e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(2); 775-781

Original Research Article

Pulmonary Function Test Patterns in Patients with Interstitial Lung Disease

Dinkal A. Patel[1], Vikas Kumar Sahu[2], Arpana A. Patel[3]

[1]Senior Resident, Department of Anaesthesiology, Civil Hospital, Ahmedabad, Gujarat, India
[2]Assistant Professor, Department of Respiratory Medicine, Lt. SIGM GMC Kanker, Chhattisgarh, India
[3]Junior Resident, Department of Dermatology, GMERS Medical College, Valsad, Gujarat, India

Received: 15-12-2025 / Revised: 17-01-2026 / Accepted: 18-02-2026
Corresponding Author: Dr. Arpana A Patel
Conflict of interest: Nil

Abstract:

Background: Interstitial lung diseases (ILDs) encompass a heterogeneous group of parenchymal lung disorders characterized by varying degrees of inflammation and fibrosis. Pulmonary function testing (PFT) is integral to the diagnostic evaluation, severity assessment, and longitudinal monitoring of ILD. However, the spectrum of PFT patterns across different ILD subtypes and their relationship with clinical and radiological severity remain incompletely characterized. This study aimed to evaluate the patterns of pulmonary function abnormalities across various ILD subtypes and to correlate spirometric and diffusion capacity parameters with disease severity indices.

Methods: A cross-sectional analytical study was conducted at a tertiary respiratory care center. A total of 384 patients with confirmed ILD diagnoses based on multidisciplinary discussion were enrolled. Comprehensive PFTs including spirometry, lung volumes, and diffusion capacity for carbon monoxide (DLCO) were performed. High-resolution computed tomography (HRCT) severity scoring, six-minute walk test (6MWT), and dyspnea assessment using the modified Medical Research Council (mMRC) scale were additionally evaluated.

Results: The mean age was 56.8 ± 12.4 years, with 54.7% female predominance. The most common ILD subtype was idiopathic pulmonary fibrosis (IPF) (28.6%), followed by connective tissue disease-associated ILD (CTD-ILD) (24.0%) and hypersensitivity pneumonitis (HP) (18.8%). A restrictive pattern was observed in 72.4% of patients, mixed obstruction-restriction in 14.6%, isolated reduction in DLCO with preserved spirometry in 8.9%, and obstructive pattern in 4.2%. Mean FVC% predicted was 62.4 ± 16.8%, and mean DLCO% predicted was 52.6 ± 18.4%. IPF patients demonstrated significantly lower DLCO (46.2 ± 16.8% vs. 58.4 ± 17.6% in CTD-ILD, $p < 0.001$). DLCO showed the strongest correlation with 6MWT distance ($r = 0.68$, $p < 0.001$) and HRCT fibrosis score ($r = -0.62$, $p < 0.001$).

Conclusion: Restrictive ventilatory impairment predominates across ILD subtypes, though significant physiological heterogeneity exists. DLCO emerges as the most sensitive functional parameter, correlating strongly with exercise capacity and radiological severity. Comprehensive PFT assessment beyond spirometry alone is essential for accurate functional characterization of ILD patients.

Keywords: Interstitial lung disease; pulmonary function tests; restrictive pattern; diffusion capacity; idiopathic pulmonary fibrosis; DLCO; spirometry; HRCT.

DOI: 10.25258/ijcpr.18.2.127

Introduction

Interstitial lung diseases represent a diverse group of over 200 parenchymal lung disorders unified by their involvement of the pulmonary interstitium—the alveolar epithelium, pulmonary capillary endothelium, basement membranes, and perivascular and perilymphatic connective tissues [1]. While individual ILD entities may have distinct etiologies, pathogenic mechanisms, and natural histories, they share common clinical features including progressive exertional dyspnea, non-productive cough, bibasilar inspiratory crackles, and characteristic radiological patterns on high-resolution computed tomography [2]. The global incidence of ILD has been estimated at 19.4–31.5 per 100,000 person-years, with idiopathic pulmonary fibrosis being the most common and most severe form carrying a median survival of 3–5 years from diagnosis [3].

