



## Original Research Article

# Study of Correlation of Six Minute Walk Test and Spirometry Severity of Chronic Obstructive Pulmonary Disease (COPD)

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## Abstract

**Background:** Chronic obstructive pulmonary disease (COPD) is associated with progressive airflow limitation and reduced exercise capacity. The six-minute walk test (6MWT) provides a simple assessment of functional status and may complement spirometry in evaluating disease severity.

**Materials and Methods:** This prospective cross-sectional study included 100 patients with spirometry-confirmed COPD attending the Department of Respiratory Medicine, K.D. Medical College and Research Centre, Mathura, between April 2024 and October 2025. Spirometric parameters (FEV<sub>1</sub>, FVC, FEV<sub>1</sub>/FVC ratio, and MVV) and 6MWD were recorded. Correlation analysis was performed using Pearson's or Spearman's correlation coefficients, with  $p < 0.05$  considered statistically significant.

**Results:** The mean FEV<sub>1</sub> was  $52.6 \pm 18.4\%$  predicted, and 64% of patients had moderate-to-severe COPD. Mean 6MWD decreased progressively from  $415 \pm 42$  m in mild COPD to  $240 \pm 48$  m in very severe COPD ( $p < 0.001$ ). A strong positive correlation was observed between 6MWD and FEV<sub>1</sub> ( $r = 0.78$ ,  $p < 0.001$ ), while moderate positive correlations were found with FVC, FEV<sub>1</sub>/FVC ratio, and MVV. Exercise-induced oxygen desaturation and heart rate increased significantly with worsening disease severity. FEV<sub>1</sub> was the strongest independent predictor of 6MWD.

**Conclusion:** Six-minute walk distance correlates significantly with spirometric impairment and declines with increasing COPD severity. The 6MWT is a simple and reliable adjunct to spirometry for assessing functional capacity and disease severity in patients with COPD.

**Keywords:** Chronic obstructive pulmonary disease, COPD, six-minute walk test, 6MWD, spirometry, FEV<sub>1</sub>, exercise capacity.

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## Introduction

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable chronic respiratory disease characterised by persistent airflow limitation caused by chronic inflammation of the airways and alveoli following prolonged exposure to noxious particles or gases, particularly cigarette smoke[1]. The disease is characterised by progressive dyspnoea, chronic cough, sputum production, and recurrent exacerbations that gradually impair pulmonary function and quality of life. Beyond pulmonary involvement, COPD is associated with systemic manifestations including

skeletal muscle dysfunction, cardiovascular disease, osteoporosis, anxiety, and depression, making it a complex multisystem disorder [2]. COPD remains a major global health problem and is currently the third leading cause of death worldwide. According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD), more than 390 million people are affected globally, with the burden expected to increase because of population ageing, tobacco smoking, biomass fuel exposure, occupational hazards, and environmental pollution [1,3]. India contributes substantially to the global

COPD burden owing to high rates of smoking, indoor biomass fuel exposure, and delayed diagnosis, resulting in considerable morbidity, mortality, and healthcare expenditure [4]. Spirometry is regarded as the gold standard for diagnosing COPD and assessing the severity of airflow limitation. The diagnosis is confirmed by a post-bronchodilator forced expiratory volume in one second (FEV<sub>1</sub>)/forced vital capacity (FVC) ratio of less than 0.70, while disease severity is graded according to the percentage predicted FEV<sub>1</sub>. Although spirometry objectively measures airflow obstruction, it does not always correlate with symptom severity, exercise tolerance, or health-related quality of life. Patients with similar spirometric values often exhibit marked differences in functional capacity and daily physical activity, indicating that airflow limitation alone cannot fully describe disease severity [1,5]. Exercise intolerance is one of the most disabling manifestations of COPD and results from the combined effects of airflow obstruction, dynamic hyperinflation, impaired gas exchange, skeletal muscle dysfunction, and cardiovascular limitation. Reduced exercise capacity adversely affects activities of daily living, increases hospitalisation rates, and is associated with poor prognosis. Therefore, assessment of functional exercise capacity has become an important component of comprehensive COPD evaluation [6,7].

