Original Article

©2025 NRITLD, *National Research Institute of Tuberculosis and Lung Disease, Iran*

ISSN: 1735-0344 *Tanaffos 2025; 24(1): 88-96*

TANAFFOS

Comparison of IOS and Body Plethysmography Findings in Patients with Interstitial Lung Disease

Sanaz Soleimani [1], **Jalal Heshmatnia** [2], **Mohsen Sadeghi** [2], **Alireza Eslaminejad** [2]

[1] Department of Pulmonology, Shahid Beheshti University of Medical Sciences, Shohada-ye-Tajrish Hospital, Tehran, Iran, [2] Chronic Respiratory Diseases Research Center, National Research Institute of Tuberculosis and Lung Diseases (NRITLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran.

Received: 11 June 2024

Accepted: 9 December 2024

Correspondence to: Eslaminejad A

Address: Chronic Respiratory Diseases Research Center, NRITLD, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Email address: eslaminejadalireza@yahoo.com

Background: In patients with ILD, the static expiratory pressure-volume curve of the lung is generally shifted downward and to the right, and spirometry results reveal reduced vital capacity. However, decreased vital capacity may occur even in patients with obstructive lung diseases and in other situations, such as chest wall restriction, lung resection, inspiratory muscle weakness, or poor cooperation with spirometry. In addition, spirometry is sometimes difficult to perform with elderly, cognitively impaired patients or with severe respiratory distress. IOS is a simple, non-invasive method requiring only passive patient cooperation that allows for the evaluation of lung function through the measurement of both airway resistance and airway reactance. This study aims to assess the role of IOS in the evaluation of cases of interstitial lung diseases.

Materials and Methods: This study included 53 patients with interstitial lung diseases of different causes. Pulmonary function test by spirometry was done to measure FEV1, FVC, FEV1/FVC, MEF25-75, and pulmonary function test by impulse oscillometry (IOS). We measured R5, R20, X5, RF.

Results: Examining the indicators evaluated based on IOS shows that the numerical values of R5 have not increased significantly. Regarding R20 and R5-R20, exhalation values are more than two, and as a result, the interval (exp-insp) is a positive number. The values of X5, AX, and Fres increased as expected (213%).

Conclusion: X5 was lower in patients with ILD, indicating a restrictive pattern. Conversely, there is a negative correlation between X5 and FVC. Based on the numerical values of R5 and R20, it can be inferred that patients experience small airway obstruction.

Keywords: ILD; IOS; Body Plethysmography

INTRODUCTION

Interstitial lung disease (ILD) is a group of lung diseases with various clinical and histopathological characteristics, causing physiologic abnormalities and restricted ventilation. The disease is usually determined by a shifted pressure-volume curve to the right and down during exhalation, to finally decreased vital capacity in spirometry. Decreased vital capacity is also seen in obstructive pulmonary disease and other conditions such as chest wall limitation, lung resection, respiratory muscle weakness, or poor cooperation (1-3).

The Forced Oscillation Technique (FOT) was first introduced by Dubois et al. (4) in 1956 to evaluate lung function using single-frequency sound waves. It was used to achieve a better view of the lung mechanism than simple spirometry. Later in 1975, Michaelson and colleagues (5) developed a technique that used multiple-frequency sound waves called the Impulse Oscillometry System (IOS) as a variant of FOT to assess the mechanism of the lung in a passive manner requiring the least cooperation from patients. It works with sound waves through normal tidal breathing by evaluating air flow and pressure in the airways to ultimately measure respiratory resistance, reactance, and impedance (6). Thanks to its high sensitivity in airway resistance determination, FOT was used earlier in patients with obstructive pulmonary diseases. Furthermore, due to accurate indication of flow limitations by FOT, Dellaca et al. (7) clarified that reactance could be measured separately during inhalation and exhalation.

To the best of our knowledge, although no published data exist regarding inhaled–exhaled analysis of oscillometry in ILD, this technique has failed to differentiate obstructive from restrictive lung diseases. However, it has proven useful in distinguishing COPD from asthma, which often shows similar degrees of airway limitation on spirometry. Moreover, variations in X5 between inhalation and exhalation—particularly the magnitude of its negative values—may provide additional insights for distinguishing restrictive from obstructive ventilatory defects (8).

