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Reference values for the 1-minute sit-to-stand test to assess functional capacity and short-term mortality in people with idiopathic pulmonary fibrosis and fibrotic connective tissue related interstitial lung diseases: a prospective real-world cohort study

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Abstract

Background Early identification of functional decline in fibrotic interstitial lung disease (F-ILD) is crucial for timely treatment and improved survival. While the 6-minute walk test (6MWT) is the standard for functional evaluation, it has practical limitations. The 1-minute sit-to-stand test (1MSTS) offers a simpler alternative; however, its correlation with the 6MWT in F-ILD patients remains unclear. This study aims to establish reference values for the 1MSTS in assessing functional capacity, evaluate its correlation with the 6MWT, and explore its utility in predicting 18-month mortality in F-ILD patients.

Methods This prospective study enrolled participants diagnosed with F-ILD based on multidisciplinary team discussions. Assessments included the 1MSTS, 6MWT, pulmonary function test (PFT), GAP score, mMRC scale, and Charlson Comorbidity Index (CCI). The association between 1MSTS repetitions and other variables was calculated using Spearman's rho. Bland-Altman plots assessed the agreement between 1MSTS repetitions and the 6MWT. Predictors of 18-month mortality were evaluated using ROC curve and Kaplan-Meier curve.

Results Of the 150 F-ILD patients, 37 (24.6%) had idiopathic pulmonary fibrosis (IPF), and 113 (75.4%) had connective tissue disease-related ILD (CTD-ILD). Using ≤ 23 repetitions as the cutoff for functional impairment in 1MSTS, 74 (47.3%) patients were classified as impaired. The 1MSTS significantly predicted 18-month mortality and demonstrated moderate correlations with GAP score (rs = -0.49), mMRC scale (rs = -0.47), and 6MWT distance (rs = 0.65). Bland-Altman analysis indicated agreement between 1MSTS repetitions and 6MWT distance. Using ≤ 23 repetitions as the cutoff value for the 1MSTS to predict 18-month mortality, the mortality rate was 76.4%, with an AUC of 0.81.

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Conclusions The findings suggest that ≤ 23 repetitions in the 1MSTS can serve as an indicator of functional impairment, demonstrate a good correlation with 6MWT distance, and effectively predict 18-month mortality in patients with F-ILD.

Clinical trial number Not applicable.

Keywords Fibrotic interstitial lung disease, 1-minute sit-to-stand test (1MSTS), 6-minute walk test (6MWT), Short-term mortality, Functional assessment

Background

Interstitial lung disease (ILD) is a heterogeneous group of disorders characterized by interstitial inflammation or fibrosis of the lungs, leading to decreased lung function and impaired gas exchange [1, 2]. Early diagnosis of functional decline in fibrotic interstitial lung disease (F-ILD) is crucial for timely treatment and improved survival [3]. Among the subtypes of F-ILD, idiopathic pulmonary fibrosis (IPF) and connective tissue disease-related interstitial lung disease (CTD-ILD) are frequently diagnosed [4]. The progression of F-ILD is marked by progressive scarring of lung tissue, resulting in a decline in respiratory function and overall health [5].

The 6-minute walk test (6MWT) is widely recognized as the gold standard for functional evaluation in chronic heart failure [6], pulmonary artery hypertension [7] and F-ILD [8] patients due to its ability to assess exercise tolerance and predict outcomes. Our recent publications also show that 6MWT can also identify patients who experience desaturation during exertion and predict outcomes based on the distance walked in six minutes [9, 10]. However, the 6MWT has practical limitations, including the need for a long, unobstructed walking course and the physical capability of the patient to complete the test [11]. Furthermore, the 6MWT can be influenced by factors unrelated to pulmonary status, such as peripheral arterial disease, muscular strength, cognitive function, and nutritional status [12, 13]. Therefore, it is important to find an alternative method to detect functional decline that is more accessible and feasible in various settings.

