Background: Assessment of functional status is vital for proper therapy and rehabilitation programs in chronic obstructive pulmonary disease (COPD) patients. Traditionally, 6 min walk test (6MWT) has been used but it by itself may not reflect the total functional status in these patients as it poorly correlates to the disease severity. A sit-to-stand test (STST) has been proposed as a better alternative to 6MWT but to test their ability to stand from the squatting position, i.e., a squat-to-stand test (SqTST) will be more appropriate in rural patients. Material and Methods: All patients, diagnosed to have stable COPD, after exclusion of asthma and other respiratory or nonrespiratory diseases were evaluated by applying 6MWT, STST, and SqTST in them. Data so obtained were statistically analyzed. Results: Ninety patients and twenty healthy controls were studied. Sixteen, 24, 23, and 27 of the patients were classed as COPD risk category A, B, C, and D, respectively. The mean post bronchodilator forced expiratory volume in 1st second (PB FEV1) and body mass index (BMI) were significantly lower in category D as compared to the rest. The cutoff values for 6MWT, STST, and SqTST were derived as 184M, 11, and 07, respectively. 6MWT correlates poorly to disease severity (P = 0.109) but there was a strong correlation between disease severity and SqTST and STST (P = 0.000). Conclusion: SqTST is a feasible and effective tool to assess functional status of COPD patients residing in rural areas. BMI is an important surrogate marker of the functional status in these patients. KEY WORDS: 6 min walk test, chronic obstructive pulmonary disease, sit-to-stand test, squat-to-stand test

INTRODUCTION

Traditionally, post bronchodilator forced expiratory volume in 1st second (PB FEV1) is used to assess the severity of chronic obstructive pulmonary disease (COPD). However, it has now been shown that functional exercise capacity is a strong predictor of survival following pulmonary rehabilitation and so assessment of functional status is very important for proper prescription of medical therapy and rehabilitation programs.[1] Van Stel et al.[2] suggested that 6 min walk test (6MWT) was an easy to perform procedure and was able to predict functional status in all patients with chronic respiratory disease; however, Pinto-Plata et al.[3] argued that walking by itself might not reflect the true functional status in these patients as a person has to do several other activities in addition to walking. A sit-to-stand test (STST)[4] was proposed as a better alternative to 6MWT but it lacks universal application, more specifically in countries like India where people resort to squat (sit on the floor) rather than sitting on chair. A more practical approach for them will be to assess the functional ability to stand from the squatting position, i.e., squat-to-stand test (SqTST). Therefore, a study was undertaken to compare SqTST with PB FEV1, 6MWT, and STST and to assess whether it is a feasible and effective tool in evaluating the functional status of the COPD patients.
MATERIALS AND METHODS

All patients attending the Outpatient Department of Respiratory Medicine, National Institute of Medical Sciences, Jaipur, with clinical history, consistent with COPD, were recruited. Twenty age- and sex-matched, healthy and nonsmoking attendants/hospital staff were also recruited to serve as controls. The Institutional Ethics Committee approved the study. Written informed consent was also taken from all the patients and controls after duly explaining the study protocol.

All the recruited patients were evaluated in detail, including present and past clinical history, physical examination, complete blood counts, random blood sugar, renal and liver function tests, two sputum smears for acid-fast bacillus using Ziehl–Neelsen staining, skigram chest posteroanterior view, and a standard electrocardiogram. Pulse oximeter was used to record oxygen saturation. Patients showing obvious pulmonary or other system abnormalities such as active pulmonary tuberculosis, malignancy, diabetes mellitus, coronary artery disease, stroke, and renal or hepatic disease were excluded. The remaining patients were subjected to spirometry including the reversibility test as per the American Thoracic Society guidelines\(^9\) using an RMS HELIOS spirometer. Three attempts were made, and the best was selected and recorded to obtain the cases of forced vital capacity (FVC), FEV\(_1\), and FEV\(_1\)/FVC ratio. A repeat spirometry was performed 20 min after inhaling 200 µg of salbutamol to obtain PB FVC, FEV\(_1\), and FEV\(_1\)/FVC ratio.