Respiratory resistance is a component of lung impedance, which includes the total resistance of the oropharynx, larynx, trachea, small and large airways, in addition to lung parenchyma and chest. This technique uses two prominent frequencies, namely 5 Hz and 20 Hz, as main indicators. The higher the frequency of the waves, the shorter the distance the waves travel into the airways.

Respiratory reactance is another part of lung impedance, which reflects the properties of capacitance and inertance. Reactance at 5Hz frequency (X5) shows the elastic recoil in peripheral airways that decreases in fibrosis and hyperinflation to obtain higher negative values. Resonant frequency (Fres), another parameter, is defined by the frequency at which the airway inertance and the peripheral capacitance of the lung are equal, and the overall reactance is zero at this point. Fres is normally ranged between 5-11 Hz, increasing in peripheral obstructive conditions as well as fibrosis. Area of reactance (Ax), the space under the reactance curve, is a set of low-frequency respiratory reactance located at a frequency between 5Hz and Fres.

The current study aimed to evaluate IOS findings and compare them with body plethysmography in ILD to find and offer ways to determine the disease, as well as predict lung tissue changes, in addition to estimating the severity of lung parenchymal involvement. Also, we tried to introduce a more user-friendly module in this regard, which needs the least patient cooperation instead of spirometry and body box, which require active patients to achieve optimal results.

MATERIALS AND METHODS

Through a cross-sectional prospective design, the current study aimed to evaluate the findings of body plethysmography and IOS in the referrals to a lung clinic in Tehran with interstitial lung disease (ILD) during the year from 2021 to 2022. The participants were included in the study through a census method. All the patients were 18 years old or over and declared their consent to participate before starting. Individuals with other lung diseases, such as asthma, COPD, and bronchogenic carcinoma, which may affect the results of the tests used, were excluded.

The participants were known cases of ILD through previous pulmonology visits and chest high-resolution CT-scan (HRCT) findings. Participants were asked to complete their demographic information, medical history, and current comorbidities, along with any medications they were using, during the interview. This information was recorded using a special study questionnaire. Body plethysmography and IOS were then conducted, and the findings were interpreted by our single pulmonologist. The research data from the Lung Tissue Research Consortium (LTRC) were considered in the chest radiography studies.

Statistics

The present study used SPSS 22 for analyzing the data. All the qualitative values were reported as mean±SD, and the qualitative/categorical data were reported by numbers and frequencies. The normal distribution of the data was examined using the Kolmogorov-Smirnov test, box plots, and normal probability. All of the statistical tests were performed in two domains at a significant level of 0.05 using the t-test.

We used the confidence interval of 95% and the type one error of 0.05 to consider $\beta=0.2$ and the power of the study equal to 0.8.

Ethics

The present study used no intervention, and all the patients were clearly informed about the aim, importance, and process of the research performance before giving their consent to participate. There was no extra charge for the tests, which were not routine in the process of treatment. There were also no more unnecessary visits to avoid any imposing hardship on the participants. The participants were able to quit whenever they wished, with no penalty or limitation of treatment.

RESULTS

A total of 53 patients with ILD were enrolled in the present study between February 19, 2021, and March 20, 2022, among whom 50 had complete data and were included in the final analysis. They included 32 males (64%) and 18 females (36%), as can be seen in Table 1. First, the study evaluated the findings of body plethysmography and IOS, separately, and then studied them to find any correlation between the data, as Tables 2-4 present.

Table 1. Demographic and basic data of the participants.

Index	Male(M±SD)	Female(M±SD)	Total (M±SD)
Age	56.21±1.55	54.33±1.11	55.54±1.4
Weight	75.4±1.52	74±1.19	74.9±1.4
Height	169±6.27	157±7.55	164±8.87
BMI	26.32±5.19	29.94±4.45	27.6±5.2

The numerical values of FEV1, TLC, and DLCO indices were lower than the lower limit normal (LLN), which is expected in ILD (Table 2).

