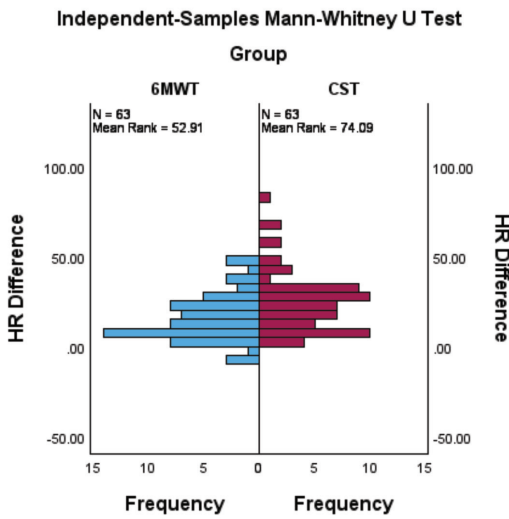


Figure 10: HR difference between groups

There was a significant increase in HR post CST as compared to 6MWT ( $p = 0.001$ )

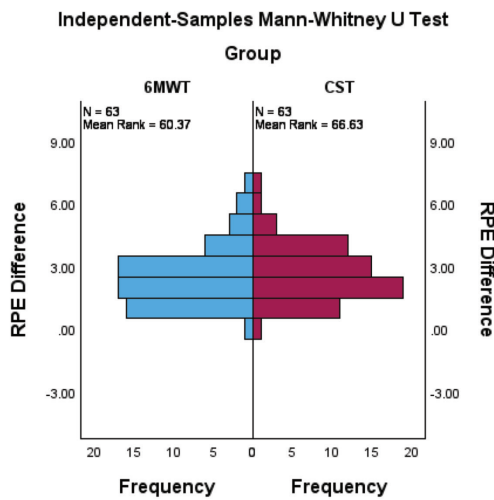


Figure 11: RPE difference between groups

Table 2. Descriptive Statistics of Age, BMI, 6 MWD, Number of Steps

	N	Mean	Std. Deviation	Std. Error Mean	95% Confidence interval
Age	65	50.9231	$\pm 12.42768$	1.54146	47.84 - 54.00
BMI	65	23.8000	$\pm 5.16460$	.64059	22.52 - 25.07
6 MWD	65	344.68	$\pm 106.47918$	13.20712	318.29 - 371.06
No of Steps	65	76.5077	$\pm 65.08987$	8.07340	60.37 - 92.63

There was no significant difference in rate of perceived exertion between both 6MWT and CST.

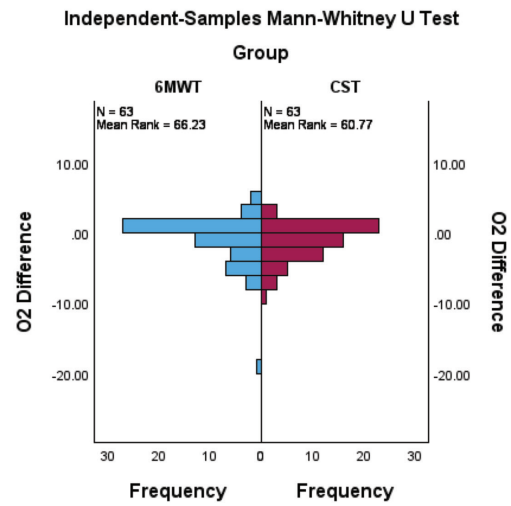


Figure 12: O2 saturation difference between groups

There was no significant difference in O2 saturation between both groups.

Table 1. Descriptive Statistics of gender

	Frequency	Percent
Male	34	52.3
Female	31	47.7
Total	65	100.0

The above table shows that mean age of subjects was 50.92 years  $\pm$  12.42 years, mean BMI was 23.8

kg/m<sup>2</sup>  $\pm$  5.16 kg/m<sup>2</sup>, mean 6 MWD was 344.68 meters  $\pm$  106.47 meters and mean number of steps performed during Chester Step Test was 76.50  $\pm$  65.08.