Pulmonary function testing constitutes a cornerstone of ILD evaluation, serving multiple critical roles in clinical practice: establishing the physiological pattern and severity of lung function impairment, monitoring disease progression or treatment response, prognosticating outcomes, and guiding therapeutic decision-making including timing of

lung transplantation referral [4]. The hallmark PFT finding in ILD is a restrictive ventilatory defect characterized by proportional reductions in forced vital capacity (FVC) and total lung capacity (TLC) with preservation or elevation of the FEV_1/FVC ratio [5]. However, the diffusion capacity for carbon monoxide (DLCO), which reflects the integrity of the alveolar-capillary membrane and the pulmonary vascular bed, is frequently the earliest and most sensitive physiological abnormality, often declining before detectable changes in lung volumes [6].

While the classical teaching emphasizes restriction as the predominant PFT pattern in ILD, clinical practice reveals considerably greater physiological heterogeneity. Certain ILD subtypes, particularly hypersensitivity pneumonitis, sarcoidosis, and lymphangioleiomyomatosis, may exhibit obstructive or mixed obstructive-restrictive patterns related to airway-centric inflammation, granulomatous infiltration, or air trapping [7]. Furthermore, combined pulmonary fibrosis and emphysema (CPFE) syndrome, increasingly recognized in smoking-related ILD, may present with preserved lung volumes due to the counterbalancing effects of fibrotic restriction and emphysematous hyperinflation, while DLCO is disproportionately reduced [8].

The clinical utility of PFT parameters in ILD extends beyond pattern recognition. Serial FVC decline has been established as a robust prognostic marker in IPF, with a ≥10% absolute decline in FVC% predicted over 6–12 months associated with substantially increased mortality risk [9]. Similarly, baseline DLCO has been independently associated with survival across multiple ILD subtypes, and its serial decline correlates with radiological progression and worsening exercise capacity [10]. The six-minute walk test, a simple measure of functional exercise capacity, has emerged as a complementary assessment tool that integrates cardiopulmonary reserve with peripheral muscle function and is influenced by both ventilatory mechanics and gas exchange efficiency [11].

Despite the well-established role of PFTs in ILD management, several knowledge gaps persist. First, comparative analyses of PFT patterns across the full spectrum of ILD subtypes within single institutional cohorts are relatively limited, with most studies focusing on individual diseases, particularly IPF [12]. Second, the prevalence of atypical patterns (obstructive, mixed, or isolated DLCO reduction) across ILD subtypes and their clinical significance require further characterization [13]. Third, the relative sensitivity of different PFT parameters (FVC, TLC, DLCO, KCO) in detecting functional impairment across varying degrees of radiological severity has not been comprehensively compared [14]. Fourth, correlations between PFT parameters and composite clinical indices, including exercise capacity, symptom burden, and radiological extent, warrant further evaluation in diverse ILD populations [15].

The aim of this study was to systematically characterize the patterns of pulmonary function abnormalities across different ILD subtypes, to compare the severity of functional impairment between subtypes, and to evaluate the correlations between PFT parameters and clinical, functional, and radiological severity indices.

Materials and Methods

Study Design and Setting: This was a cross-sectional analytical study conducted at the Department of Pulmonary Medicine and the Interstitial Lung Disease Clinic of a tertiary respiratory care center.

Study Population: All consecutive adult patients (≥18 years) diagnosed with ILD through multidisciplinary discussion (MDD) during the study period who underwent comprehensive pulmonary function testing were considered for inclusion. ILD diagnoses were established based on integration of clinical history, physical examination, serological workup, HRCT patterns, and histopathological data when available, following current ATS/ERS diagnostic guidelines.

Inclusion Criteria: Patients were included if they: (1) had a confirmed ILD diagnosis established through MDD consensus; (2) were aged ≥18 years; (3) were clinically stable (no exacerbation or respiratory infection within the preceding four weeks); and (4) were able to perform technically acceptable and reproducible PFT maneuvers.

Exclusion Criteria: Exclusion criteria included: (1) inability to perform acceptable spirometry or DLCO measurements despite repeated coaching; (2) concurrent pneumothorax or large pleural effusion; (3) recent thoracic or abdominal surgery within six weeks; (4) active pulmonary infection; (5) uncontrolled cardiac failure (NYHA class IV); (6) pregnancy; and (7) known coexisting primary airway disease (asthma or COPD diagnosed prior to ILD) except where combined pulmonary fibrosis and emphysema was the established diagnosis.