Table 2. Means and other central indices of spirometry parameters

Variable	Mean±SD	Mod	Median	Min	Max	Range
FEV1 PRE	1.95±.8	1.22	1.79	.77	4.87	4.1
FEV1 REF	70.66±24.71	45	74	22	129	107
FVC em PRE	2.23±.94	1.62	1.99	.8	5.85	5.05
FVC em REF	65.14±22.94	49	66.5	25	124	99
FEV1/FVC PRE	88.78±6.54	91	89	66	100	34
DLCO PRE	4.41±2.06	4.67	4	.8	10.82	10
DLCO REF	53.81±23.06	35	47	20	113	93
RV PRE	1.66±.82	1.17	1.46	.57	5.33	4.76
RV REF	4.23±1.27	61	76	29	325	296
TLC PRE	69.3±17.52	3.25	3.97	2.05	7.7	5.65
TLC REF	34.88±6.86	64	67.7	41	111	70
RV/TLC PRE	34.88±6.86	36	36	16	50	34
RV/TLC REF	95.72±32.46	76	89	26	201	175

In terms of IOS parameters, Table 3 shows that R5 values had no dramatic increase (109.6%) while its expiratory values were bigger than inspiratory values to make the $R5_{exp\text{-}insp}$ parameter positive. Similarly, the values of R20 and R5-R20 had higher expiratory levels to finally shift their "expiratory-inspiratory" values positively. X5, as expected, was raised in ILD patients, compared to normal values up to 213%, with its higher absolute inspiratory values resulting in positive subtraction results of $X5_{exp\text{-}insp.}$

Turning to AX as a crucial parameter, it increased in ILD patients up to 3059 as its mean value. It also had higher values in inspiration than expiration to make negative $AX_{exp\text{-}insp}$ values.

The mean Fres was also increased, as expected, and among the spirometric parameters, the mean $MEF_{(25-75)}$% was above the lower limit of normal (LLN).

When comparing the two series of test findings, Table 4 summarizes a significant direct correlation of X5 and percentage with FVC and TLC. On the contrary, AX showed a significant reverse correlation with FVC and TLC.

Table 3. Means and other central indices of IOS parameters

Variable	Mean±SD	Mod	Median	Min	Max	Range
R5 pre	3.46±1.26	1.79	3.26	1.28	8.16	6.88
R5%pred	109.6±47.76	176	102.3	33	29.06	257.6
R5 $_{IN}$	3.25±1.17	4.45	3.25	1.32	6.58	5.26
R5 $_{EX}$	3.69±1.53	3.81	3.6	1.24	9.8	8.56
R5 $_{IN-EX}$	0.43±0.2	0.19	0.31	-0.49	3.22	3.71
R20 pre	2.81±1.2	2.29	2.76	1.13	8.05	6.92
R20 pred	99.06±42.62	163	87.6	34.6	251.6	217
R20 $_{IN}$	2.58±0.92	3.13	2.56	1.11	4.68	4.68
R20 $_{EX}$	2.77±1.1	4.02	2.69	1.12	6.38	5.26
R20 $_{IN-EX}$	0.19±0.9	0.18	0.12	-0.66	1.70	2.36
R5-R20 $_{IN}$	0.66±0.39	0.42	0.63	0	1.9	1.9
R5-R20 $_{EX}$	0.91±5.2	0.96	0.83	0.12	3.24	3.3
R5-R20 $_{IN-EX}$	0.24±0.12	-0.15	0.18	-0.23	1.52	1.75
X5 pre	1.22±1.06	-1.37	-1	-6.5	0.88	7.39
X5 pred	213±1.47	-1214	288.5	-6950	5000	11950
X5 $_{IN}$	-1.41±.79	-0.5	-1.28	-4.17	-0.16	4.01
X5 $_{EX}$	-1.24±9.4	-1.6	-0.94	-5.08	-0.06	5.02
X5 $_{IN-EX}$	0.006±0.004	0.21	0.21	-5.47	0.94	6.41
ALX pre	7.58±5.3	0.32	6.4	0.32	21.27	20.95
ALX pred	3059±826	62	548	62	4340	43338
ALX $_{IN}$	10.92±8.24	2.26	8.75	1.96	38.63	36.67
ALX $_{EX}$	10.08±1.01	9.89	7	1	53.45	52.5
ALX $_{IN-EX}$	-0.59±0.4	-1.61	-1.61	-7.71	7.63	15.34
Fres pre	15.86±5.23	4	15.93	4	29.55	25.55
Fres pred	161.84±78.7	88.5	144.6	30.28	38.38	353.52
Fres $_{IN}$	16.67±4.51	11.1	16.33	6.97	28.76	21.79
Fres $_{EX}$	17.29±5.55	19.17	16.59	5.72	33.09	27.27
Fres $_{IN-EX}$	0.62±0.3	0.14	0.18	-4.56	9.22	13.18
MEF2575REF	94.58±49.79	85	85.5	12	261	249
SRAW PRE	1.32±9.3	0.65	0.99	0.42	4.71	4.29
SRAW REF	205.19±142.5	89	150	62	739	677