The 1-minute sit-to-stand test (1MSTS) is a simple and quick assessment that requires only a chair and can be completed in a short time [14]. This test measures the number of times a patient can stand from a seated position within one minute, reflecting lower body strength and endurance [15]. Research has demonstrated a good correlation between the 1MSTS and exercise capacity in patients with chronic obstructive pulmonary disease (COPD) [16], pulmonary artery hypertension [17], and interstitial lung disease [18]. The 1MSTS is easier to administer and does not require the space or time needed for the 6MWT, making it a more practical option in many clinical settings. However, the correlation between 1MSTS and the 6MWT in F-ILD patients, and whether the 1MSTS can predict short-term mortality, remains unclear [19]. Few studies have addressed this issue, and their findings are inconclusive due to limited case numbers, retrospective and varied study designs [18, 20, 21]. Establishing this correlation could validate the 1MSTS as a reliable alternative to the 6MWT for functional assessment in F-ILD, providing a more accessible method for evaluating patient condition and monitoring disease progression.

The aim of the current study is to investigate the diagnostic value of the 1MSTS in predicting short-term mortality and its correlation with the 6MWT. Short-term mortality is defined as death occurring within eighteen months following the performance of the 1MSTS and 6MWT.

Method

Study design, patient enrollment, and ethics

The current data is derived from a subgroup analysis of a prospective, single-center, real-world registry study conducted at an ILD referral medical center in central Taiwan. The Registry of Interstitial Lung Disease (REGILD) has been enrolling both IPF and non-IPF populations since December 28, 2018. Diagnoses were confirmed through multidisciplinary team discussions (MDD) involving pulmonologists, rheumatologists, radiologists, and pathologists. Utilizing the REGILD cohort, several studies have been published exploring prognostic factors [9, 10, 22–24].

In the current study, we enrolled patients over 20 years of age diagnosed with F-ILD who had completed evaluations of the 6MWT and 1MSTS between November 1, 2022, and June 30, 2023. Patients were excluded if they did not complete the 1MSTS, 6MWT, or pulmonary function test, or if they were diagnosed with ILD other than IPF or CTD-ILD after MDD. We excluded patients with ILD other than IPF or CTD-ILD to focus on the majority of the population—IPF and CTD-ILD. This study was conducted in compliance with the Declaration of Helsinki and was approved by the Ethics Committee of Taichung Veterans General Hospital (IRB number: CE18325B; date of approval: December 18, 2018). The study was also registered on ClinicalTrials.gov (NCT06476470).

ILD assessment protocol in the REGILD registry cohort

Baseline clinical characteristics, including age, gender, smoking history, body mass index, physical examination findings, and comorbidities, were recorded on the day of enrollment. The follow-up protocol included pulmonary function tests (PFT) and the 1-minute sit-to-stand test (1MSTS) every six months. Additionally, patients underwent high-resolution computed tomography (HRCT) and cardiopulmonary exercise testing (CPET) at enrollment and annually. Questionnaires, such as the modified medical research council (mMRC) score, 36-Item Short Form Survey (SF-36), St. George's Respiratory Questionnaire (SGRQ), and the gender-age-physiology (GAP) index, which have been used to evaluate the outcome and health condition of patients with ILD and have been published as our previous studies [9, 25–27] were also evaluated at enrollment and annually. The comorbidities of enrolled patients were summarized using the Charlson Comorbidity Index (CCI) [28].

PFT, 6MWT and IMSTS procedure

Forced vital capacity (FVC) was obtained from spirometry results and DL_{CO} was examined according to the recommendations of the American Thoracic Society (ATS) [29]. The 6-minute walk test (6MWT) was performed in accordance with ATS guidelines [13]. Patients were instructed to walk as far as possible in six minutes in a corridor between two orange traffic cones placed 30 m apart. Data on oxygen saturation, including resting SpO2, nadir SpO2, exercise SpO2, and the walking distance in six minutes, were recorded. The 1-minute sit-to-stand test (1MSTS) was performed as described in a previous study [30], using a standard height chair (46 cm) without armrests positioned against a wall. SaO2, heart rate, and modified Borg scale [31] measurements before and after the test, as well as the number of 1MSTS repetitions, were recorded.

