Section: Pulmonary Medicine

Original Research Article

SPIROMETRIC INDICES AND SQUAT-TO-STAND TEST: A COMPARISON STUDY AMONG STABLE COPD PATIENTS

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Received : 18/03/2026
Received in revised form : 29/04/2026
Accepted : 14/05/2026

Keywords:
Chronic Obstructive Pulmonary Disease (COPD), Spirometry, Squat-to-Stand Test (SqTST), Functional assessment, FEV_1 (Forced Expiratory Volume in 1 second), FVC (Forced Vital Capacity), Global initiative for chronic obstructive lung disease (GOLD).

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DOI: 10.47009/jamp.2026.8.3.242

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (3); 1366-1371

ABSTRACT

Background: Chronic Obstructive Pulmonary Disease (COPD) is characterized by persistent airflow limitation and progressive functional impairment. While spirometry is the gold standard for assessment, simple functional tests are valuable, especially in resource-limited settings. The Squat-to-Stand Test (SqTST) may offer a culturally relevant alternative. This study evaluated its correlation with spirometric indices in stable COPD patients. **Aim:** To compare the Squat-to-Stand Test with spirometric indices in patients with stable COPD and to evaluate whether the Squat-to-Stand Test can serve as an effective alternative to spirometry for assessing the severity of COPD. **Materials and Methods:** This prospective observational study included 80 stable COPD patients (40–80 years) diagnosed as per GOLD criteria at a tertiary care center from June to December 2024. Detailed clinical evaluation and anthropometric measurements were recorded. Spirometry (pre- and post-bronchodilator) assessed FEV1, FVC, and FEV1/FVC ratio. SqTST performance was measured as the number of repetitions completed in one minute. Statistical analysis included descriptive measures, ROC Curve analysis and Pearson's correlation. **Results:** Most patients had severe (48.75%) or moderate (40%) COPD. Mean SqTST repetitions were 12.8 ± 3.16, with a cut-off value of < 12.5 in ROC analysis, showing sensitivity of 82.93%, specificity of 84.62%, diagnostic accuracy of 83.75%, with a positive predictive value of 85% and a negative predictive value of 82.5% for in distinguishing severe COPD from mild to moderate disease. SqTST demonstrated strong positive correlation with pre- and post-bronchodilator FEV1 in liter ($r = 0.807$ and 0.821, respectively; $p < 0.001$), pre and post FEV1 % predicted ($r = 0.761$ and $r = 0.779$ respectively, $p < 0.001$), and significant correlations with FVC and FEV_1/FVC ratio ($p < 0.001$). **Conclusion:** SqTST correlates strongly with spirometric indices and can serve as a simple, cost-effective functional assessment tool in stable COPD, particularly in settings where spirometry is unavailable.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a heterogeneous lung condition characterized by persistent respiratory symptoms and chronic airflow limitation resulting from abnormalities of the airways and/or alveoli, typically caused by long-term exposure to harmful particles or gases.[1] COPD is a leading cause of morbidity and mortality worldwide.[2,3] It is the fourth leading cause of death globally.[4] In India, COPD contributes to approximately 500,000 deaths annually, posing a significant public health burden, and is the second common cause of deaths due to NCD.[5,6]

Spirometry remains the most reproducible and objective method for measuring airflow limitation and is the standard tool for diagnosis and classification of disease severity in COPD.[1] However, recent evidence highlights that functional exercise capacity is a strong predictor of survival, particularly following pulmonary rehabilitation. Therefore, assessment of functional status has become essential for guiding treatment and rehabilitation strategies.[7]

The Six-Minute Walk Test (6MWT) is widely used to evaluate functional capacity in COPD patients, as it is simple, well tolerated, and reflects activities of daily living better than other walk tests.8 However, walking alone may not adequately represent the full

ISSN (O): 2687-5365; ISSN (P): 2753-6556

spectrum of functional ability, as daily activities often involve multiple movements beyond ambulation.[9]

In countries like India, where squatting is a common posture for daily activities such as sitting and toileting, assessing the ability to rise from a squatting position may provide a more culturally relevant and functional measure of physical capacity. The Squat-to-Stand Test (SqTST), first described by Gupta PR et al. in 2017, evaluates this functional movement and may serve as a practical alternative in rural and resource-limited settings.[10]

This study aims to compare the Squat-to-Stand Test with spirometric indices in patients with COPD, to evaluate its potential as a functional assessment tool.