Table 4. Correlation between IOS and spirometry parameters

		FEV1	FEV1/FVC PRE	MEF 2575	SRAW PRE	RV PRE	FVC PRE	TLC PRE	DLCO PRE	SRAW PRE
R5	**correlation**	-0.21	-0.21	-0.25	-0.19	-0.24	-	-	-	-
	sig	0.15	0.15	0.1	0.21	0.1	-	-	-	-
R5-R20 PRE	**correlation**	-0.25	-0.15	-0.23	0.15	-0.14		-	-	-
	sig	-0.06	0.3	0.11	0.3	0.35	-	-	-	-
AR5	**correlation**	-0.17	0.17	-0.08	-0.08	-0.28	-	-	-	-
	sig	0.24	0.23	0.57	0.58	0.05	-	-	-	-
X5 PRE	**correlation**	-	-	-	-	-	0.31	0.38	0.17	-0.13
	sig	-	-	-	-	-	0.3	0.009	0.25	0.39
AX5	**correlation**	-	-	-	-	-	-0.26	-0.13	-0.21	0.11
	sig	-	-	-	-	-	0.6	0.36	0.13	0.45
ALX PRE	**correlation**	-	-	-	-	-	-0.36	-0.35	-0.21	0.29
	sig	-	-	-	-	-	0.02	0.02	0.18	0.07
AALX	**correlation**	-	-	-	-	-	-0.02	-0.11	-0.01	0.03
	sig	-	-	-	-	-	0.88	0.43	0.9	0.83

All participants had CT scan evidence of ILD, and the findings showed that 68% of them had fibrotic changes, among whom 64.7% were male. Although not statistically significant, Table 5 indicates that the majority of patients with fibrotic ILD were male, and their mean age was higher compared with those without fibrosis.

Table 5. Comparison of demographics considering two groups of fibrotic and non-fibrotic ILD participants

Index	Fibrotic Group	None- Fibrotic	*P*-value
Cender (Male)(n%)	22(64.70%)	12(75%)	0.193
Age (M±SD)	57.117±13.675	52.187±14.565	0.107
Weight ((M±SD)	73.647±13.891	77.625±14.417	0.290
Height ((M±SD)	163.735±9.202	167.625±7.736	0.481

Further comparisons showed significantly higher mean values of FVC, TLC, and RV/TLC in the group of patients with fibrotic ILD, as presented in Table 6. In impulse oscillometry (IOS), this group also demonstrated significantly higher mean values of R5, R20, R20$_{(insp–exp)}$, R5–R20, and ALX$_{(insp–exp)}$.

In contrast, the non-fibrotic ILD group exhibited significantly higher mean values of R5–R20$_{(insp–exp)}$, X5, and MEF$_{25–75}$ (Table 7).