Statistical analysis

Data are expressed as median (interquartile range, IQR) unless otherwise stated. Categorical variables were analyzed using the chi-squared test or Fisher's exact test, as appropriate. Continuous variables were compared using the Mann–Whitney U test. Cox regression analysis was performed to evaluate the incidence of 18-month mortality. Spearman's rho was calculated to measure the strength and direction of the association between 1MSTS repetitions and different parameters across the entire cohort. The Bland-Altman plot was used to assess the agreement between 1MSTS repetitions and the 6MWT using Z-score. Receiver Operating Characteristic (ROC) curve analysis was conducted to evaluate predictors of mortality and using Youden's index to determine the cut points. Kaplan–Meier estimates and log-rank tests were used to calculate 18-month mortality rates. Data analysis was performed using IBM SPSS software version 21.0 and MedCalc Software version 22.023. A two-sided p-value of < 0.05 was considered statistically significant.

Result

Baseline characteristics and the performance of IMSTS and 6MWT

One hundred and ninety-three patients diagnosed with F-ILD who underwent evaluations of the 6MWT and 1MSTS between November 1, 2022, and June 30, 2023, were initially enrolled. We excluded 33 patients who were not classified as having IPF or CTD-ILD and 10 patients who had missing data or failed to complete the 6MWT and the 1MSTS. Consequently, a total of 150 patients were included in the final analysis (Fig. 1). The baseline characteristics of this cohort showed a median age of 64.5 years (IQR: 56.8–71.3), with 57.7% being female and 64% being non-smokers. The classification of F-ILD at enrollment included CTD-ILD ($n = 113$, 75.3%) and IPF ($n = 37$, 24.7%) (Table 1). The median number of repetitions in the 1MSTS was 24 (IQR: 20–31). Using ≤ 23 repetitions as the cutoff, 47.3% (71 out of 150) of patients were classified as functionally impaired. The 6MWT demonstrated a median distance of 421.5 m (IQR: 323.8-495.3), with resting, exercise and nadir oxygen saturation levels at 96% (IQR: 95–98), 91% (IQR: 86.5–94), and 89% (IQR: 83–92), respectively. Short-term mortality, defined as death within eighteen months following the 1MSTS and 6MWT examinations, occurred in 17 out of 150 patients (11.3%).

Factors associated with patients alive or deceased within eighteen months following the 1MSTS and 6MWT examinations

As shown in Table 2, epidemiological indicators such as age (64 vs. 69, $p = 0.027$), clubbing fingers (24.8% vs. 58.8%, $p = 0.008$), mMRC Scores (0 vs. 1, $p < 0.001$) and GAP Score (3 vs.3 $p = 0.002$) exhibited statistically significant differences between those who survived and those who died within eighteen months. Although the number of deaths within eighteen months in this study was only seventeen, we found statistically significant differences in the 1MSTS-related indicators. The deceased group had lower resting SaO2 levels (95% vs. 97%, $p = 0.001$) and lower nadir SaO2 levels (90% vs. 94%, $p = 0.008$), as well as higher pre-exercise Borg Scale scores (1 vs. 0, $p = 0.008$) and less 1MSTS repetitions (18 vs.25, $p < 0.001$) compared to the survival group. Most patients in deceased group have 1MSTS repetitions < 23 compared with survival group (94.1% vs. 41.4%, $p < 0.001$) (Table 2).