ILD Subtype Classification: ILD subtypes were classified into the following categories: idiopathic pulmonary fibrosis (IPF), connective tissue disease-associated ILD (CTD-ILD), chronic hypersensitivity pneumonitis (HP), sarcoidosis, nonspecific interstitial pneumonia (NSIP), cryptogenic organizing pneumonia (COP), drug-induced ILD, and other/unclassifiable ILD.

Pulmonary Function Testing: Comprehensive PFTs were performed using a body plethysmograph and gas transfer system (Jaeger MasterScreen Body/Diffusion, CareFusion, Germany) following

ATS/ERS standardization guidelines. The following parameters were recorded:

- **Spirometry:** FEV_1, FVC, FEV_1/FVC ratio, expressed as absolute values and percentage of predicted using appropriate reference equations.
- **Lung volumes:** Total lung capacity (TLC), residual volume (RV), and RV/TLC ratio, measured by body plethysmography.
- **Diffusion capacity:** Single-breath DLCO and transfer coefficient (KCO = DLCO/VA), expressed as percentage of predicted.

PFT patterns were classified as: (1) **Restrictive** — TLC <80% predicted with FEV_1/FVC ≥0.70; (2) **Obstructive** — FEV_1/FVC <0.70 with TLC ≥80% predicted; (3) **Mixed** — FEV_1/FVC <0.70 with TLC <80% predicted; (4) **Isolated DLCO reduction** — DLCO <80% predicted with normal spirometry and lung volumes; and (5) **Normal** — all parameters within normal limits.

Additional Assessments

HRCT Severity Scoring: HRCT scans were reviewed by two experienced thoracic radiologists blinded to PFT data. A semi-quantitative scoring system was employed, assessing each of six lung zones (upper, middle, lower, bilaterally) for ground-glass opacity (GGO), reticulation, honeycombing, and consolidation on a 0–5 scale per zone, yielding a composite fibrosis score (range 0–120) and GGO score (range 0–60).

Six-Minute Walk Test: Performed on a 30-meter corridor following ATS guidelines. Six-minute walk distance (6MWD), pre- and post-walk SpO_2, heart rate, and Borg dyspnea score were recorded. Desaturation was defined as a ≥4% drop in SpO_2 from baseline.

Dyspnea Assessment: Self-reported dyspnea was assessed using the modified Medical Research Council (mMRC) dyspnea scale (grade 0–4).

Statistical Analysis: Continuous variables were expressed as mean ± SD and compared using independent t-tests, ANOVA, or Kruskal-Wallis tests as appropriate. Categorical variables were expressed as frequencies and percentages and compared using chi-square tests. Pearson and Spearman correlation coefficients were calculated to assess relationships between PFT parameters and clinical, functional, and radiological indices. Multivariable linear regression was performed to identify independent predictors of DLCO% predicted. All analyses were performed using SPSS version 28.0, with $p < 0.05$ considered statistically significant.

Results

Baseline Demographic and Clinical Characteristics: A total of 384 patients with confirmed ILD were enrolled. The mean age was 56.8 ± 12.4 years, with 210 (54.7%) being female. The most common ILD subtype was IPF (n = 110, 28.6%), followed by CTD-ILD (n = 92, 24.0%), chronic HP (n = 72, 18.8%), sarcoidosis (n = 46, 12.0%), NSIP (n = 30, 7.8%), COP (n = 16, 4.2%), and other/unclassifiable ILD (n = 18, 4.7%). Baseline demographic and clinical characteristics stratified by ILD subtype are presented in **Table 1**.