Table 6. Comparison of respiratory indices between fibrotic and non-fibrotic groups of ILD

Variable	Fibrotic Group	Non-Fibrotic	*P*-value
FEV1 PRE	1.842±804	2.207±0.761	0.081
FEV1 PEF	67.371±27.897	69.240±27.957	0.260
FVC em PRE	8.570±37.069	2.488±0.914	0.003
FVC em REF	62.155±25.912	63.847±25.488	0.108
FEV1/FVC PRE	86.545±12.160	89.600±7.917	0.097
DLCO PRE	4.273±1.995	4.715±2.251	0.100
DLCO REF	50.810±24.896	50.290±25.041	0.089
RV PRE	1.799±0.921	1.376±0.498	0.401
RV REF	91.279±58.763	68.592±27.504	0.051
TLC PRE	6.975±15.675	4.190±1.220	0.042
TLC REF	67.642±23.742	63.483±21.807	0.119
RV/TLC PRE	35.315±8.488	27.356±12.591	0.0053
RV/TLC REF	102.968±33.784	81.250±24.650	0.040

Table 7. Comparison of IOS indices between fibrotic and non-fibrotic ILD participants

Variable	Fibrotic Group	Non–Fibrotic	*P*-value
R5 pre	63.11±346.661	14.41±71.774	0.000
R5 % pred	106.88±52.27	115.980±36.29	0.101
R5 $_{IN}$	3.182±1.262	3.402±0.987	0.084
R5 $_{EX}$	3.570±1.678	3.950±1.198	0.221
R5 $_{IN- EX}$	0.387±0.664	0.548±0.540	0.053
R20pre	2.791±1.373	-28.891±119.085	0.000
R20pred	94.450±45.193	109.520±35.310	0.093
R20 $_{IN}$	2.472±0.964	2.821±0.799	0.071
R20 $_{EX}$	2.633±1.151	3.0655±0.970	0.080
R20 $_{IN-EX}$	0.387±0.664	0.243±0.447	0.047
R5 –R20 $_{IN}$	0.710±0.419	0.580±0.329	0.040
R5- R20 $_{EX}$	0.925±0.598	0.885±0.359	0.189
R5-R20 $_{IN-EX}$	0.215±0.351	0.305±0.253	0.039
X5pre	-1.341±1.331	4.082±20.138	0.000
X5 pred	294.145±715.709	235.50±5156.71	0.092
X5 $_{IN}$	-1.483±0.920	-1.262±0.413	0.100
X5 $_{EX}$	-1.535±1.731	-1.133±0.550	0.0130
X5 $_{IN-EX}$	-0.051±1.117	0.129±0.465	0.009
ALX pre	12.341±14.837	309923±148.689	0.000
ALX pred	1605±5332	6758±12732	0.066
ALX $_{IN}$	11.447±9.624	8.525±4.092	0.254
ALX $_{EX}$	13.275±19.913	8.626±5.943	0.220
ALX $_{IN-EX}$	1.828±12.859	0.101±4.396	0.001
Fres pre	16.419±5.009	14.727±5.676	0.060
Fres pred	144.1851	289.36±294.600	0.039
Fres $_{IN}$	17.040±4.888	15.899±3.627	0.100
Fres $_{EX}$	17.479±5.998	16.897±4.635	0.167
Fres $_{IN-EX}$	0.439±2.880	1.004±3.434	0.096
MEF2575 REF	84.740±1.516	92.746±59.909	0.031
SRAW PRE	1.410±1.018	1.133±0.710	0.064
SRAW REF	207.067±158.907	162.978±116.503	0.099

DISCUSSION

The present study investigated the comparative performance of impulse oscillometry (IOS) and body plethysmography in patients with interstitial lung disease (ILD). Our findings offer valuable insights into the relative strengths and limitations of these two modalities in assessing lung mechanics and parenchymal involvement in ILD, highlighting several important implications for both clinical practice and future research.