Among the 6MWT indicators, the deceased group had significantly lower resting SpO2 and nadir SpO2 levels (95% vs.96%, $p = 0.010$; 89% vs.92%, $p = 0.044$,

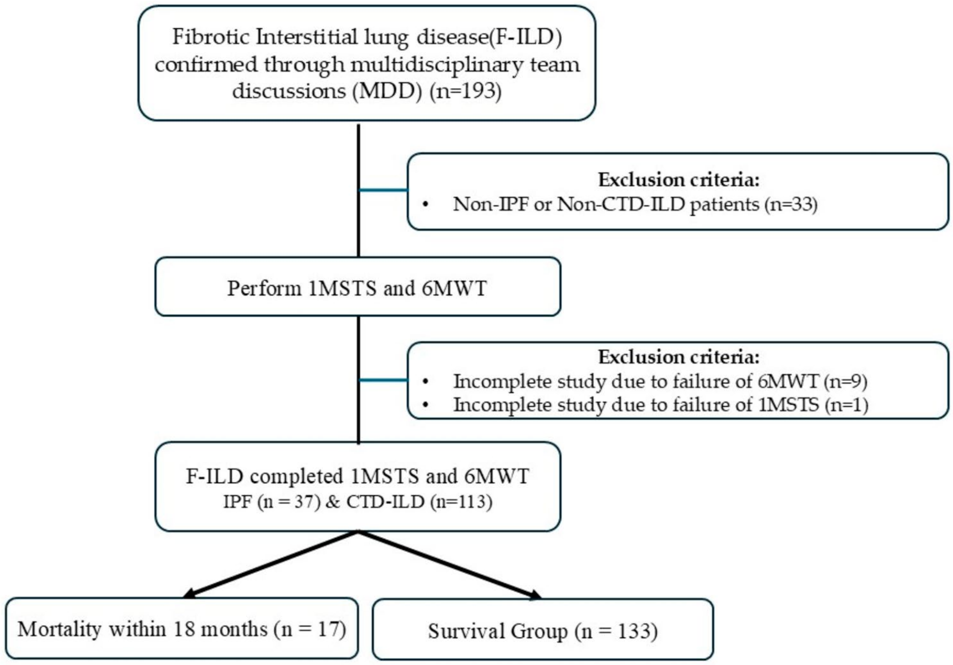

Fig. 1 The flow chart of patient enrollment. CTD-ILD, Connective tissue disease associated interstitial lung disease; IPF, Idiopathic pulmonary fibrosis; MDD, multidisciplinary team discussion; 1MSTS, one minute sit-to-stand test; 6MWT, six minutes walking test

respectively) compared to the survival group. The distance walked by the deceased group was significantly less than the survival group (307 m vs. 433 m, $p<0.001$). Most patients in the deceased group had a 6MWT distance ≤ 416 compared with survival group (94.1% vs. 42.9%, $p<0.001$) (Table 2).

Cox regression analysis for the incidence of 18-month mortality

As seen in Table 3, in the simple model, both patients with ≤ 23 repetitions in the 1MSTS and ≤ 416 m walked in the 6MWT showed significantly higher risk of mortality, with hazard ratios of 19.83 (95% CI 2.63–149.61, $p<0.001$) and 18.84 (95% CI 2.50–142.13, $p=0.004$), respectively. Other significant parameters included age (HR 1.05, 95% CI 1.01–1.10, $p=0.026$), mMRC score (HR 2.63, 95% CI 1.89–3.64, $p<0.001$), GAP score (HR 1.66, 95% CI 1.30–2.12, $p<0.001$), pre-test SaO2 from the 1MSTS (HR 0.69, 95% CI 0.58–0.81, $p<0.001$), post-test SaO2 from the 1MSTS (HR 0.94, 95% CI 0.89–0.99, $p=0.020$), pre-test heart rate (HR 1.04, 95% CI 1.00–1.08, $p=0.034$), pre-test Borg scale (HR 1.31, 95% CI 1.02–1.67, $p=0.031$), 1MSTS repetitions (HR 0.87, 95% CI 0.81–0.93, $p<0.001$), and 6MWT distance (HR 0.99, 95% CI 0.99–0.996, $p<0.001$).