The Six-Minute Walk Test (6MWT) is a simple, inexpensive, reproducible, and well-standardised test used to assess functional exercise capacity in patients with chronic respiratory diseases. The six-minute walk distance (6MWD) reflects the integrated responses of the respiratory, cardiovascular, and musculoskeletal systems during physical activity and closely resembles routine daily activities. Several studies have demonstrated that reduced 6MWD is associated with worsening COPD severity, increased dyspnoea, frequent exacerbations, poor quality of life, and increased mortality. Moreover, the 6MWT constitutes an important component of the BODE index, which predicts survival more accurately than spirometry alone [8–11]. Recent GOLD guidelines recommend a multidimensional assessment of COPD that includes spirometry, symptom burden, exacerbation history, and functional status rather than relying solely on pulmonary function tests. However, data evaluating the relationship between spirometric severity and functional exercise capacity in the Indian population remain limited. Understanding this correlation may help identify patients with disproportionate functional impairment, facilitate early pulmonary rehabilitation, and improve clinical decision-making. Therefore, the present study was undertaken to evaluate the correlation between the

Six-Minute Walk Test and spirometric severity in patients with chronic obstructive pulmonary disease.

### Methodology:

This prospective cross-sectional observational study was conducted in the Department of Respiratory Medicine, K.D. Medical College and Research Centre, Mathura, Uttar Pradesh, India.

### Study Population

Patients attending the outpatient and inpatient departments with spirometry-confirmed COPD were consecutively recruited until the required sample size was achieved.

### Inclusion Criteria

- Age  $\geq 40$  years.
- Spirometry-confirmed COPD.
- Willingness to provide written informed consent.

### Exclusion Criteria

Patients with inability to provide consent, resting heart rate  $>120$  beats/min, blood pressure  $>180/100$  mmHg, resting SpO<sub>2</sub>  $<92\%$  or on long-term oxygen therapy, BMI  $>30$  kg/m<sup>2</sup>, COPD exacerbation or hospitalization within the previous three months, active infection, or significant comorbidities such as congestive heart failure, coronary artery disease, ischemic heart disease, systemic hypertension, or diabetes mellitus were excluded.

### Study Procedure

All participants underwent detailed clinical evaluation followed by post-bronchodilator spirometry according to ATS/ERS guidelines. Forced expiratory volume in one second (FEV<sub>1</sub>), forced vital capacity (FVC), and FEV<sub>1</sub>/FVC ratio were recorded, and COPD severity was graded according to GOLD criteria. After a 10-minute rest period, the Six-Minute Walk Test (6MWT) was performed following ATS guidelines in a 30-metre corridor. Heart rate (HR), blood pressure (BP), and oxygen saturation (SpO<sub>2</sub>) were recorded before and immediately after the test. The total six-minute walk distance (6MWD) was measured in metres.

### Outcome Measures

The primary outcome was to determine the correlation between spirometric parameters (FEV<sub>1</sub>, FVC, and FEV<sub>1</sub>/FVC ratio) and six-minute walk distance (6MWD) in patients with COPD.

### Statistical Analysis

Data were entered into Microsoft Excel and analysed using SPSS version 26.0. Continuous variables were expressed as mean  $\pm$  standard deviation (SD), while categorical variables were presented as frequencies and percentages. Pearson's

or Spearman's correlation coefficient was used to evaluate the relationship between spirometric parameters and 6MWD, as appropriate. Differences in 6MWD among GOLD severity grades were analysed using one-way ANOVA or the Kruskal-Wallis test. A  $p$ -value  $<0.05$  was considered statistically significant.

### Results:

A total of 100 patients with spirometry-confirmed COPD were enrolled in the study. The majority of participants belonged to the 60–69 years age group (32%), followed by 50–59 years (28%), while 40–49 years and  $\geq 70$  years each accounted for 20% of the study population. Males predominated (72%), and 70% of participants had a history of smoking. Farmers/outdoor workers constituted the largest occupational group (40%), followed by industrial workers (25%), office/other occupations (20%), and homemakers (15%) (Table 1).