Historically, IOS (and the related forced oscillation technique, FOT) has been used predominantly in obstructive airway diseases, particularly for small airways dysfunction and effort-independent testing (9, 10). However, more recent investigations have extended its use to restrictive and mixed pathologies, including ILD. For example, Faria *et al.* demonstrated in an ILD cohort that IOS parameters correlated strongly with conventional pulmonary function test (PFT) indices, supporting the feasibility of oscillometry in fibrotic lung disease (11). Similarly, in another study, oscillometric measures such as R5–R19 and reactance (Xrs) correlated with disease severity, as reflected by FVC, and provided additional prognostic information (12). Building on these observations, our study extends prior work by directly comparing IOS with body plethysmography in a well-defined ILD population.

In our cross-sectional study, IOS abnormalities—including increased airway resistance, more negative reactance, and greater frequency dependence were observed in a substantial proportion of patients, even when plethysmographic lung volumes were only modestly reduced. This finding underscores one of the key advantages of IOS: its minimal dependence on patient effort and its ability to detect subtle mechanical alterations. In situations where patients are markedly breathless or unable to perform forced expiratory maneuvers, IOS can provide valuable complementary information. For example, in connective tissue disease–associated ILD, a recent study reported that IOS had a sensitivity of 72.2% for detecting interstitial involvement, compared with 81.5% for HRCT (13). Collectively, these findings suggest that IOS may serve as a useful screening or adjunctive tool in the evaluation of ILD.

First, several reviews have emphasized that oscillometry still lacks full standardization, particularly in the assessment of restrictive lung diseases (10, 14). Second, although IOS reflects global respiratory mechanics—encompassing both airway and peripheral lung components—it does not provide direct volumetric measurements such as total lung capacity (TLC) or residual volume (RV), which are uniquely obtained through body plethysmography. Therefore, interpretative caution is warranted when inferring volume loss or parenchymal restriction solely from IOS findings.

Body plethysmography remains the gold standard for measuring static lung volumes, including TLC, RV, functional residual capacity (FRC), and specific airway resistances in many centers. In ILD, assessment of lung volumes helps quantify restrictive physiology (reduced TLC), air-trapping (elevated RV/TLC or RV), and mixed ventilatory defects. Indeed, lung volumes are core endpoints for ILD monitoring (15). In our study, plethysmographic volume loss (reduced TLC, elevated RV/TLC) corresponded with more advanced disease, reinforcing its value.

Moreover, plethysmography assists in calculating indices such as the composite physiologic index (CPI) in ILD and therefore has prognostic relevance (16). The ability to measure lung volumes makes it indispensable in quantifying the loss of aerated lung tissue and guiding antifibrotic or immunomodulatory therapies.

That said, plethysmography also has notable limitations: it is effort-dependent, requiring good patient cooperation, an airtight mouth seal, and the absence of leaks while being time-consuming and often poorly tolerated in severely dyspneic patients. In addition, plethysmography does not assess airway resistance under tidal-breathing conditions and may therefore fail to detect early small-airway abnormalities.

Our results suggest that IOS and body plethysmography provide overlapping yet distinct information in ILD. Some patients exhibited IOS abnormalities in the absence of marked volume loss on plethysmography, implying that mechanical changes (e.g., increased airway and parenchymal impedance) may precede gross volume reduction. This aligns with prior observations that reactance measures (e.g., Xrs) correlate with prognosis in idiopathic pulmonary fibrosis (IPF) (17). In other words, IOS may detect “early” functional impairment before plethysmographic evidence of restriction.

Conversely, there were patients in whom plethysmography showed severe volume loss, but IOS changes were modest. This could reflect the fact that once fibrotic changes are advanced, volume loss dominates the functional picture, and airway impedance abnormalities may plateau or be less sensitive. Thus, plethysmography retains value for quantifying established disease. The combination of both tests may therefore yield richer phenotyping: IOS for early detection or monitoring of airway/parenchymal impedance, and plethysmography for volumetric quantification and traditional restrictive indices.

Clinically, this opens up several potential scenarios. For patients who cannot perform forced maneuvers or are frail, IOS may offer a rapid, effort-independent adjunct. In screening high-risk populations (e.g., connective tissue disease patients), combining IOS with diffusion capacity and volume measures may improve sensitivity (13). For monitoring progression, IOS changes may precede volumetric decline, potentially enabling earlier intervention. Finally, phenotyping ILD patients into small airway-dominant against volume loss-dominant may influence prognosis, therapy, and follow-up scheduling.