When adjusted for GAP score, both thresholds of ≤ 23 repetitions in the 1MSTS (HR 10.99, 95% CI 1.37–88.25, $p=0.024$) and ≤ 416 m in the 6MWT (HR 10.23, 95% CI 1.26–83.10, $p=0.030$) were independently associated with increased mortality risk. 1MSTS repetitions (HR 0.91, 95% CI 0.84–0.98, $p=0.017$) and 6MWT distance (HR 0.995, 95% CI 0.99–0.99998, $p=0.049$) remained significant parameters as well (Table 3).

The correlation among 1MSTS, 6MWT, lung function test, GAP score and mMRC scale

Table 4 showed Spearman's rho correlations between 1MSTS repetitions and various factors in total study population, including the GAP index, mMRC scale, pulmonary function tests, and the 6MWT. Both the GAP Score and mMRC Score showed a moderate negative correlation with 1MSTS repetitions (GAP: rs = -0.49; mMRC: rs = -0.47). The correlations between FVC with 1MSTS repetitions showed weak positive relationships (FVC: rs = 0.23). DL_{CO}/VA also showed a moderate positive correlation with 1MSTS repetitions (DL_{CO}/VA: rs = 0.30). The correlation between 6MWT distance and 1MSTS repetitions showed a moderate correlation (rs = 0.65). Additionally, both resting and exercise SpO2 showed weak positive correlations with 1MSTS repetitions (Resting SpO2: rs = 0.27; Exercise SpO2: rs = 0.23). Furthermore, Nadir SpO2 also showed a weak positive correlation (rs = 0.23, $p=0.044$) (Table 4).

The agreement between the 1MSTS repetitions and the 6MWT distance and cutoff values to predict 6MWT distance

The Bland-Altman plot compared the 1MSTS repetitions and the 6MWT distance, indicating the agreement between these two measures. The central line represented

Table 1 Baseline characteristics in ILD patients

	Total (*n* = 150)
Age, years (median, IQR)	64.5 (56.8–71.3)
Sex (n, %)	
Female	85 (56.7%)
Male	65 (43.3%)
Smoker (n, %)	54 (36.0%)
pack-year (median, IQR)	30 (14.4–54.4)
Classification of ILD (n, %)	
CTD-ILD	113 (75.3%)
IPF	37 (24.7%)
Body mass index (kg/m^2) (median, IQR)	23.6 (21.2–25.8)
Physical examination (n, %)	
Basal crackles	101 (67.3%)
Clubbing finger	43 (28.7%)
mMRC (median, IQR)	0 (0–0)
GAP (median, IQR)	3 (1–4)
CCI (median, IQR)	2 (1–4)
Pulmonary Function Test	
FVC % of predict	77 (61.8–90.3)
FVC (L)	2.3 (1.8–2.8)
DL_{CO} % of predict	67 (54-83.5)
DL_{CO} absolute value	12.1 (9.1–15)
1-minute sit-to-stand test (median, IQR)	
SaO2-Pre	96 (95–98)
SaO2-Post	93 (90-95.8)
HR-Pre	84.5 (77–94)
HR-Post	105.5 (93-115.3)
Borg Scale-Pre	0 (0–1)
Borg Scale-Post	3 (2–5)
1MSTS repetitions	24 (20–31)
1MSTS repetitions ≤ 23 (n, %)	71 (47.3%)
Six-minute Walk Test (median, IQR)	
Resting SpO_2 (%)	96 (95–98)
Nadir SpO_2 (%)	89 (83–92)
Exercise SpO_2 (%)	91 (86.5–94)
Distance (m)	421.5 (323.8-495.3)
18-month mortality (n, %)	17 (11.3%)