All patients with FEV\(_1\)/FVC ratio <70% and fixed airway obstruction on spirometry (PB improvement in FEV\(_1\) of <200 ml or in FEV\(_1\)/FVC of <12%) were included in the study, but patients with history of wheeze, chest tightness, eye allergy, nasal allergy, or skin allergy, suggesting bronchial asthma, those suffering from osteoarthritis and oxygen saturation <90%, were also excluded from the study. The body mass index (BMI) of the study patients was calculated as body weight in kg/height in meters square and was classified as follows: Underweight - <18.5 kg/m\(^2\), normal - 18.5–25.0 kg/m\(^2\) or overweight - >25 Kg/m\(^2\) as per the World Health Organization criteria.\(^6\)

Pack years of smoking was calculated as: number of bidi packs smoked/day \(\times\) number of years smoked (where a bidi pack was calculated as number of bidies/20).\(^7\)

The study patients were further subjected to combined risk assessment, which included the Modified British Medical Research Council Questionnaire, history of exacerbations in the past 2 years, and history of exacerbations needing hospitalization in the past 2 years and categorized as risk category A, B, C, or D as per GOLD guidelines.\(^8\) All the patients and controls were then subjected to 6MWT\(^7\), STST\(^4\), and SqTST\(^4\) (a modified form of STST, used for the first time for rural patients) as follows:

The participants were instructed by the command “start” for them to stand from their squatting position and they then asked to go to their squatting position without any delay, repeating these steps as many times as possible in 1 min at a self-selected speed which was felt safe and comfortable by them or until asked to stop. In case a patient was unable to stand unaided, support of a wide block of one feet height was allowed. Oxygen saturation was recorded at the end of the test. The patient’s functional status was recorded as (a) unable to stand even with support, (b) able to stand with support only, and (c) number of times he was able to stand in 1 min without support.

Since normal ranges of 6MWT in meters (M), STST, and SqTST are not available for universal use, the mean of the respective parameters minus twice the standard deviation in normal controls was used as cutoff for normal values for these parameters.

Data so obtained were tabulated and assessed for statistical significance using Student’s t-test, ANOVA test/test, and Fisher’s exact test, as and when applicable. \(P < 0.05\) was considered statistically significant.

RESULTS

Ninety stable COPD patients and twenty controls could be studied, between July 2014 and January 2016. The basic parameters of the study patients and the controls are shown in Table 1. The mean age of the patients in the four categories was similar to that of the controls (\(P = 0.0059\)). The mean age was higher in category B patients, but the differences from other categories were statistically insignificant (\(P = 0.058\)). Males outnumbered the females in all the risk categories but the sex-wise distribution was also fair (\(P = 1.000\)). The duration of illness was higher in category A patients as compared to the rest, but the differences from other categories were statistically insignificant (\(P = 0.823\)). All the patients of the study were bidi smokers. Sixty-eight patients were current smokers and the rest 22 were reformed or ex-smokers. There were no differences in the COPD categories with regard to the smoking status (\(P = 0.913\)), but the mean pack years of smoking was lower in category A patients as compared to the rest (\(P = 0.914\)). The mean BMI and PB FEV\(_1\)% were significantly lower in category D patients as compared to the rest (\(P = 0.000\)).

The mean of 6MWT, STST, and SqTST in controls were 244 + 30.15M, 27.05 + 7.89, and 17.8 + 5.38, respectively, so the respective cutoff values were derived as 184 M, 11, and 07. The mean distance walked by category D patients was lower as compared to the rest (\(P = 1.47\), \(P = 0.109\)), but the difference was statistically insignificant. On the contrary, the STST and SqTST values were significantly lower in category D patients as compared to the rest (\(P = 0.000\)). Eight patients desaturated (\(\text{SaO}_2 <90\%\)) at the end of SqTST in Group D as compared to 3 and 2
in Group C and B, respectively, but all recovered of their own in due course. None of the patients in Group A or the controls desaturated. Table 2 shows the correlation of SQST values with other parameters. It significantly correlated to BMI, STST and to some extent with 6MWT.

**DISCUSSION**

The study of functional status is very vital in assessment of severity of COPD as it has been shown to be a strong predictor of survival following pulmonary rehabilitation. 6MWT and more recently STST have been used in functional assessment of COPD, but for rural population, squatting is also an important routine activity. This study was, therefore, undertaken to assess the feasibility and efficacy of SqTST in evaluation of the functional status of COPD patients residing in rural areas. Data of this study were found to be valid for statistical comparisons as the controls in the study were age and sex matched, and the distribution of the patients in various risk categories of COPD was fair.