However, our study also highlights the need for further research to define normal values, cut-offs, test reproducibility, and the added prognostic value of IOS in ILD populations. Current literature emphasizes this gap: a recent review highlighted the “window of opportunity” for oscillometry in lung disease, but emphasized the need for normative data, especially in non-obstructive settings (14).

Limitations and Future Directions

First, our study population may represent a single-center referral bias with relatively heterogeneous ILD subtypes; thus, generalizability may be limited. Second, as with many functional studies, the cross-sectional design challenges inference about progression; serial data would strengthen conclusions about monitoring utility. Third, although we compared IOS and plethysmography, neither modality directly replaced imaging (e.g., HRCT) for structural assessment, nor replaced diffusion capacity measurement, which remains integral to ILD assessment. Fourth, normative IOS reference data specific to ILD stratified by age, sex, and ethnicity are limited, which may complicate absolute interpretation. Finally, while we explored associations between test results and disease severity indices (such as FVC, CPI), we did not link test outcomes to hard clinical outcomes (e.g., mortality, exacerbations) in this performance; future longitudinal research is needed.

For future directions, several lines of investigation appear promising. Longitudinal studies assessing how changes in IOS parameters predict decline in lung volumes, FVC, DLCO, or survival would clarify the monitoring utility. Defining IOS thresholds that correspond to clinically meaningful changes (minimal clinically important difference) in ILD is key. Moreover, combining IOS with AI-assisted interpretation of PFTs and imaging may enhance early detection and risk stratification, as recent work has shown that AI-based decision support improves ILD diagnosis from PFTs (18). Exploring the role of IOS in therapeutic response (e.g., antifibrotic treatment) is also of interest. From a practical standpoint, the cost-effectiveness and feasibility of widespread IOS implementation in ILD clinics remain to be evaluated.

Integration into ILD Pathophysiology

From a mechanistic perspective, the findings reflect how ILD affects lung mechanics: fibrosis, collagen deposition, and alveolar wall thickening reduce compliance and increase elastic recoil, while concomitant airway remodeling and small airway involvement increase resistance and reduce reactance. IOS parameters such as elevated R5–20 (frequency-dependent resistance) and more negative X5 reflect such changes (16). Plethysmographic volume loss (reduced TLC, increased RV/TLC) reflects loss of functional lung units and air-trapping. Thus, the two modalities capture complementary aspects of pathophysiology: IOS, emphasizing dynamic impedance, and plethysmography, emphasizing static volumes. This dual perspective may improve the phenotyping of disease and guide personalized follow-up strategies.

CONCLUSION

In summary, our study demonstrates that both IOS and body plethysmography provide valuable, albeit distinct, information in the assessment of ILD. IOS offers a rapid, effort-independent measure of airway and parenchymal impedance that may detect early mechanical changes even when lung volumes are relatively preserved. Body plethysmography remains essential for quantifying volumetric restriction and air-trapping and for traditional ILD monitoring. The complementary use of both modalities may enhance early detection, risk stratification, and monitoring of ILD. In the interim, consideration of combining IOS and plethysmography in ILD diagnostic and follow-up pathways may help optimize patient care.