Spirometric evaluation demonstrated a predominantly obstructive ventilatory defect, with a mean  $FEV_1$  of  $52.6 \pm 18.4\%$  predicted, FVC of  $68.5 \pm 14.7\%$  predicted,  $FEV_1/FVC$  ratio of  $58.2 \pm 9.8\%$ , and MVV of  $55.7 \pm 12.5\%$  predicted. According to the GOLD 2024 classification, 18% of patients had mild COPD, 36% had moderate disease, 28% had severe disease, and 18% had very severe disease, indicating that nearly two-thirds of patients had moderate-to-severe airflow limitation (Table 2, Figure 1).

Functional exercise capacity progressively declined with increasing COPD severity. The mean six-minute walk distance (6MWD) decreased significantly from  $415 \pm 42$  m in patients with mild COPD to  $365 \pm 50$  m,  $300 \pm 55$  m, and  $240 \pm 48$  m in those with moderate, severe, and very severe disease, respectively. Similarly, exercise-induced oxygen desaturation increased with disease severity, while heart rate responses were more pronounced in patients with advanced COPD. One-way ANOVA demonstrated a statistically significant difference in 6MWD across GOLD stages ( $F = 22.4$ ,  $p < 0.001$ ) (Table 3).

Correlation analysis revealed significant positive associations between pulmonary function parameters and exercise capacity. The strongest correlation was observed between  $FEV_1$  (% predicted) and 6MWD ( $r = 0.78$ ,  $p < 0.001$ ), followed by MVV ( $r = 0.69$ ,  $p < 0.001$ ), FVC ( $r = 0.62$ ,  $p < 0.001$ ), and  $FEV_1/FVC$  ratio ( $r = 0.56$ ,  $p < 0.001$ ). In contrast, oxygen desaturation and heart rate rise during the six-minute walk test demonstrated significant negative correlations with walking distance (Table 4, Figure 2).

Stepwise multiple linear regression identified  $FEV_1$  (% predicted) as the strongest independent predictor of 6MWD ( $\beta = 0.62$ ,  $t = 6.2$ ,  $p < 0.001$ ), followed by

MVV ( $\beta = 0.41$ ,  $t = 4.1$ ,  $p < 0.01$ ) and FVC ( $\beta = 0.28$ ,  $t = 3.0$ ,  $p = 0.003$ ) (Table 5.1, Figure 3.1).

Receiver operating characteristic (ROC) analysis demonstrated that a 6MWD  $\leq 300$  m effectively predicted severe COPD, yielding a sensitivity of 84%, specificity of 80%, and an area under the curve (AUC) of 0.87, indicating excellent discriminative ability (Table 5.2, Figure 3.2).

Regarding additional clinical findings, 32% of patients had mMRC Grade 3 dyspnoea, followed by Grade 2 (28%), while Grades 1 and 4 each accounted for 20% of participants. Smokers exhibited significantly lower exercise capacity than non-smokers, with mean 6MWD values of  $310 \pm 72$  m and  $360 \pm 65$  m, respectively ( $p = 0.021$ ). Chest radiography most frequently demonstrated a low and flattened diaphragm (48%), followed by hyperinflated lungs (45%) and tubular heart (45%), whereas bullae (8%) and cardiomegaly (9%) were relatively uncommon (Table 6).