ILD, Interstitial lung disease; IQR, interquartile range; CTD-ILD, Connective tissue disease related interstitial lung disease; IPF, Idiopathic pulmonary fibrosis; mMRC, Modified medical research council; GAP, Gender-Age-Physiology; CCI, Charlson Comorbidity Index; FVC, Forced vital capacity; DL_{CO}, Diffusion capacity for carbon monoxide; 1MSTS, one minute sit-to-stand test

the mean difference, showing no systematic bias, while the dashed lines marked the limits of agreement (± 1.96 standard deviations). Most data points lay within these limits, suggesting good agreement between the tests. The p-value of 1.000 indicated no statistically significant difference, confirming the correlation and supporting the use of 1MSTS as a reliable alternative to 6MWT for assessing functional capacity (Supplement Fig. 1).

ROC curve analysis was performed to evaluate the efficacy of the 6MWT distance and the 1MSTS repetitions for predicting 18-month mortality in this cohort. The cut-off value was 416 m for the 6MWT, with an area under the curve (AUC) of 0.79 (95% CI 0.72–0.85). The sensitivity was 94.12% (95% CI 71.3–99.9) and the specificity was 57.14% (95% CI 48.3–65.7) for 18-month mortality. The cut-off value was 23 times for the 1MSTS, with an area under the curve (AUC) of 0.81 (95% CI 0.74–0.87). The sensitivity was 94.12% (95% CI 71.3–99.9) and the specificity was 58.65% (95% CI 49.8–67.1) for 18-month mortality (Fig. 2). The 18-month mortality rates were 77.3% using a cutoff value of 416 m for the 6MWT distance and 76.4% using a cutoff of 23 repetitions for the 1MSTS, as shown by Kaplan-Meier curve analysis. (Fig. 3)

Discussion

In this prospective real-world study, we enrolled 150 F-ILD patients whose functional status was evaluated using both the 1-minute sit-to-stand test (1MSTS) and the 6-minute walk test (6MWT). We followed up on their short-term mortality eighteen months later. Our data revealed that the 6MWT distance and the 1MSTS repetitions significantly predicted 18-month mortality. The repetitions of 1MSTS also showed significant correlation with the GAP score, mMRC scale, and 6MWT distance. Additionally, the correlation between 1MSTS repetitions and various physical parameters, including mMRC Score and 6MWT distance was consistent across the overall cohort and within subgroups analysis (FVC < 70% and DL_{CO}/VA < 55%), indicating the robustness of these findings. Furthermore, we identified a cutoff value of 1MSTS repetitions ≤ 23 and 6MWT distances ≤ 416 m have similar value of predicting 18-month mortality using ROC curve analysis. To the best of our knowledge, this is the first study to address the correlation between 1MSTS and 6MWT and to provide real-world evidence for using 1MSTS repetitions ≤ 23 and 6MWT distances ≤ 416 m to predict 18-month mortality.

The movement of standing up and sitting down is a crucial function of daily life, and the inability to perform these actions reflects a patient's functional impairment [32]. Consequently, the sit-to-stand (STS) test, a simple and practical assessment, has been widely adopted to evaluate functionality in community-dwelling elderly individuals [33, 34]. Although some researches have reported the using of STS in F-ILD recently [35, 36], we referenced studies on COPD patients as well. The three most common protocols of the STS test applied in COPD patients are the 5-repetition STS (5-rep STS) test, the 30-second protocol (30-s STS), and the 1-minute protocol (1MSTS) [37]. Previous studies have shown that all three protocols have significant correlations with important clinical outcomes in subjects with COPD [14]. However, the 1MSTS was found to be more demanding, leading to greater desaturation and increased symptoms of dyspnea and fatigue at the end of the test [14]. Additionally, three studies have used 1MSTS to detect

Table 2 Characteristics of patients alive or deceased within 18-Month following the 1MSTS and 6MWT examinations