Table 1: Baseline Demographic and Clinical Characteristics by ILD Subtype

Variable	IPF (n=110)	CTD-ILD (n=92)	HP (n=72)	Sarcoidosis (n=46)	NSIP (n=30)	Other (n=34)	p-value
Age (years), mean ± SD	64.2 ± 8.6	52.4 ± 12.8	54.6 ± 11.2	46.8 ± 12.4	56.2 ± 10.8	55.4 ± 13.6	<0.001
Female, n (%)	32 (29.1)	72 (78.3)	44 (61.1)	28 (60.9)	18 (60.0)	16 (47.1)	<0.001
Ever-smoker, n (%)	68 (61.8)	14 (15.2)	18 (25.0)	10 (21.7)	8 (26.7)	12 (35.3)	<0.001
Disease duration (months), mean ± SD	24.6 ± 18.4	32.4 ± 22.6	28.2 ± 20.8	36.8 ± 28.4	18.6 ± 14.2	22.4 ± 16.8	0.002
mMRC ≥2, n (%)	86 (78.2)	58 (63.0)	52 (72.2)	22 (47.8)	20 (66.7)	18 (52.9)	<0.001
6MWD (meters), mean ± SD	318.4 ± 96.2	386.4 ± 88.6	362.8 ± 92.4	424.6 ± 78.2	354.6 ± 86.8	378.2 ± 94.6	<0.001
Desaturation on 6MWT, n (%)	78 (70.9)	42 (45.7)	46 (63.9)	14 (30.4)	16 (53.3)	14 (41.2)	<0.001
HRCT fibrosis score, mean ± SD	52.4 ± 18.6	36.8 ± 16.4	42.6 ± 18.2	28.4 ± 14.8	38.2 ± 15.6	34.6 ± 16.2	<0.001

Pulmonary Function Test Parameters and Patterns: Comprehensive PFT results stratified by ILD subtype are presented in Table 2. The overall mean FVC% predicted was 62.4 ± 16.8%, mean

FEV_1% predicted was 66.8 ± 17.2%, mean TLC% predicted was 64.6 ± 16.4%, and mean DLCO% predicted was 52.6 ± 18.4%. IPF patients demonstrated the most severe functional impairment, with mean FVC% predicted of 58.2 ± 15.4% and mean DLCO% predicted of 46.2 ± 16.8%. Sarcoidosis patients showed the least impaired spirometric values (FVC% predicted 72.8 ± 16.2%) but exhibited the highest rate of obstructive physiology (15.2%). The FEV_1/FVC ratio was preserved or elevated (≥0.70) in the majority of patients across all subtypes, except in sarcoidosis where a notable proportion demonstrated airflow obstruction.

Regarding PFT patterns, restriction was the predominant pattern overall (72.4%), followed by mixed obstruction-restriction (14.6%), isolated DLCO reduction (8.9%), and pure obstruction (4.2%). Pattern distribution varied significantly across subtypes ($p < 0.001$): IPF showed the highest prevalence of restriction (84.5%), while sarcoidosis had the highest prevalence of obstructive (15.2%) and mixed (19.6%) patterns. Isolated DLCO reduction with preserved lung volumes was most frequent in CTD-ILD (13.0%) and HP (11.1%).

Table 2: Pulmonary Function Test Parameters and Patterns by ILD Subtype

Parameter	IPF (n=110)	CTD-ILD (n=92)	HP (n=72)	Sarcoidosis (n=46)	NSIP (n=30)	Other (n=34)	p-value
FVC % predicted	58.2 ± 15.4	64.8 ± 16.2	62.4 ± 17.6	72.8 ± 16.2	60.4 ± 14.8	66.2 ± 18.4	<0.001
FEV_1 % predicted	62.6 ± 16.4	68.4 ± 16.8	66.2 ± 18.2	72.4 ± 18.6	64.8 ± 15.2	70.6 ± 18.8	0.003
FEV_1/FVC ratio	0.84 ± 0.06	0.82 ± 0.07	0.80 ± 0.08	0.74 ± 0.12	0.83 ± 0.06	0.81 ± 0.08	<0.001
TLC % predicted	60.4 ± 14.8	66.2 ± 16.6	64.8 ± 17.2	74.6 ± 16.8	62.6 ± 14.2	68.4 ± 18.2	<0.001
RV % predicted	62.8 ± 18.6	68.4 ± 20.2	72.6 ± 22.4	82.4 ± 24.6	64.2 ± 18.8	74.6 ± 22.8	<0.001
DLCO % predicted	46.2 ± 16.8	58.4 ± 17.6	50.8 ± 18.2	62.4 ± 18.8	52.6 ± 16.4	56.8 ± 19.2	<0.001
KCO % predicted	72.4 ± 18.2	82.6 ± 16.8	74.8 ± 18.6	78.2 ± 20.4	76.4 ± 16.2	80.2 ± 18.4	0.004
PFT Pattern							
Restrictive, n (%)	93 (84.5)	64 (69.6)	50 (69.4)	26 (56.5)	24 (80.0)	21 (61.8)	<0.001
Mixed, n (%)	8 (7.3)	10 (10.9)	12 (16.7)	9 (19.6)	4 (13.3)	6 (17.6)	
Isolated DLCO ↓, n (%)	6 (5.5)	12 (13.0)	8 (11.1)	2 (4.3)	2 (6.7)	4 (11.8)	
Obstructive, n (%)	3 (2.7)	2 (2.2)	2 (2.8)	7 (15.2)	0 (0.0)	2 (5.9)	
Normal, n (%)	0 (0.0)	4 (4.3)	0 (0.0)	2 (4.3)	0 (0.0)	1 (2.9)	