**Table 1. Baseline Demographic and Clinical Characteristics of the Study Population (n = 100)**

| Variable                        | Value     |
|---------------------------------|-----------|
| Age Group (years), n (%)        |           |
| 40–49                           | 20 (20.0) |
| 50–59                           | 28 (28.0) |
| 60–69                           | 32 (32.0) |
| $\geq 70$                       | 20 (20.0) |
| Male sex, n (%)                 | 72 (72.0) |
| Female sex, n (%)               | 28 (28.0) |
| Smoking history, n (%)          | 70 (70.0) |
| Non-smokers, n (%)              | 30 (30.0) |
| Farmers/Outdoor workers, n (%)  | 40 (40.0) |
| Industrial workers, n (%)       | 25 (25.0) |
| Homemakers, n (%)               | 15 (15.0) |
| Office/Other occupations, n (%) | 20 (20.0) |

**Table 2. Spirometric Characteristics and GOLD Severity Classification**

| Variable                                     | Value           |
|----------------------------------------------|-----------------|
| <b>Spirometry (Mean <math>\pm</math> SD)</b> |                 |
| FEV <sub>1</sub> (% predicted)               | 52.6 $\pm$ 18.4 |
| FVC (% predicted)                            | 68.5 $\pm$ 14.7 |
| FEV <sub>1</sub> /FVC (%)                    | 58.2 $\pm$ 9.8  |
| MVV (% predicted)                            | 55.7 $\pm$ 12.5 |
| <b>GOLD Severity, n (%)</b>                  |                 |
| Mild                                         | 18 (18.0)       |
| Moderate                                     | 36 (36.0)       |
| Severe                                       | 28 (28.0)       |
| Very Severe                                  | 18 (18.0)       |

**Table 3. Functional Exercise Capacity According to COPD Severity**

| GOLD Severity | 6MWD (m), Mean $\pm$ SD | Pre-test SpO <sub>2</sub> (%) | Post-test SpO <sub>2</sub> (%) | $\Delta$ HR (bpm)  |
|---------------|-------------------------|-------------------------------|--------------------------------|--------------------|
| Mild          | 415 $\pm$ 42            | 97 $\pm$ 1.2                  | 95 $\pm$ 1.5                   | 17                 |
| Moderate      | 365 $\pm$ 50            | 96 $\pm$ 1.5                  | 93 $\pm$ 1.8                   | 20                 |
| Severe        | 300 $\pm$ 55            | 95 $\pm$ 1.8                  | 91 $\pm$ 2.2                   | 22                 |
| Very Severe   | 240 $\pm$ 48            | 94 $\pm$ 1.9                  | 89 $\pm$ 2.5                   | 25                 |
| <b>ANOVA</b>  | <b>F = 22.4</b>         |                               |                                | <b>p &lt;0.001</b> |

**Table 4. Correlation Between Six-Minute Walk Distance and Spirometric Parameters**

| Variable                       | Correlation Coefficient (r) | p-value |
|--------------------------------|-----------------------------|---------|
| FEV <sub>1</sub> (% predicted) | 0.78                        | <0.001  |
| FVC (% predicted)              | 0.62                        | <0.001  |
| FEV <sub>1</sub> /FVC (%)      | 0.56                        | <0.001  |
| MVV (% predicted)              | 0.69                        | <0.001  |
| SpO <sub>2</sub> Drop          | -0.52                       | <0.001  |
| Heart Rate Rise                | -0.45                       | 0.002   |

**Table 5.1 Predictors of Six-Minute Walk Distance**

| Predictor            | $\beta$ Coefficient | t-value | p-value |
|----------------------|---------------------|---------|---------|
| FEV <sub>1</sub> (%) | 0.62                | 6.2     | <0.001  |
| MVV (%)              | 0.41                | 4.1     | <0.01   |
| FVC (%)              | 0.28                | 3.0     | 0.003   |

**Table 6. Additional Clinical Findings**

| Variable                     | Value        |
|------------------------------|--------------|
| mMRC Grade 1, n (%)          | 20 (20.0)    |
| mMRC Grade 2, n (%)          | 28 (28.0)    |
| mMRC Grade 3, n (%)          | 32 (32.0)    |
| mMRC Grade 4, n (%)          | 20 (20.0)    |
| Mean 6MWD in Smokers (m)     | 310 $\pm$ 72 |
| Mean 6MWD in Non-smokers (m) | 360 $\pm$ 65 |
| p-value                      | 0.021        |

|                                |           |
|--------------------------------|-----------|
| Low & Flat Diaphragm, n (%)    | 48 (48.0) |
| Hyperinflated Lungs, n (%)     | 45 (45.0) |
| Tubular Heart, n (%)           | 45 (45.0) |
| Prominent Hilar Vessels, n (%) | 15 (15.0) |
| Bullae, n (%)                  | 8 (8.0)   |
| Cardiomegaly, n (%)            | 9 (9.0)   |