	Alive (n = 133)	Death (n = 17)	p value
Age, years (median, IQR)	64 (56–71)	69 (62–77)	0.027*
Sex (n, %)			0.849
Female	75 (56.4%)	10 (58.8%)	
Male	58 (43.6%)	7 (41.2%)	
Smoker (n, %)	47 (35.3%)	7 (41.2%)	0.637
pack-year (median, IQR)	30 (10–50)	40 (18–60)	0.414
Classification of ILD (n, %)			0.132
CTD-ILD	103 (77.4%)	10 (58.8%)	
IPF	30 (22.6%)	7 (41.2%)	
Body mass index (kg/m^2) (median, IQR)	23.5 (21.2–25.6)	23.9 (20.8–27.2)	0.870
Physical examination (n, %)			
Basal crackles	86 (64.7%)	15 (88.2%)	0.051
Clubbing finger	33 (24.8%)	10 (58.8%)	0.008**
mMRC (median, IQR)	0 (0–0)	1 (1–2)	< 0.001**
GAP (median, IQR)	3 (1–3)	3 (2.5-7)	0.002**
CCI (median, IQR)	2 (1–3)	3 (1.5-5)	0.084
1-minute sit-to-stand test (median, IQR)			
SaO2-Pre	97 (95–98)	95 (92–96)	0.001**
SaO2-Post	94 (91–96)	90 (87–93)	0.008**
HR-Pre	84 (76.5–91)	95 (81.5–102)	0.042*
HR-Post	105 (93–114)	106 (95–117)	0.931
Borg Scale-Pre	0 (0–1)	1 (0–3)	0.008**
Borg Scale-Post	3 (2–4)	5 (1.5-6)	0.089
1MST repetitions	25 (20-31.5)	18 (14-21.5)	< 0.001**
1MST repetitions ≤ 23 (n, %)	55 (41.4%)	16 (94.1%)	< 0.001**
Six-minute Walk Test (median, IQR)			
Resting SpO_2 (%)	96 (95–98)	95 (92.5–97)	0.010*
Nadir SpO_2 (%)	89 (83.8–92)	85 (79-88.5)	0.072
Exercise SpO_2 (%)	92 (88–94)	89 (80–92)	0.044*
Distance (m)	433 (345-501.5)	307 (259.5–366)	< 0.001**
Distance (m) ≤ 416 (n, %)	57 (42.9%)	16 (94.1%)	< 0.001**

Mann-Whitney U test. Chi-Square test. Fisher's exact test. *$p < 0.05$, **$p < 0.01$

6MWT, six minutes walking test

desaturation during the 6MWT in ILD patients [18, 20, 21] with positive findings. Based on these reasons, we chose 1MSTS to evaluate its correlation with and prediction of short-term mortality in the current study.

Compared to previous studies that were limited in finding the correlation between 1MSTS and 6MWT in F-ILD [18, 20, 21], the strength of our data not only demonstrates a strong correlation between these two tests but also shows a moderate negative correlation between GAP score and mMRC score with 1MSTS repetitions. This indicates that higher GAP and mMRC scores, which signify worse disease severity and dyspnea, are associated with fewer 1MSTS repetitions. Additionally, our data found positive correlations between FVC with 1MSTS repetitions, indicating that better lung function is associated with more 1MSTS repetitions. Furthermore, we found that DLCO/VA were significantly positively correlated with 1MSTS repetitions, suggesting that better gas exchange capability is associated with more repetitions. In subgroup analysis, similar correlation of 1MSTS repetition and other parameter are found between the whole study population and patients with FVC < 70%, indicated that in patients with worse lung function, oxygen saturation, functional capacity and gas exchange can affect repetitions significantly. But in patients with DL_{CO}/VA < 55%, there are no obvious correlation between 1MSTS repetition and parameters, except for 6MWT distance and mMRC Score, this result may be interfered by our small sample size, further evaluation is required. All in all, our study still provides valuable applications for 1MSTS in evaluating F-ILD patients.