MATERIALS AND METHODS

This was an observational prospective study conducted at the Out Patient Department of Pulmonary Medicine at Al Azhar Medical College, Thodupuzha. The study period was between 1st June 2024 to 31th December 2024. All consecutive registered old and new patients of COPD diagnosed as per GOLD guidelines who met our inclusion and exclusion criteria was taken up as study group.1

Inclusion Criteria

- Mild to Severe COPD patients as per GOLD criteria.
- Baseline SpO2 ≥ 90%.
- Age 40-80 years.
- No acute exacerbation for the past 6 weeks.

Exclusion Criteria

- Patients with history or clinical evidence of lung disease other than COPD.
- Patients with resting heart rate >120 beats per minute, systolic blood pressure of >180 mmHg and/ or diastolic blood pressure >100 mmHg.
- Patients with pulmonary hypertension, obstructive sleep apnoea, central sleep apnoea.
- Patients with cardiovascular disease, renal disease, unstable angina , or myocardial infarction during previous 1 month
- Patients having co-morbid neuromuscular, musculoskeletal, vascular diseases, or cardiovascular diseases which limit their ability to perform SqTST
- Patients who deny informed consent.

Data Collection Technique and Tools

Clinical history, risk factors, detailed physical examination findings were collected in a proforma for all patients. Basic blood investigations - CBC, Blood sugar, RFT & Plain chest radiograph was done. Electrocardiogram, echocardiography was also performed whenever relevant. Patients satisfying inclusion criteria and not excluded by exclusion criteria were enrolled for the study. Patients age, sex, height, weight and BMI were noted. Spirometry was performed in these patients before and after giving short acting bronchodilator (200-400 µg of salbutamol) and spirometric parameters - Pre FVC, Pre FEV1, Pre FEV1/FVC ratio, post FVC, post FEV1, post FEV1/FVC ratio were noted and they were categorized as per GOLD guidelines.[1]

Squat to stand test (SqTST)

Squat to stand test (SqTST) was done in all patients. 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. 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. Heart rate, blood pressure and saturation before and after test were also measured.[10]

Statistical methods

Descriptive and inferential statistical analysis has been carried out in the present study. Data were statistically described in terms of mean standard deviation (SD), and range, or frequencies (number of cases) and percentages when appropriate using Microsoft Excel and IBM SPSS V 30.0 software. The data was reported as mean ± standard deviation. Correlation was evaluated by Pearson's correlation coefficient. Cut off value for SqTST was found using ROC curve analysis.

Consent and ethical consideraton

The study was carried out after obtaining approval from the Institutional Human Ethics Committee. An informed, written consent was obtained from all the patients. Patients who had given written consent was enrolled in study. All patients had given freedom of opting out of study at any point of time during study.

Confidentiality of data

Confidentiality was ensured and maintained throughout the study. Study result was only be used for scientific purposes and publications. All information about patient's illness and results of the tests was kept confidential and retained in the institute as required under rules. Results may be presented at conferences and published without any disclosure of patient identity directly or indirectly.

RESULTS

Total of 80 COPD patients who satisfied the inclusion and exclusion criteria was enrolled in the study between June 1, 2024 to December 31, 2024. The study population age ranged between 42 – 75 years. Out of the 80 cases, males 64 (80%) were more than females 16 (20%), with male to female ratio being 4:1. The mean BMI of the group was 21.94 ± 4.08 k.g / m2.

According to GOLD Classification of severity of airflow limitation in COPD,1 majority of patients 39 (48.75%) in this study had Severe obstruction (GOLD 3), followed by 32 (40%) patients having

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Moderate obstruction (GOLD 2), and 9 having Mild obstruction (GOLD 1) based on spirometry testing. Those patients with Very Severe Obstruction (GOLD 4) was not included in the study.

The spirometric indices - pre FVC in liters minimum was 0.82 and maximum 3.61 with a mean value of 2.04 liters and standard deviation (SD) of 0.69. The Pre FVC% ranged from 34 % to 106.8%. The mean Pre FVC% was 64.52 with standard deviation (SD) of 18.66. The minimum and maximum Post FVC in liters was 0.88 and 3.67 respectively with a mean of 2.25 liters and standard deviation (SD) of 0.75 as shown in Table 1. The Post FVC% ranged from 36.30 to 110.7. The mean post FVC% was 71.20 with standard deviation (SD) of 19.69.