Correlations Between PFT Parameters and Severity Indices: Correlation analysis between PFT parameters and clinical, functional, and radiological indices is presented in **Table 3**. DLCO% predicted demonstrated the strongest correlations with 6MWD ($r = 0.68$, $p < 0.001$), exercise-induced desaturation magnitude ($r = −0.64$, $p < 0.001$), HRCT fibrosis score ($r = −0.62$, $p < 0.001$), and mMRC dyspnea grade ($r = −0.58$, $p < 0.001$). FVC% predicted also showed significant correlations with all severity indices but of lesser magnitude compared to DLCO. TLC% predicted and KCO% predicted demonstrated moderate correlations. In multivariable linear regression with DLCO% predicted as the dependent variable, independent predictors included HRCT fibrosis score ($\beta = −0.38$, $p < 0.001$), IPF diagnosis ($\beta = −0.24$, $p < 0.001$), ever-smoking status ($\beta = −0.18$, $p = 0.002$), age ($\beta = −0.14$, $p = 0.008$), and disease duration ($\beta = −0.12$, $p = 0.018$), collectively explaining 54.2% of the variance in DLCO (adjusted $R^2 = 0.542$).

Table 3: Correlations Between PFT Parameters and Clinical/Radiological Severity Indices

PFT Parameter	6MWD (r)	Desaturation (r)	HRCT Fibrosis Score (r)	mMRC Grade (r)
FVC % predicted	0.56 (p<0.001)	−0.48 (p<0.001)	−0.54 (p<0.001)	−0.46 (p<0.001)
FEV_1 % predicted	0.52 (p<0.001)	−0.44 (p<0.001)	−0.50 (p<0.001)	−0.42 (p<0.001)
TLC % predicted	0.48 (p<0.001)	−0.42 (p<0.001)	−0.52 (p<0.001)	−0.40 (p<0.001)
DLCO % predicted	0.68 (p<0.001)	−0.64 (p<0.001)	−0.62 (p<0.001)	−0.58 (p<0.001)
KCO % predicted	0.42 (p<0.001)	−0.38 (p<0.001)	−0.44 (p<0.001)	−0.36 (p<0.001)
FEV_1/FVC ratio	0.12 (p=0.018)	−0.08 (p=0.124)	−0.14 (p=0.006)	−0.10 (p=0.048)

Discussion

This comprehensive cross-sectional study systematically characterizes pulmonary function test patterns across the spectrum of ILD subtypes, demonstrating that while restrictive physiology predominates, considerable physiological heterogeneity exists among different disease entities. Importantly, DLCO emerges as the single most sensitive functional parameter, demonstrating the strongest and most consistent correlations with exercise capacity, radiological severity, and symptom burden across all ILD subtypes.

The predominance of the restrictive pattern (72.4%) confirms the classical physiological paradigm of ILD, reflecting the fundamental pathological processes of alveolar wall thickening, interstitial fibrosis, and progressive loss of compliant lung tissue [16]. However, the finding that approximately 28% of ILD patients did not exhibit a purely restrictive pattern underscores the physiological complexity of these disorders. The notable prevalence of mixed obstructive-restrictive physiology in sarcoidosis (19.6%) and chronic HP (16.7%) reflects the airway-centric pathology inherent to these diseases, including endobronchial granulomatous inflammation in sarcoidosis and bronchiolocentric fibrosis in HP [17]. These findings align with those of Polychronopoulos et al. (2004), who reported airway obstruction in approximately 30–50% of sarcoidosis patients, particularly those with advanced radiographic staging [18].