**Table 3. Descriptive Statistics of HR**

	Mean	Std. Deviation	Std. Error Mean	95% Confidence interval
HR pre	89.3333	$\pm$ 14.71120	1.85344	85.62- 93.03
HR peak 6MWT	106.1111	$\pm$ 21.92812	2.76268	100.58- 111.63
HR peak CST	115.2698	$\pm$ 20.94171	2.63841	109.99- 120.54

The above table shows that mean HR pre tests of subjects was 89.33 bpm  $\pm$  14.71 bpm, mean HR peak during 6MWT was 106.11 bpm  $\pm$  21.92 bpm, mean HR peak during CST was 115.26 bpm  $\pm$  20.94 bpm

significant difference in O<sub>2</sub> saturation between both groups (figure 12), In both groups, there was an equal drop in oxygen saturation which returned to baseline during recovery period.<sup>(24)</sup>

### Results

The data was analyzed using SPSS 16 software. Data was tested for Normality using the Shapiro Wilk Test. Spearman correlation was used to correlate between 6MWD and number of steps. There were 31 female and 34 male COPD patients (figure 7). Mean age of the subjects was 50.92 years  $\pm$  12.42 years, and mean BMI of subjects was 23.80 kg/m<sup>2</sup>  $\pm$  5.16 kg/m<sup>2</sup>. The mean 6MWD walked was 344.68 m  $\pm$  106.47 m and the mean number of steps performed during the CST was 76.50  $\pm$  65.08 (Table 2). A strong significant positive linear correlation ( $\rho=0.713$ ,  $p=0.000$ ) between 6MWD and number of steps during CST was seen (figure 8). The mean HR pre tests of subjects was 89.33 bpm  $\pm$  14.71 bpm, mean HR peak during 6MWT was 106.11 bpm  $\pm$  21.92 bpm, mean HR peak during CST was 115.26 bpm  $\pm$  20.94 bpm (Table 3). There was a significant increase in HR post CST as compared to 6MWT ( $p=0.001$ ). Heart rate response is directly related to intensity of exercise<sup>(24)</sup> Stepping up and down involves lifting the body up against gravity and lowering it and hence it is an exercise of higher intensity or MET value as compared to level walking (figure 10).<sup>(25)</sup> There was no significant difference in rate of perceived exertion between both tests (figure 11), as in CST, as most of the patients could only complete stage 1 of CST (figure 9) which is a slow paced stage of 15 steps/min.<sup>(28)</sup> There was no

### Discussion

Similar findings were seen in studies done by De Camargo AA et al. (2011)<sup>(12)</sup> and by Karloh M et al. (2013)<sup>(3)</sup> De Camargo et al studied the reliability of CST in patients with COPD and correlated it with pulmonary function test. They found a significant correlation between the number of steps in CST and 6MWD in COPD patients ( $r= 0.60$ ,  $p=0.001$ )<sup>(12)</sup>. Karloh M et al compared the CST with other tests of functional capacity like 6MWT and 6 minute Shuttle Walk Test in COPD patients and compared the cardiorespiratory responses with healthy individuals. They found a positive correlation between CST and Shuttle walk test ( $r=0.67$ ,  $p<0.05$ ) as well as 6MWT ( $r=0.83$ ,  $p<0.05$ )<sup>(3)</sup>. Hence, CST can be used as a test for functional capacity in patients with COPD.