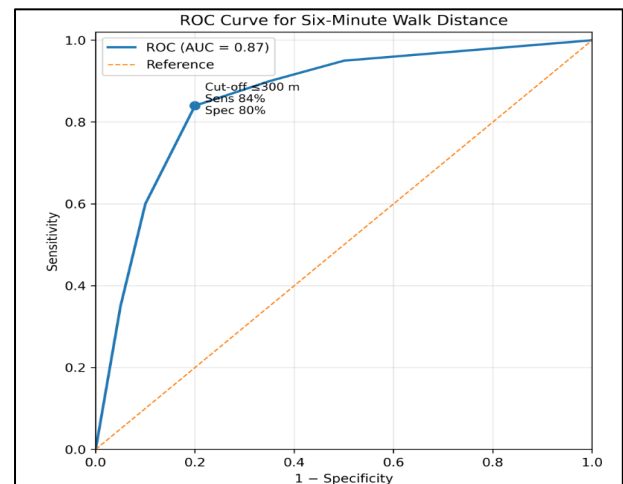


Figure 3.2. ROC Analysis

### Discussion

The present study evaluated the relationship between spirometric parameters and functional exercise capacity measured by the six-minute walk test (6MWT) in patients with chronic obstructive pulmonary disease (COPD). A significant decline in six-minute walk distance (6MWD) was observed with increasing GOLD severity. Moreover, 6MWD showed a strong positive correlation with FEV<sub>1</sub> and moderate positive correlations with FVC, FEV<sub>1</sub>/FVC ratio, and maximal voluntary ventilation (MVV), indicating that worsening airflow limitation is associated with reduced exercise capacity. The majority of patients were aged 60–69 years, with a predominance of males and smokers. Similar demographic characteristics have been reported by Chandra et al. [12], Hajare et al. [13], and other Indian studies, where COPD predominantly affected older male smokers with prolonged tobacco exposure.

The mean post-bronchodilator FEV<sub>1</sub> of the study population indicated moderate airflow limitation, and nearly two-thirds of patients had moderate-to-severe COPD. Comparable findings have been reported by Agustí et al. (2023) [14], who observed that most patients presenting to tertiary care centres