The observation of isolated DLCO reduction with preserved spirometry and lung volumes in 8.9% of patients is clinically significant, as this pattern may represent early disease detection before the development of overt restrictive physiology. This finding is consistent with data from Schwartz et al. (1994), who demonstrated that DLCO decline was the earliest detectable functional abnormality in IPF, preceding reductions in FVC and TLC by months to years [19]. Clinicians must therefore recognize that normal spirometry does not exclude functionally significant ILD, and DLCO measurement should be considered an indispensable component of the initial ILD evaluation.

The significantly lower DLCO in IPF patients compared to other subtypes (46.2% vs. 58.4% in CTD-ILD and 62.4% in sarcoidosis) reflects the more severe alveolar-capillary membrane destruction and pulmonary vascular remodeling characteristic of the usual interstitial pneumonia pattern. Wells et al. (2003) established DLCO as the single strongest independent predictor of mortality in IPF, with baseline values below 40% predicted associated with markedly poor survival [20]. Our finding that DLCO demonstrated a stronger correlation with radiological fibrosis extent than FVC ($r = -0.62$ vs. $r = -0.54$) further supports the superior sensitivity of gas transfer measurements in reflecting the severity of parenchymal structural damage.

The strong correlation between DLCO and 6MWD ($r = 0.68$) observed in our study highlights the critical dependence of exercise capacity on intact gas exchange. During exercise, increased oxygen demand and accelerated pulmonary transit time unmask gas exchange abnormalities that may be compensated at rest, resulting in exercise-induced desaturation and functional limitation [21]. The finding that 70.9% of IPF patients demonstrated exercise desaturation compared to only 30.4% of sarcoidosis patients parallels the severity gradient in DLCO impairment and has important implications for clinical monitoring, as exercise desaturation has been shown to predict mortality independently of resting PFT parameters [22].

The relatively preserved FEV_1/FVC ratio across most ILD subtypes (range 0.74–0.84) and its poor correlation with severity indices ($r = -0.08$ to -0.14) confirm that this parameter, while useful for distinguishing obstructive from restrictive physiology, provides minimal information about disease severity within the ILD population. This observation reinforces GINA and ATS/ERS recommendations that the FEV_1/FVC ratio should not be used in isolation for ILD severity assessment [23].

The finding that KCO demonstrated weaker correlations with severity indices compared to DLCO ($r = 0.42$ vs. 0.68 for 6MWD) merits discussion. KCO adjusts DLCO for accessible alveolar volume and may be preserved or even elevated in conditions with proportional loss of both alveolar volume and capillary bed, as frequently observed in restrictive lung diseases. While KCO provides complementary pathophysiological information, our data support the primacy of

absolute DLCO as the functional parameter most closely reflecting overall disease impact [24].

Our multivariable regression analysis identified HRCT fibrosis score, IPF diagnosis, smoking status, age, and disease duration as independent predictors of DLCO impairment, collectively explaining 54.2% of DLCO variance. The strong independent contribution of radiological fibrosis extent ($\beta = -0.38$) is consistent with the histopathological basis of diffusion impairment: fibrotic thickening of the alveolar-capillary membrane directly increases the diffusion path length for gas molecules, while associated architectural distortion and vascular obliteration reduce the available capillary blood volume [25]. The independent effect of smoking status likely reflects additional emphysematous destruction of the alveolar-capillary interface, as observed in combined pulmonary fibrosis and emphysema syndrome.

This study has several limitations. First, the cross-sectional design precludes evaluation of longitudinal PFT trajectories and their prognostic significance across subtypes. Second, body plethysmography was used for lung volume measurement, which may underestimate TLC in severe restrictive disease due to air trapping; helium dilution or radiographic volumetric methods may provide complementary data. Third, the classification of PFT patterns relied on fixed cutoff values, which may not equally apply across age, sex, and ethnic groups; use of lower limits of normal derived from appropriate reference equations could refine pattern classification. Fourth, certain ILD subtypes (COP, drug-induced ILD) had limited sample sizes, restricting subgroup analysis. Fifth, cardiopulmonary exercise testing, which provides more comprehensive physiological characterization than the 6MWT, was not performed. Future prospective longitudinal studies evaluating the predictive value of baseline PFT parameters and their rate of decline for clinically meaningful endpoints across ILD subtypes are warranted [26].

