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Assessment of Slow and Forced Vital Capacity in COPD Patients and Its Correlation with Exercise Capacity.

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Abstract

Background: Chronic Obstructive Pulmonary Disease (COPD) is a progressive inflammatory lung disorder characterized by persistent airflow limitation and reduced exercise tolerance. Dynamic hyperinflation and airway collapse during exertion may lead to differences between slow vital capacity (SVC) and forced vital capacity (FVC), which can influence functional capacity.***Aim:*** To compare SVC and FVC in COPD patients and evaluate their association with exercise tolerance.***Methodology:*** A prospective observational study was conducted in the Department of Pulmonology, Sree Mookambika Institute of Medical Sciences, Kulasekharam, from June 2025 to December 2025. A total of 100 patients with COPD having mild to moderate airflow obstruction as per GOLD criteria were included. Patients with neuromuscular diseases, peripheral vascular diseases, chronic lung diseases such as PTB, bronchiectasis, pulmonary hypertension, cor pulmonale, and cardiovascular comorbidities were excluded. All patients underwent spirometry, including measurement of SVC and FVC, before and after the six-minute walk test (6MWT). Exercise tolerance was assessed using 6MWT distance. Statistical analysis was performed using appropriate descriptive and inferential tests.***Results:*** The mean SVC decreased from 2.08 L to 1.96 L after 6MWT, while mean FVC decreased from 1.79 L to 1.67 L, indicating a reduction in lung volumes following exercise. Patients with mild obstruction covered a mean distance of 408 ± 15 meters, whereas those with moderate obstruction covered 355.6 ± 57 meters. The fall in FVC was more pronounced compared to SVC, and the difference between SVC and FVC increased after exercise, suggesting worsening dynamic airflow limitation. Exercise tolerance was reduced with increasing disease severity.***Conclusion:*** COPD patients demonstrate significant reductions in SVC and FVC after exercise, with a greater decline in FVC. The increasing SVC–FVC difference after exertion reflects dynamic airway obstruction and may serve as a useful marker of functional impairment. Exercise tolerance decreases with disease severity, emphasizing the importance of combined spirometric and functional assessment in COPD management.

Keywords: COPD, slow vital capacity, forced vital capacity, six-minute walk test, exercise tolerance, dynamic hyperinflation.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a progressive inflammatory airway disorder characterized by persistent airflow limitation that is not fully reversible and is associated with an abnormal inflammatory response of the lungs to noxious particles or gases, most commonly cigarette smoke and biomass fuel exposure (1,2). The disease is marked by chronic inflammation involving increased numbers of macrophages in the peripheral airways, lung parenchyma, and pulmonary vasculature, along with increased neutrophils and lymphocytes. These inflammatory cells, along with epithelial and structural cells, release multiple mediators including cytokines, chemokines, and growth factors that perpetuate inflammation, recruit additional immune cells, and promote structural airway remodeling (1,2). Importantly, this inflammatory process may persist even after smoking cessation, suggesting self-perpetuating mechanisms that are not fully understood.

COPD is pathologically characterized by a combination of small airway disease and parenchymal destruction (emphysema), with varying contributions among individuals (1,2). Chronic inflammation leads to airway wall thickening, luminal narrowing, mucus hypersecretion, and destruction of alveolar attachments. These structural alterations reduce elastic recoil and impair expiratory airflow, leading to air trapping and pulmonary hyperinflation. As a consequence, there is a progressive reduction in forced expiratory volume in one second (FEV1) and a decreased FEV1/FVC ratio, which forms the basis for spirometric diagnosis of COPD (1,2,4). Airflow obstruction is most commonly assessed using spirometry due to its reproducibility and wide availability in clinical practice (3).

Beyond pulmonary impairment, COPD is increasingly recognized as a systemic disease with multiple extrapulmonary manifestations. Systemic inflammation is believed to contribute to a wide spectrum of comorbidities, including cardiovascular disease, skeletal muscle dysfunction, osteoporosis, metabolic disorders such as diabetes mellitus, nutritional abnormalities, weight loss, and anemia (1,2). These comorbid conditions significantly worsen functional status, reduce exercise tolerance, and increase morbidity and mortality in COPD patients. The recognition of COPD as a multisystem disease has shifted clinical focus from purely pulmonary function improvement to comprehensive disease management.