The mean age of the patients, sex, duration of illness, smoking status, and pack years of smoking did not correlate to severity of COPD in this study ($P > 0.5$). Uppal et al.\(^1\) have observed similarly but Kobayashi et al.\(^1\) have reported more dyspnea, lower exercise tolerance, and higher incidence of severe exacerbations in the elderly ($P < 0.05$). Shavro et al.\(^1\) stated that duration of illness influenced the functional status in COPD patients. Movahed and Milne\(^1\) could observe a direct correlation between amount of expectoration/cough and the duration or amount of smoking. Some of these observations, made at variance from the current study, can be explained on the basis of differences in the disease progression in COPD in individual patients of different studies.\(^2\) It has been observed that smoking patterns of the cases, such as depth of smoking and the holding time, may play a more crucial role in pathogenesis of COPD than the duration or pack years of smoking.

The mean BMI was significantly lower in COPD patients as compared to the controls. Further, it was significantly lower in category D patients as compared to the rest of the risk categories in this study ($P = 0.003$). Similar observations have been made by Yang et al.\(^3\) Gupta et al.\(^4\) and Feroz et al.\(^5\) Harik-Khan et al.\(^6\) reasoned that the nutritional abnormality and weight loss in COPD are caused due to decreased caloric intake and increased basal metabolic rate. Agarwal et al.\(^6\) stated that COPD produced malnutrition due to loss of fat as well as fat-free components.

The mean distance covered in 6 min (6MWT) was significantly lower in COPD patients as compared to controls ($P = 0.003$). Further, it progressively declined with progression of the severity of the disease, but at the cutoff distance of 184 meters, there was a significant

### Table 1: Basic parameters of the patients and controls

| Parameter | A (n=16) | B (n=24) | C (n=23) | D (n=27) | E (n=20) | $P$ |
|-----------|----------|----------|----------|----------|----------|-----|
| Mean age in years | 58.88±4.99 | 64.23±9.84 | 60.16±9.50 | 61.04±7.45 | 60.15±7.99 | 0.059 |
| Sex | | | | | | |
| Male | 14 | 21 | 20 | 24 | 17 | 0.999 |
| Female | 2 | 3 | 3 | 3 | 3 | |
| Mean duration in years | 3.27±1.53 | 2.87±1.36 | 2.93±1.13 | 3.01±1.29 | - | 0.823 |
| Smoking status | | | | | | |
| Current | 13 | 17 | 18 | 20 | - | 0.913 |
| Ex/reform | 3 | 7 | 5 | 7 | | |
| Mean pack year | 13.16±6.67 | 15.22±11.64 | 15.36±8.67 | 15.64±11.22 | - | 0.914 |
| Mean BMI (kg/m$^2$) | 23.17±3.25 | 23.44±2.19 | 19.98±3.23 | 18.79±2.13 | 25.20±3.37 | 0.000 |
| 6MWT (m) | | | | | | |
| Normal (>184) | 12 | 16 | 12 | 11 | - | 0.109 |
| Abnormal (<184) | 4 | 8 | 11 | 16 | | |
| Mean distance walked (m) | 224.61±68.14 | 202.38±48.57 | 192.38±54.21 | 142.60±41.93 | 244±30.15 | 0.003 |
| STST | | | | | | |
| Normal (>11) | 16 | 5 | 3 | 0 | - | 0.000 |
| Abnormal (<11) | 0 | 19 | 20 | 27 | | |
| Mean SqTST* | 7.38±0.48 | 5.71±1.64 | 5.85±1.98 | 2.36±2.34 | 17.8±5.38 | 0.000 |
| SqTST | | | | | | |
| Normal (>7) | 16 | 3 | 1 | 0 | - | 0.000 |
| Abnormal (<7>1) | 0 | 21 | 21 | 16 | | |
| With support only | 0 | 0 | 1 | 11 | | |
| Mean SaO$_2$ at the end of SqTST | 94.08±2.34 | 92.08±3.23 | 92.48±2.84 | 89.40±4.34 | 96.20±1.45 | 0.47 |