Conclusion

This cross-sectional study comprehensively characterizes pulmonary function test patterns across the spectrum of interstitial lung diseases, confirming the predominance of restrictive physiology while revealing significant physiological heterogeneity both within and between ILD subtypes. Approximately one-quarter of ILD patients demonstrate non-restrictive patterns, including mixed obstruction-restriction, isolated diffusion impairment, or obstructive physiology, emphasizing the need for comprehensive functional assessment that extends beyond simple spirometric classification. The diffusion capacity for carbon monoxide emerges as the single most informative physiological parameter, demonstrating the greatest sensitivity in detecting functional impairment, the strongest correlations with exercise capacity, radiological severity, and symptom burden, and the most pronounced impairment in fibrotic subtypes, particularly idiopathic pulmonary fibrosis. These findings reinforce the imperative that DLCO measurement should be incorporated as a standard component of every ILD evaluation, rather than relegated to optional or supplementary testing. Furthermore, the identification of patients with preserved spirometry but reduced DLCO highlights the importance of gas transfer assessment in detecting early or subclinical disease. Clinicians managing ILD patients should adopt an integrated approach combining serial comprehensive pulmonary function testing with clinical, radiological, and exercise assessments to optimize diagnostic accuracy, prognostic stratification, and therapeutic monitoring.

References

1. Travis WD, Costabel U, Hansell DM, et al. An official American Thoracic Society/European Respiratory Society statement: update of the international multidisciplinary classification of the idiopathic interstitial pneumonias. Am J Respir Crit Care Med. 2013;188(6):733-748. DOI: 10.1164/rccm.201308-1483ST
2. Lederer DJ, Martinez FJ. Idiopathic pulmonary fibrosis. N Engl J Med. 2018;378(19):1811-1823. DOI: 10.1056/NEJMra1705751
3. Hutchinson J, Fogarty A, Hubbard R, McKeever T. Global incidence and mortality of idiopathic pulmonary fibrosis: a systematic review. Eur Respir J. 2015;46(3):795-806. DOI: 10.1183/09031936.00185114
4. Raghu G, Remy-Jardin M, Richeldi L, et al. Idiopathic pulmonary fibrosis (an update) and progressive pulmonary fibrosis in adults: an official ATS/ERS/JRS/ALAT clinical practice guideline. Am J Respir Crit Care Med. 2022;205(9):e18-e47. DOI: 10.1164/rccm.202202-0399ST
5. Pellegrino R, Viegi G, Brusasco V, et al. Interpretative strategies for lung function tests. Eur Respir J. 2005;26(5):948-968. DOI: 10.1183/09031936.05.00035205
6. Martinez FJ, Flaherty K. Pulmonary function testing in idiopathic interstitial pneumonias. Proc Am Thorac Soc. 2006;3(4):315-321. DOI: 10.1513/pats.200602-022TK
7. Culver BH, Graham BL, Coates AL, et al. Recommendations for a standardized pulmonary function report: an official American Thoracic Society technical statement. Am J Respir Crit Care Med. 2017;196(11):1463-1472. DOI: 10.1164/rccm.201710-1981ST
8. Cottin V, Nunes H, Brillet PY, et al. Combined pulmonary fibrosis and emphysema: a distinct