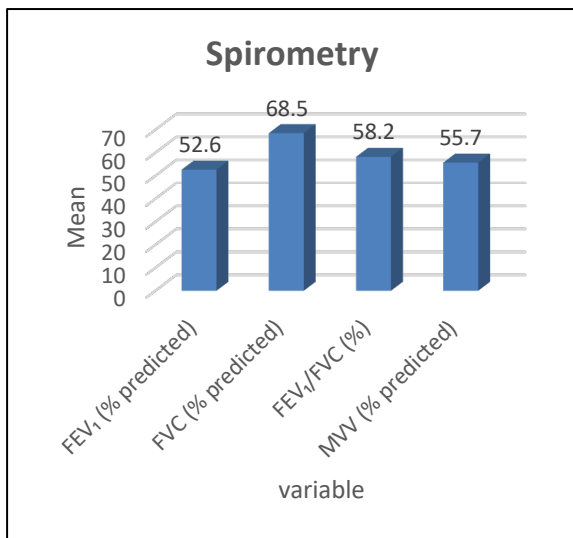


Figure 1. Spirometric Characteristics and GOLD Severity Classification

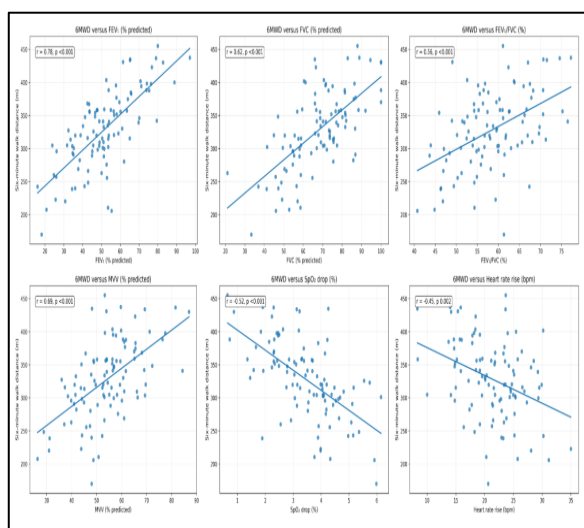


Figure 2. Correlation Between Six-Minute Walk Distance and Spirometric Parameters



have established airflow obstruction at diagnosis.[15,16]A key finding of the present study was the progressive reduction in 6MWD with increasing COPD severity. Patients with mild disease achieved the greatest walking distance, whereas those with very severe COPD had the poorest exercise capacity. Similar observations were reported by Chandra et al. [12], who demonstrated a significant reduction in 6MWD across GOLD stages. Likewise, Hajare et al. [13] reported shorter walking distances among patients with severe COPD, confirming the usefulness of the 6MWT in assessing functional limitation. The strongest correlation observed was between 6MWD and FEV<sub>1</sub> (% predicted), indicating that better lung function is associated with greater exercise tolerance. Similar findings were reported by Chandra et al. [12]. Chen et al. [17] also demonstrated that FEV<sub>1</sub> correlates closely with 6MWD, particularly in patients with severe COPD, supporting the role of the 6MWT as a practical measure of functional status. Moderate positive correlations were also observed between 6MWD and FVC, FEV<sub>1</sub>/FVC ratio, and MVV. Reduced FVC reflects hyperinflation and air trapping, while MVV represents ventilatory reserve. Similar observations have been reported by Celli et al. [18] and Spruit et al. [19], who showed that pulmonary function parameters collectively influence exercise performance, although FEV<sub>1</sub> remains the strongest predictor. Exercise-induced oxygen desaturation and heart rate response increased progressively with disease severity and were associated with shorter walking distances. These findings indicate worsening gas exchange and greater cardiopulmonary stress during exercise. Abdelwahab et al. [20] similarly demonstrated that exercise-induced desaturation is significantly associated with airflow limitation and hyperinflation in COPD. Regression analysis identified FEV<sub>1</sub> as the strongest independent predictor of 6MWD, followed

by MVV and FVC. Comparable findings have been reported by Chandra et al. [12] and Hajare et al. [13], who also identified FEV<sub>1</sub> as the principal determinant of functional exercise capacity in COPD patients. The ROC analysis showed that a 6MWD  $\leq$  300 m predicted severe COPD with good diagnostic accuracy (AUC = 0.87). Similar prognostic significance of the 6MWT has been reported by Cote et al. [21], who demonstrated that reduced 6MWD is associated with increased hospitalization and mortality among patients with COPD.

Smoking was also associated with significantly lower 6MWD in the present study. Similar findings have been reported by Chandra et al. [12] and Hajare et al. [13], suggesting that continued smoking accelerates lung function decline and contributes to poorer exercise capacity.

### Conclusion

The present study demonstrated a significant positive correlation between spirometric parameters, particularly FEV<sub>1</sub>, and six-minute walk distance in patients with COPD. Functional exercise capacity declined progressively with increasing GOLD severity and was associated with greater exercise-induced oxygen desaturation and cardiovascular response. These findings support the use of the 6MWT as a simple, reliable, and complementary tool to spirometry for functional assessment and disease severity evaluation in COPD.

### Limitations

This was a single-centre study with a relatively small sample size, which may limit the generalizability of the findings. In addition, the cross-sectional design precluded assessment of longitudinal changes and the prognostic value of the 6MWT over time.

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