*With support was considered as zero for the purpose of calculating the mean of SqTST. SqTST: Squat-to-stand test, STST: Sit-to-stand test, 6MWT: 6 min walk test, FEV$_1$: Forced expiratory volume 1 s, BMI: Body mass index
Table 2: Correlation of squat-to-stand test with various parameters

| Parameter                  | Normal (n=20) | Abnormal (n=58) | With support (n=12) | P     |
|----------------------------|---------------|-----------------|---------------------|-------|
| Age in years               |               |                 |                     |       |
| <60                        | 10            | 31              | 3                   | 0.198 |
| >60                        | 10            | 27              | 9                   |       |
| Sex                        |               |                 |                     |       |
| Female                     | 5             | 6               | 0                   | 0.119 |
| Male                       | 15            | 52              | 12                  |       |
| Duration (years)           |               |                 |                     | 0.245 |
| <3                         | 14            | 28              | 6                   |       |
| >3                         | 6             | 30              | 6                   |       |
| BMI (kg/m²)                |               |                 |                     |       |
| <18.5                      | 4             | 11              | 10                  | 0.000 |
| >18.5-<25                  | 10            | 41              | 2                   |       |
| >25                        | 6             | 6               | 0                   |       |
| Smoking status             |               |                 |                     |       |
| Current                    | 13            | 48              | 7                   | 0.088 |
| Ex/reform                  | 7             | 10              | 5                   |       |
| Pack years                 |               |                 |                     |       |
| ≤10                        | 8             | 22              | 3                   | 0.299 |
| >10-<20                    | 8             | 25              | 3                   |       |
| >20                        | 4             | 11              | 6                   |       |
| FEV₃ (%)                   |               |                 |                     |       |
| >50                        | 7             | 17              | 0                   | 0.091 |
| >30-<50                    | 8             | 26              | 5                   |       |
| <30                        | 5             | 15              | 7                   |       |
| 6MWT (m)                   |               |                 |                     |       |
| Normal (>184)              | 15            | 34              | 2                   | 0.004 |
| Abnormal (<184)            | 5             | 24              | 10                  |       |
| STST                       |               |                 |                     |       |
| Normal (>11)               | 20            | 4               | 0                   | 0.000 |
| Abnormal (<11)             | 0             | 54              | 12                  |       |

SqTST: Squat-to-stand test, BMI: Body mass index, STST: Sit-to-stand test, 6MWT: 6 min walk test, FEV₁: Forced expiratory volume 1 s

There is an overlap in different categories and the correlation was rather poor (P = 0.109). This shows that 6MWT has poor correlation to disease severity. Similar observations have been made earlier by Pinto-Plata et al. also.[3]

Ozalevi et al.[4] suggested STST as a superior alternative to 6MWT, the former being less stressful, easier to apply, and more sensitive for the patient's clinical status, compared to the latter. In the present study, STST significantly correlated to the disease severity (P = 0.000). Further, at a cutoff of 11, all patients in category A were classed as normal and all patients in category D as abnormal. Thus, STST was found to be superior to 6MWT in the present study also.

In this study, the cutoff of SqTST for normal controls was derived at seven. At this cutoff, none of the category A patients had abnormal SqTST and none in category D was classed as normal. Further, the mean SqTST value was highest in category A and lowest in category D as compared to rest (P ≤ 0.000). Thus, a strong correlation was observed between SqTST and disease severity (P = 0.000). Further, a strong correlation was also observed between SqTST and STST (P = 0.000), but its correlation with 6MWT was moderate (P = 0.004) and to that with FEV₃, was poor (P = 0.091). SqTST in this study strongly correlated to BMI as well. Thus, BMI emerged as a strong surrogate marker of functional status in COPD.

The major limitations of the study are the small number of patients and exclusion of patients with evident hypoxia due to fear of further drop in oxygen saturation. In spite of these limitations, SqTST was found to be an easy, feasible, and effective tool to study the functional status in stable, rural COPD patients, as the test is very close to their routine daily activities. Whether the findings of this study are applicable to other population groups who routinely resort to squat or not needs to be studied further.

CONCLUSION

SqTST is an easy, feasible, and effective tool to study the functional status in stable COPD patients of rural India as it is physiologically more close to their routine daily activities. STST was found to be equally effective in them. Further, BMI of the patients was observed to be an important surrogate marker of the functional status in these patients.

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Conflicts of interest
There are no conflicts of interest.

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