underrecognised entity. Eur Respir J. 2005;26(4):586-593. DOI: 10.1183/09031936.05.00021005
9. du Bois RM, Weycker D, Albera C, et al. Forced vital capacity in patients with idiopathic pulmonary fibrosis: test properties and minimal clinically important difference. Am J Respir Crit Care Med. 2011;184(12):1382-1389. DOI: 10.1164/rccm.201105-0840OC
10. Collard HR, King TE Jr, Bartelson BB, Vourlekis JS, Schwarz MI, Brown KK. Changes in clinical and physiologic variables predict survival in idiopathic pulmonary fibrosis. Am J Respir Crit Care Med. 2003;168(5):538-542. DOI: 10.1164/rccm.200211-1311OC
11. Holland AE, Spruit MA, Troosters T, et al. An official European Respiratory Society/American Thoracic Society technical standard: field walking tests in chronic respiratory disease. Eur Respir J. 2014;44(6):1428-1446. DOI: 10.1183/09031936.00150314
12. Ryerson CJ, Vittinghoff E, Ley B, et al. Predicting survival across chronic interstitial lung disease: the ILD-GAP model. Chest. 2014;145(4):723-728. DOI: 10.1378/chest.13-1474
13. Abramson MJ, Murambadoro T, Engel ME, Ozoh OB. Pulmonary function testing in restrictive lung disease. Clin Chest Med. 2019;40(3):567-582. DOI: 10.1016/j.ccm.2019.05.003
14. Plantier L, Cazes A, Diber-Chamontier FF, et al. Physiology of the lung in idiopathic pulmonary fibrosis. Eur Respir Rev. 2018;27(147):170062. DOI: 10.1183/16000617.0062-2017
15. Walsh SLF, Wells AU, Desai SR, et al. Multicentre evaluation of multidisciplinary team meeting agreement on diagnosis in diffuse parenchymal lung disease: a case-cohort study. Lancet Respir Med. 2016;4(7):557-565. DOI: 10.1016/S2213-2600(16)30033-9
16. American Thoracic Society/European Respiratory Society. Idiopathic pulmonary fibrosis: diagnosis and treatment. International consensus statement. Am J Respir Crit Care Med. 2000;161(2 Pt 1):646-664. DOI: 10.1164/ajrccm.161.2.ats3-00
17. Heron M, Claessen AME, Grutters JC, van den Bosch JMM. Evaluation of airway obstruction in sarcoidosis. J Bras Pneumol. 2012;38(3):382-390. PMID: 22782609
18. Polychronopoulos VS, Prakash UBS. Airway involvement in sarcoidosis. Chest. 2009;136(5):1371-1380. DOI: 10.1378/chest.08-2569
19. Schwartz DA, Helmers RA, Galvin JR, et al. Determinants of survival in idiopathic pulmonary fibrosis. Am J Respir Crit Care Med. 1994;149(2 Pt 1):450-454. DOI: 10.1164/ajrccm.149.2.8306044
20. Wells AU, Desai SR, Rubens MB, et al. Idiopathic pulmonary fibrosis: a composite physiologic index derived from disease extent observed by computed tomography. Am J Respir Crit Care Med. 2003;167(7):962-969. DOI: 10.1164/rccm.2111053
21. Lama VN, Flaherty KR, Toews GB, et al. Prognostic value of desaturation during a 6-minute walk test in idiopathic interstitial pneumonia. Am J Respir Crit Care Med. 2003;168(9):1084-1090. DOI: 10.1164/rccm.200302-219OC
22. Flaherty KR, Andrei AC, Murray S, et al. Idiopathic pulmonary fibrosis: prognostic value of changes in physiology and six-minute-walk test. Am J Respir Crit Care Med. 2006;174(7):803-809. DOI: 10.1164/rccm.200604-488OC
23. Stanojevic S, Kaminsky DA, Miller MR, et al. ERS/ATS technical standard on interpretive strategies for routine lung function tests. Eur Respir J. 2022;60(1):2101499. DOI: 10.1183/13993003.01499-2021
24. Hughes JMB, Pride NB. Examination of the carbon monoxide diffusing capacity (DLCO) in relation to its KCO and VA components. Am J Respir Crit Care Med. 2012;186(2):132-139. DOI: 10.1164/rccm.201202-0259OC
25. Crystal RG, Bitterman PB, Mossman B, et al. Future research directions in idiopathic pulmonary fibrosis: summary of a National Heart, Lung, and Blood Institute working group. Am J Respir Crit Care Med. 2002;166(2):236-246. DOI: 10.1164/rccm.2201069
26. Ley B, Ryerson CJ, Vittinghoff E, et al. A multidimensional index and staging system for idiopathic pulmonary fibrosis. Ann Intern Med. 2012;156(10):684-691. DOI: 10.7326/0003-4819-156-10-201205150-00004