Table 1: Descriptive Statistics for Pre and Post FVC (in liter), Pre and Post FVC%

Descriptive Statistics for Pre and Post FVC (in liter), Pre and Post FVC%				
	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Pre FVC (in liter)	0.82	3.61	2.04	0.69
Pre FVC%	34.00	106.80	64.52	18.66
Post FVC (in liter)	0.88	3.67	2.25	0.75
Post FVC%	36.30	110.70	71.20	19.69

The minimum Post FEV1 in liters was 0.57 and maximum was 2.35. The mean value of Post FEV1 in liters was 1.31 with standard deviation (SD) of 0.50. The Post FEV1% ranged from 31 to 85. The mean value Post FEV1% was 52.14 with standard deviation (SD) of 16.49 as shown in Table 2. Pre FEV1 in liters ranged from 0.49 and 2.1 with a mean of 1.20 and standard deviation (SD) of 0.47. The minimum Pre FEV1% was 23.8 % and maximum was 80 %. The mean value of Pre FEV1% was 47.59 with standard deviation (SD) of 15.85.

Table 2: Descriptive Statistics for Post FEV 1 (in liter) and Post FEV 1%

Descriptive Statistics Post FEV 1 (in liter) and Post FEV 1%				
	Minimum	**Maximun**	**Mean**	**Std.Deviation**
Post FEV_1(in liter)	0.57	2.35	1.31	0.50
Post FEV_1%	31.00	85.00	52.14	16.49

In the present study, minimum and maximum Pre FEV1/FVC% was 37 and 71 respectively. The mean value of Pre FEV1/FVC% was 58.05 with standard deviation (SD) of 7.85. The minimum and maximum Post FEV1/ FVC% was 37 and 69 respectively. The mean value of Post FEV1/ FVC% was 58.08 with standard deviation (SD) of 8.31 as shown in Table 3.

Table 3: Descriptive Statistics Pre FEV1/FVC % and post FEV1/FCV %

Descriptive Statistics Pre FEV_1/FVC % and post FEV_1/FCV %				
	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Pre FEV1/FVC%	37.00	71.00	58.05	7.85
Post FEV1/FVC%	37.00	69.00	58.08	8.31

SqTST

The minimum SqTST (number of times) done was 6 and maximum was 19 in the study group. The mean for SqTST was 12.8 with standard deviation of 3.16. The Receiver Operating Characteristic Curve (ROC) analysis (Figure 1, Table 4, Table 5) of SqTST demonstrated good discriminative ability, with an area under the curve (AUC) of 0.910 (p value < .001). An optimal cut-off value of <12.5 yielded a sensitivity of 82.93% and specificity of 84.62% for predicting severe COPD. At this threshold, SqTST showed an overall diagnostic accuracy of 83.75%, with a positive predictive value of 85% and a negative predictive value of 82.5% in distinguishing severe COPD from mild to moderate disease.

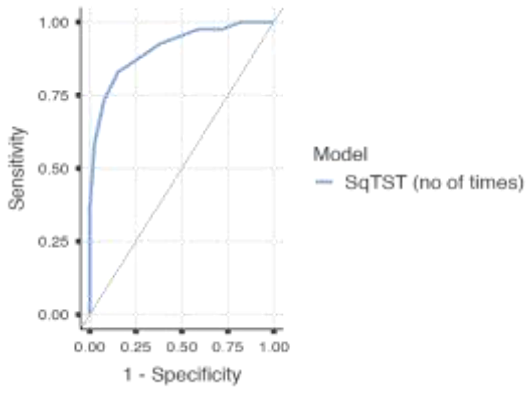

Figure 1: Showing combined ROC Curves for SqTST

Table 4: ROC Curve Summary

			95% Confidence Interval		
	AUC	**Std. Error**	**Lower**	**Upper**	**p**
SqTST (no of times)	0.91	0.0316	0.848	0.972	<.001

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Table 5: Diagnostic Accuracy - SqTST (no of times)

		95% Confidence Interval	
	Result	Lower	Upper
Sensitivity	82.93 %	67.94 %	92.85 %
Specificity	84.62 %	69.47 %	94.14 %
Positive Predictive Value	85.00 %	72.82 %	92.30 %
Negative Predictive Value	82.50 %	70.33 %	90.36 %
Accuracy	83.75 %	73.82 %	91.05 %