Spirometric indices such as Forced Vital Capacity (FVC) and Slow Vital Capacity (SVC) play an important role in evaluating pulmonary function. FVC is defined as the maximal volume of air forcibly exhaled after full inspiration, and it is widely used to assess airflow limitation and disease severity. In contrast, SVC is measured during a slow and unforced expiration following full inspiration. In obstructive airway diseases like COPD, dynamic airway compression during forced expiration may lead to premature airway closure and air trapping, resulting in a lower FVC compared to SVC. This difference between SVC and FVC may reflect the degree of small airway collapse and hyperinflation.

Exercise intolerance is a hallmark of COPD and is closely linked to both ventilatory limitation and systemic factors such as muscle dysfunction and cardiovascular comorbidities. Reduced ventilatory capacity, dynamic hyperinflation, and gas exchange abnormalities contribute to early onset dyspnea during physical activity. Pulmonary rehabilitation has been shown to improve exercise capacity, dyspnea, and quality of life while reducing healthcare utilization in COPD patients (5). Therefore, evaluating the relationship between spirometric parameters such as SVC and FVC with exercise tolerance may provide valuable insight into functional impairment in COPD patients. In this context, the present study aims to assess the difference between slow vital capacity and forced vital capacity in patients with COPD and to evaluate their association with exercise tolerance, thereby contributing to a better understanding of functional limitation in COPD.

Aim

To compare slow vital capacity (SVC) and forced vital capacity (FVC) in patients with Chronic Obstructive Pulmonary Disease (COPD) and to assess their association with exercise tolerance.

Objectives

1. To measure and compare slow vital capacity (SVC) and forced vital capacity (FVC) in COPD patients.
2. To determine the difference between SVC and FVC values in COPD patients.
3. To assess exercise tolerance in COPD patients using appropriate clinical parameters (e.g., mMRC scale / 6-minute walk distance, if used).

METHODOLOGY

This prospective observational study was conducted in the Department of Pulmonology, Sree Mookambika Institute of Medical Sciences, Kulasekharam, during the study period from June 2025 to December 2025. Patients diagnosed with Chronic Obstructive Pulmonary Disease (COPD) presenting with mild to moderate airflow obstruction as per GOLD guidelines were included in the study. The inclusion criteria comprised all confirmed COPD patients with mild or moderate severity, while the exclusion criteria included COPD patients with neuromuscular disorders, peripheral vascular diseases, and those with associated chronic lung diseases such as pulmonary tuberculosis (PTB), bronchiectasis, pulmonary hypertension, cor pulmonale, and COPD associated with cardiovascular diseases, in order to avoid confounding factors affecting pulmonary function and exercise tolerance.

After obtaining informed written consent, a detailed clinical history was taken and a thorough physical examination was performed for all participants. Baseline investigations included complete blood picture (CBP), random blood sugar (RBS), renal function tests (RFT), chest X-ray, resting electrocardiogram (ECG), two-dimensional echocardiography (2D ECHO), arterial blood gas (ABG) analysis, spirometry, and six-minute walk test (6MWT). Spirometric assessment was performed to record slow vital capacity (SVC) and forced vital capacity (FVC). For SVC measurement, patients were instructed to take a few normal tidal breaths, followed by a maximal inspiration and a slow, complete expiration to residual volume, after which a slow maximal inspiration was performed, and SVC was recorded. For FVC measurement, patients were instructed to take a full inspiration followed by a forceful and rapid expiration until complete emptying of the lungs, with encouragement provided throughout the maneuver. At least three acceptable spirometry maneuvers were performed, and the best reproducible values with optimal quality and no cough in the first second, leaks, or early termination were considered for final analysis. A minimum exhalation time of six seconds was ensured.

COPD severity was classified based on post-bronchodilator FEV1 values according to GOLD staging criteria, where patients were categorized into mild (GOLD 1) and moderate (GOLD 2) airflow obstruction groups. The six-minute walk test was performed in a 30-meter indoor corridor following American Thoracic Society (ATS) guidelines. Each patient rested for at least 10 minutes before the test, and baseline vital parameters were recorded. Standardized encouragement phrases were used during the test to ensure maximal effort. The test was stopped if patients developed severe symptoms such as chest pain, marked dyspnea, muscle cramps, or requested to discontinue. Resting time was included within the total six-minute duration. Post-test measurements including blood pressure, heart rate, oxygen saturation using pulse oximetry, and total distance walked were recorded in meters. Both pre-walk and post-walk SVC and FVC values were documented. Patients were observed for 10–15 minutes post-procedure for any complications.