REFERENCES

1. American Thoracic Society; European Respiratory Society. American Thoracic Society/European Respiratory Society International Multidisciplinary Consensus Classification of the Idiopathic Interstitial Pneumonias. This joint statement of the American Thoracic Society (ATS), and the European Respiratory Society (ERS) was adopted by the ATS board of directors, June 2001 and by the ERS Executive Committee, June 2001. ***Am J Respir Crit Care Med*** 2002;165(2):277-304.
2. Thompson MJ, Colebatch HJ. Decreased pulmonary distensibility in fibrosing alveolitis and its relation to decreased lung volume. ***Thorax*** 1989;44(9):725-31.
3. Kubota M, Shirai G, Nakamori T, Kokubo K, Masuda N, Kobayashi H. Low frequency oscillometry parameters in COPD patients are less variable during inspiration than during expiration. ***Respir Physiol Neurobiol*** 2009;166(2):73-9.
4. DUBOIS AB, BRODY AW, LEWIS DH, BURGESS BF Jr. Oscillation mechanics of lungs and chest in man. ***J Appl Physiol*** 1956;8(6):587-94.
5. Michaelson ED, Grassman ED, Peters WR. Pulmonary mechanics by spectral analysis of forced random noise. ***J Clin Invest*** 1975;56(5):1210-30.
6. Desai U, Joshi JM. Impulse oscillometry. ***Adv Respir Med*** 2019;87(4):235-8.
7. Dellacà RL, Santus P, Aliverti A, Stevenson N, Centanni S, Macklem PT, et al. Detection of expiratory flow limitation in COPD using the forced oscillation technique. ***Eur Respir J*** 2004;23(2):232-40.
8. Paredi P, Goldman M, Alamen A, Ausin P, Usmani OS, Pride NB, et al. Comparison of inspiratory and expiratory resistance and reactance in patients with asthma and chronic obstructive pulmonary disease. ***Thorax*** 2010;65(3):263-7.
9. Sarkar S, Jadhav U, Ghewade B, Sarkar S, Wagh P. Oscillometry in Lung Function Assessment: A Comprehensive Review of Current Insights and Challenges. ***Cureus*** 2023;15(10):e47935
10. Kostorz-Nosal S, Jastrzębski D, Błach A, Skoczyński S. Window of opportunity for respiratory oscillometry: A review of recent research. ***Respir Physiol Neurobiol*** 2023;316:104135.
11. Matesanz-López C, Raboso-Moreno B, Saldaña-Pérez LE, Rodríguez-Nieto MJ, Río-Ramírez MT. Is lung function measured by oscillometry useful in interstitial lung diseases?. ***Open Respiratory Archives*** 2024;6(1):100278.
12. Gogali A, Gkrepi G, Kyriakopoulos C, Tatsis K, Katsoulis K, Tselepi C, Kostikas K. Oscillometry Assesses Small Airway Disease and Reveals Peripheral Lung Pathology in Early Pulmonary Fibrosis: A Cross-Sectional Study. ***Diagnostics (Basel)*** 2024;14(24):2873.
13. Hiekal AH, Dayem AM, Gomaa AA, Mohamed MR, Ali WR, Hendawy MM. Role of impulse oscillometry together with diffusing capacity of the lungs for carbon monoxide and high-resolution computed tomography for the chest in early diagnosis of interstitial lung disease in patients with connective tissue diseases. ***The Egyptian Journal of Chest Diseases and Tuberculosis*** 2024;73(2):181-92.
14. Unnithan J, Krishnamurthy S, Velayuthaswamy N, Srinivasan N. Can Oscillometry Replace Spirometry as a Major Tool for Lung Function Testing?–An Overview. ***Journal of Association of Pulmonologist of Tamil Nadu*** 2024;7(2):54-60.

15. Behr J, Salisbury ML, Walsh SLF, Podolanczuk AJ, Hariri LP, Hunninghake GM, et al. The Role of Inflammation and Fibrosis in Interstitial Lung Disease Treatment Decisions. ***Am J Respir Crit Care Med*** 2024;210(4):392-400.
16. Ishikawa T, Nishikiori H, Mori Y, Fujino K, Saito A, Takahashi M, et al. The impact of respiratory reactance in oscillometry on survival in patients with idiopathic pulmonary fibrosis. ***BMC Pulm Med*** 2024;24(1):10.
17. Shao G, Thöne P, Kaiser B, Lamprecht B, Lang D. Functional Improvement at One Year in Fibrotic Interstitial Lung Diseases-Prognostic Value of Baseline Biomarkers and Anti-Inflammatory Therapies. ***Diagnostics (Basel)*** 2024;14(14):1544.
18. Gompelmann D, Gysan MR, Desbordes P, Maes J, Van Orshoven K, De Vos M, et al. AI-powered evaluation of lung function for diagnosis of interstitial lung disease. ***Thorax*** 2025;80(7):445-50.