Correlation of SqTST with age, weight, height and BMI

In the present study there was a negative correlation between SqTST and age with coefficient of correlation (r) -0.187, but a not significant p value 0.098. The positive correlation between SqTST and weight was also not significant (coefficient of correlation (r) 0.178, p = 0.115). There was a significant correlation between SqTST and height with coefficient of correlation (r) 0.284 and p value 0.011 (<0.05). SqTST and BMI also had a postive correlation (coefficient of correlation (r) 0.042) but was not significant (p = 0.712). This is shown in Table 6.

Table 6: Correlation of SqTST with Age, Weight, Height and BMI

Correlation of SqTST with Age, Weight, Height and BMI		
	SqTST	
	Pearson Correlation(r)	P value
Age	-0.187	0.098
Weight	0.178	0.115
Height	0.284	0.011*
BMI	0.042	0.712
* Correlation is significant at 0.05 level (2-tailed) **. Correlation is significant at the 0.01 level (2-tailed).		

Correlation of SqTST with spirometric indices

In the present study there was a positive correlation between SqTST and Pre FEV1 in liter with coefficient of correlation (r) + 0.807 and p value .000 (<0.001) which is highly significant. There was a positive correlation between SqTST and Pre FEV1% with coefficient of correlation (r) + 0.761 and p value .000 (<0.001) which is also significant. This indicates that with increase in pre FEV1 or pre FEV1 %, SqTST also will increase.

Positive correlation was found between SqTST and Post FEV1 in liter with coefficient of correlation +0.821 and P value .000 (<0.001) which is highly significant which indicate that with increase in post FEV1 value SqTST will increase. There was also a positive correlation between SqTST and Post FEV1 % with coefficient of correlation (r) +0.779 and P value .000 (<0.001) indicating that with increase in post FEV1 %, SqTST will increase. This is shown in Table 7.

Table 7: Correlation of SqTST with Post FEV1%, Post FEV1 in liter

Correlation of SqTST with Post FEV1%, Post FEV1 in liter		
	SqTST	
	Pearson Correlation(r)	P value
Post FEV1%	0.779	0.000**
Post FEV1 in liter	0.821	0.000**
**. Correlation is significant at the <0.001 level (2-tailed).		

Significant positive correlation was also found between SqTST and Pre FVC in liter [coefficient of correlation (r) + 0.743 and p value .000 (<0.001)]. There was also a positive correlation between SqTST and Post FVC in liter with coefficient of correlation (r) +0.743 and P value .000 (<0.001) which is highly significant which indicate that with increase in post FVC, SqTST will increase. In the present study SqTST and Pre FVC% also showed positive correlation with coefficient of correlation (r) + 0.646 and p value .000 (<0.001) indicating that with increase in pre FVC%, SqTST also will increase. There was also a positive correlation between SqTST and Post FVC% with coefficient of correlation (r) +0.645 and P value .000 (<0.001).

SqTST and Pre FEV1/FVC% had positive correlation, coefficient of correlation (r) + 0.454 and p value .000 (<0.001). There was also a positive correlation between SqTST and Post FEV1/FVC% with coefficient of correlation (r) +0.385 and P value .000 (<0.001).

DISCUSSION

Out of 80 patients in this study, 39 participants (48.75%) had Severe Obstruction (GOLD 3 category) while 41(51.25%) had Mild to Moderate disease. Patients with Very severe obstruction was not included in the study.

In previous study by Islam MA et al, the majority of patients 21(35.0%) had Very severe COPD, and

ISSN (O): 2687-5365; ISSN (P): 2753-6556

almost half (48.3%) of the patients had abnormal SqTST, using a cut-off value of SqTST as < 7.0 by ROC curve analysis, with an area under curve of 0.901, with 82.1% sensitivity, 85.7% specificity, 83.3% accuracy, 91.4% positive predictive value, and 72.0% negative predictive value to predict Severe COPD.[11]

In the present study, the ROC analysis of SqTST gave a cut-off value of <12.5, with AUC of 0.910 (p value < .001), sensitivity of 82.93% and specificity of 84.62% for predicting severe COPD. At this threshold, SqTST showed an overall diagnostic accuracy of 83.75%, with a positive predictive value of 85% and a negative predictive value of 82.5% in distinguishing severe COPD from mild to moderate disease. Using 12.5 as cut off for SqTST in the current study, 33 out of 39 severe COPD patients were correctly identified, while 34 out of 41 mild-to-moderate cases were correctly classified (as shown in Table 8), suggesting need for a higher cut off for SqTST.