Sunil Kumar et al (2020)<sup>(21)</sup> compared the effect of ground walking versus stair climbing on exercise capacity in patients with moderate COPD. They found that stair climbing showed a better improvement in exercise tolerance, 6MWD and reduction in the amount of resting intervals during 6MWT as compared to ground walking, because of the improvement in peripheral muscle strength<sup>(21,22)</sup> Step training has been used as part of aerobic training in pulmonary rehabilitation programs, but the protocols for training are not standardized. Usually, aerobic training is based on a percentage of

the maximum load reached in a maximum test. Thus, the step training should be done in the same way. In this context, we have suggested that, first, the subject undergo CST to establish the peak workload, which is represented by the total number of steps, and then a percentage of it that is around 60-80% would be performed during the training session<sup>(28)</sup> and there should be a gradual increase in the workload by 10% each week as per the guidelines suggested by ACSM.<sup>(13)</sup> Study conducted by Grove T. (2020)<sup>(11)</sup> reviewed the practical applications of the CST in the context of its validity, reliability and predictability in measuring cardiorespiratory fitness, where he found that the CST can provide valuable information on the patient's exercise tolerance to specific levels of sub-maximal stress, risk stratification, and physical activity/exercise prescription by giving example of a case study.<sup>(30)</sup> Hence CST can be used not only as a test for functional capacity for COPD patients but also as an exercise prescription.<sup>(10)</sup>

CST is a graded step test, where after every stage the speed of stepping up and down is increased and hence a better VO<sub>2</sub> is achieved as compared to 6MWT. Its advantage is that it may be used to assess functional capacity when long hallways are unavailable; requiring less infrastructure, a stepper which is one of the primary requirements in a densely populated urban city in India; and is also comparatively cheaper. The number of steps was used as an outcome measure for CST due to the wide variation between subjects at each stage of CST (figure 9). During CST, patients were able to manage performing the test initially, that is at the rate of 15 steps per minute but with increase in the stepping rate by 5 steps per minute after each stage, they were unable to match the pace that caused anxiety and hyperventilation in them as they are intolerant to exercise due to peripheral muscle dysfunction, and ventilatory limitations that led to early termination of the test (figure 4), this is supported by the study done by Carlos et. al (2012)<sup>(28)</sup> where they compared the exercise tolerance time, cardiopulmonary stress, and perception of effort between CST and a modified incremental step test (MIST) and found that a slower and progressive increment in work rate during step test is better tolerated by subjects with COPD.<sup>(28)</sup>

6MWT is the gold standard tool for assessing functional capacity (6MWD) and CST has a strong correlation with 6MWD, hence CST can also be used as a clinical tool for assessing functional capacity.

According to a review article "Home-based and remote exercise testing in chronic respiratory disease, during the COVID-19 pandemic and beyond: a rapid review" by Holland AE et al (2020), pulmonary rehabilitation clinicians can confidently perform STS, step and TUG tests at home in people with chronic lung disease, where in-person supervision is possible<sup>(23)</sup>. Another study done by A. Alves et al. (2022)<sup>(27)</sup> stated that step tests emerged as a reliable and validated measure during the COVID-19 pandemic, when the need to transfer patients to rehabilitation facilities or discharge them to home increased exponentially and so did the demand for home-based and/or remote rehabilitation.<sup>(27)</sup> Therefore in a pandemic situation, where telerehabilitation has gained popularity, CST can be used as an exercise test which can be performed indoors under supervision of a caregiver.

## Conclusion

The number of steps in CST showed a strong correlation with the distance walked in the 6MWT in patients with COPD, which confirms the applicability of CST to assess the functional capacity of patients with COPD.

## Future Recommendations

Whenever the space is compromised CST can be an alternative clinical tool for assessing functional capacity since a step or a stool is easily available as compared to a long corridor in a densely populated urban city in India. In a pandemic situation, where telerehabilitation has gained popularity, CST can be used as an exercise test which can be performed indoors under supervision of a caregiver. Future research should be done to explore CST practicality and reliability in different environments and prepare guidelines for exercise prescription.

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**Ethical Clearance:** The study has been approved by the Ethics Committee for Academic Research Projects (ECARP), TN Medical College & BYL Nair Ch Hospital, Mumbai, Maharashtra, India. (Date 13/02/2020, Project no. ECARP/2019/155)

**Conflicts of interest statement:** There are no conflicts of interest

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