The collected data were compiled and statistically analyzed using appropriate software. Descriptive statistics such as mean and standard deviation were used for continuous variables, while categorical variables were expressed as frequencies and percentages. The comparison between SVC and FVC was performed using paired statistical tests, and correlation between spirometric parameters and 6MWT distance was assessed using correlation analysis. A p-value of less than 0.05 was considered statistically significant. The study population was further stratified into GOLD mild and moderate groups for subgroup analysis.

RESULTS

Table 1: Trends Depicting Correlates of COPD With Clinical Variables in Study Population

	COPD (n=100) P value	Mild obstruction (n=38) P value	Moderate obstruction (n=62) P value
Age 40-60	0.50(n=49)	0.50(n=16)	0.50(n=33)
Age >60	0.50(n=51)	0.50(n=22)	0.50(n=29)
Male	0.167(n=81)	0.167(n=34)	0.167(n=47)
Female	0.167(n=19)	0.167(n=4)	0.167(n=15)

Table 2: Spirometricand Clinical Parameters in Each Group (*Before 6MWT, **After 6MWT, #SVC, ##FVC)

	6MWT	Total (N=100) Mean +SD	Mild Obstruction (n=38) Mean +SD	Moderate Obstruction (n=62) Mean +SD
SVC (L)	Before 6MWT	*2.08+0.62	*2.40+0.58	*1.90 +0.57
	After 6MWT	**1.96+0.55	**2.30+0.59	**1.72 +0.41
FVC (L)	Before 6MWT	*1.79+0.60	*2.19 +0.64	*1.69+0.50
	After 6MWT	**1.67+0.55	**1.90+0.58	**1.47 +0.458

The mean distance covered in mild obstruction patients was 408 ±15m both pre and post 6MWT PFT was performed to record SVC and FVC. Mean of SVC, before 6 MWT was 2.40L and after 6 MWT was 2.30L. Mean of FVC in mild obstruction before 6 MWT was 2.19L and after 6 MWT was 1.90L. It indicates that in mild COPD patients, both FVC and SVC decreased after 6 MWT. The fall in FVC is 0.39L which is more compared to fall in SVC that is 0.10L and the p value of fall in FVC is 0.04 (<0.05) which is statistically significant. The difference between SVC and FVC (SVC-FVC) after 6 MWT is 0.40 which is more than the difference before 6 MWT (0.21L).

Table 3: SVC and FVC values Before and After 6 MWT in patients with mild obstruction

Spirometer	Before 6 MWT	After 6 MWT	P Value
SVC (L)	2.40	2.30	0.45
FVC(L)	2.19	1.90	0.04
P Value	0.13	0.003	

The mean distance covered in moderate obstruction patients was 355.6 ±57m. PFT was performed to record SVC and FVC pre and post 6MWT. Mean of SVC before 6 MWT in these patients is 1.90L and after 6 MWT is 1.72L. Mean of FVC in moderate obstruction before 6 MWT is 1.69L and after 6 MWT is 1.47L. It indicates that both SVC and FVC decreased after 6 MWT. Both fall in FVC and SVC are statistically significant.

The difference in SVC and FVC before and after 6 MWT IS 0.21L and 0.25L respectively, both of which are statistically significant.

Table 4: Distribution of Patients with Moderate Obstruction and Their SVC and FVC

Spirometer	Before 6 MWT	After 6 MWT	P Value
SVC (L)	1.90	1.72	0.04
FVC(L)	1.69	1.47	0.01
P value	0.03	0.001	

DISCUSSION

In the present prospective observational study, we evaluated the relationship between slow vital capacity (SVC), forced vital capacity (FVC), and exercise tolerance in patients with Chronic Obstructive Pulmonary Disease (COPD) of mild and moderate severity. COPD is a progressive disorder characterized by airflow limitation due to a combination of small airway disease and parenchymal destruction, leading to air trapping, hyperinflation, and reduced expiratory flow rates (6,7). These physiological alterations significantly impact functional capacity and exercise performance in affected individuals. In our study, patients with mild obstruction had a mean age of 61.66 years, while those with moderate obstruction had a slightly lower mean age of 58.60 years. The majority of patients belonged to the older age group (>60 years), reflecting the chronic and progressive nature of the disease. Similar age-related distribution has been reported in COPD populations, where cumulative exposure to risk factors such as smoking and biomass fuel contributes to disease progression over time (6). The predominance of male patients in our study is consistent with higher smoking prevalence among males in many populations, although increasing female involvement is also observed due to indoor air pollution exposure.