Table 8: Contingency Table - SqTST (no of times)

		FEV1 GRADING - Transform 1		
		Mild & Moderate	Severe	Total
SqTST (no of times)	≥12.5	34	6	40
	<12.5	7	33	40
Total		41	39	80
Note. Based on optimal cut-off (Youden's Index)				

In the present study there was a negative correlation between SqTST and age with coefficient of correlation (r) -0.187, but p value 0.098 was not significant. In previous study by Gupta PR et al correlation between SqTST and age doesn't had any statistical significance (p = 0.198). Present study there was a positive correlation between SqTST and BMI (coefficient of correlation (r) 0.042) but it was not statistically significant (p = 0.712). A significant positive correlation was observed between SqTST and BMI in previous study.[10] There was a significant correlation between SqTST and height with coefficient of correlation (r) 0.284 and p value 0.011 (<0.05) in the current study.

In the present study there was a positive correlation between SqTST and Post FEV1% with coefficient of correlation (r) +0.779 and p value 0.000 (<0.001) which was highly significant, as depicted in the scatter diagram (Fig. 1). This indicate that with increase in post FEV1%, SqTST will increase. This was in contrast to the study done by Gupta PR et al where the correlation of SqTST with FEV1% was poor (p = 0.091).[10] Positive correlation was found between SqTST and Post FEV1 in liter with coefficient of correlation +0.821 and P value .000 (<0.001) as shown in Figure 2, which is highly significant which indicate that with increase in post FEV1 value SqTST will increase. In study by Islam MA et al, a significant relation was found between the severity of COPD with SqTST (p=0.001) in patients who were categorized on the basis of post-bronchodilator FEV1.[11]

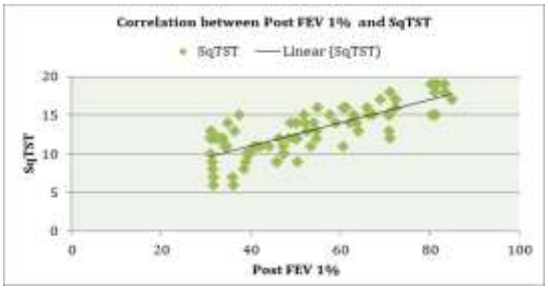

Figure 2: Scatter Diagram showing Correlation between Post FEV 1% and SqTST

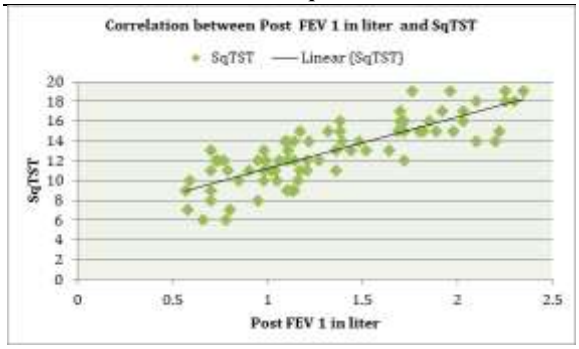

Figure 3: Scatter diagram showing correlation between Post FEV 1 in liter and SqTST

CONCLUSION

The present study demonstrates a strong and statistically significant positive correlation between Squat-to-Stand Test (SqTST) performance and spirometric indices, particularly Pre, Post FEV1 in liter and Pre, Post FEV1 % ; also Pre and Post FVC values, in patients with stable COPD. Study also highlights the importance of a standardized cut off value for distinguishing normal from abnormal SqTST. These findings indicate that SqTST reflects pulmonary function and functional capacity effectively. Given its simplicity, minimal resource requirement, and cultural relevance in populations accustomed to squatting, SqTST can serve as a practical adjunct or alternative to spirometry, especially in rural and low resource settings.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Although not a replacement for spirometry, it offers valuable clinical insight for assessing disease severity and monitoring functional status in COPD patients.

Conflicts of Interest

There are no conflicts of interest

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ISSN (O): 2687-5365; ISSN (P): 2753-6556