A key finding of this study was the reduction in both SVC and FVC following the six-minute walk test (6MWT) in both mild and moderate COPD groups. In the overall population, mean SVC decreased from 2.08 L to 1.96 L, and FVC decreased from 1.79 L to 1.67 L after exercise. This reduction reflects exercise-induced dynamic hyperinflation and airway closure, which are well-recognized mechanisms in COPD. During physical exertion, increased respiratory demand leads to shortened expiratory time, worsening air trapping and further reducing expiratory volumes (7). In mild obstruction patients, the mean distance covered during 6MWT was 408 ± 15 meters, whereas in moderate obstruction patients it was reduced to 355.6 ± 57 meters, indicating impaired exercise tolerance with increasing disease severity. This finding is consistent with previous studies showing that 6MWT distance correlates with ventilatory limitation and disease severity in COPD (9). The greater functional impairment in moderate COPD further supports the progressive nature of exercise limitation.

Interestingly, the fall in FVC after 6MWT was more pronounced than the fall in SVC, particularly in mild COPD patients, where FVC decreased significantly ($p = 0.04$), while SVC reduction was comparatively less marked. The post-exercise increase in the SVC–FVC difference suggests that forced expiration exaggerates airway collapse and gas trapping, which is less evident during slow expiration. This physiological difference highlights the potential utility of comparing SVC and FVC as an indicator of dynamic airway limitation and hyperinflation in COPD. In moderate obstruction patients, both SVC and FVC showed statistically significant reductions after exercise, with a greater overall decline compared to mild COPD. This indicates that exercise further exacerbates ventilatory limitation in advanced disease stages. The observed increase in SVC–FVC difference after 6MWT suggests worsening expiratory flow limitation and reduced elastic recoil, consistent with established pathophysiological mechanisms (6,7).

Exercise intolerance in COPD is multifactorial and includes ventilatory limitation, dynamic hyperinflation, skeletal muscle dysfunction, and cardiovascular deconditioning. The reduced 6MWT distance in our study population reinforces the functional impact of these mechanisms. Pulmonary rehabilitation and structured exercise programs have been shown to improve exercise capacity and quality of life in COPD patients (5). Overall, our findings demonstrate that both SVC and FVC decrease after exertion, with FVC showing a greater decline, and that these changes correlate with exercise tolerance. This suggests that SVC–FVC difference may serve as a useful physiological marker for assessing dynamic airway limitation in COPD patients.

CONCLUSION

The present study demonstrates that patients with Chronic Obstructive Pulmonary Disease (COPD) exhibit a significant reduction in both slow vital capacity (SVC) and forced vital capacity (FVC) following exercise, as assessed by the six-minute walk test (6MWT). The decline in FVC was more pronounced than SVC, suggesting that forced expiratory maneuvers exaggerate airflow limitation due to dynamic airway collapse and air trapping.

Exercise tolerance, as measured by 6MWT distance, was reduced in both mild and moderate COPD patients, with greater impairment observed in those with moderate obstruction. This indicates a clear relationship between disease severity and functional limitation. The increased difference between SVC and FVC after exercise further reflects worsening expiratory flow limitation and hyperinflation in COPD patients.

Overall, the study highlights that SVC and FVC are not only useful spirometric parameters for assessing baseline lung function but may also provide additional insight into dynamic ventilatory impairment when measured before and after exercise. The findings suggest that SVC–FVC differences, particularly after exertion, may serve as a useful functional marker in evaluating exercise-induced ventilatory limitation in COPD patients. Early identification of functional impairment using combined spirometric assessment and exercise testing can aid in better disease characterization and may help in optimizing management strategies, including pulmonary rehabilitation, thereby improving patient outcomes and quality of life.

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