Table 3 Cox regression analysis for incidence of 18-month mortality

	Simple model		Adjusted for GAP	
	HR (95% CI)	*p* value	HR (95% CI)	*p* value
Age, years	1.05 (1.01–1.10)	0.026*		
Sex				
Female	1.00			
Male	0.95 (0.36–2.49)	0.911		
Smoker	1.32 (0.50–3.47)	0.572		
pack-year	1.01 (0.98–1.03)	0.649		
Classification of ILD				
CTD-ILD	1.00			
IPF	2.33 (0.89–6.13)	0.087		
Body mass index (kg/m^2)	0.98 (0.85–1.11)	0.716		
Physical examination				
Basal crackles	4.00 (0.91–17.51)	0.066		
Clubbing finger	3.88 (1.48–10.19)	0.006**		
mMRC	2.63 (1.89–3.64)	< 0.001**		
GAP	1.66 (1.30–2.12)	< 0.001**		
CCI	1.12 (0.97–1.29)	0.124		
1-minute sit-to-stand test				
SaO2-Pre	0.69 (0.58–0.81)	< 0.001**		
SaO2-Post	0.94 (0.89–0.99)	0.020*		
HR-Pre	1.04 (1.00-1.08)	0.034*		
HR-Post	1.00 (0.97–1.02)	0.792		
Borg Scale-Pre	1.31 (1.02–1.67)	0.031*		
Borg Scale-Post	1.08 (0.97–1.21)	0.142		
1MSTS repetitions	0.87 (0.81–0.93)	< 0.001**	0.91 (0.84–0.98)	0.017*
1MSTS repetitions ≤ 23	19.83 (2.63-149.61)	< 0.001**	10.99 (1.37–88.25)	0.024*
Six-minute Walk Test				
Resting SpO_2 (%)	0.73 (0.61–0.89)	0.002**		
Nadir SpO_2 (%)	0.96 (0.90–1.02)	0.202		
Exercise SpO_2 (%)	0.98 (0.95–1.01)	0.275		
Distance (m)	0.99 (0.99–0.996)	< 0.001**	0.995 (0.99-0.99998)	0.049*
Distance (m) ≤ 416	18.84 (2.50-142.13)	0.004**	10.23 (1.26–83.10)	0.030*

Cox regression. *$p < 0.05$, **$p < 0.01$

Table 4 The correlation among 1MSTS, 6MWT, lung function test, GAP score and mMRC scale

r_s	1-minute sit-to-stand test			Six-minute Walk Test		
	1MSTS repetitions	SaO2 (Pre)	SaO2 (Post)	Distance (m)	Resting SpO_2 (%)	Nadir SpO_2 (%)
1-minute sit-to-stand test						
1MSTS repetitions	1.00	0.33**	0.31**	0.65**	0.27**	0.23*
SaO2-Pre	0.33**	1.00	0.61**	0.35**	0.43**	0.45**
SaO2-Post	0.31**	0.61**	1.00	0.21	0.49**	0.58**
Six-minute Walk Test						
Distance (m)	0.65**	0.35**	0.21*	1.00	0.34**	0.22
Resting SpO_2 (%)	0.27**	0.43**	0.49**	0.34**	1.00	0.41**
Nadir SpO_2 (%)	0.23*	0.45**	0.58**	0.22	0.41**	1.00
Lung function						
FVC (L)	0.23**	0.15	0.21*	0.36**	0.11	0.14
FVC (% predicted)	0.16	0.22**	0.34**	0.11	0.20*	0.20
DL_{CO}/VA (% predicted)	0.27**	0.38**	0.49**	0.28**	0.25**	0.48**
GAP	-0.49**	-0.51**	-0.53**	-0.55**	-0.51**	-0.39**
mMRC	-0.47**	-0.40**	-0.41**	-0.48**	-0.27**	-0.38**

Spearman's rho, *$p < 0.05$, **$p < 0.01$

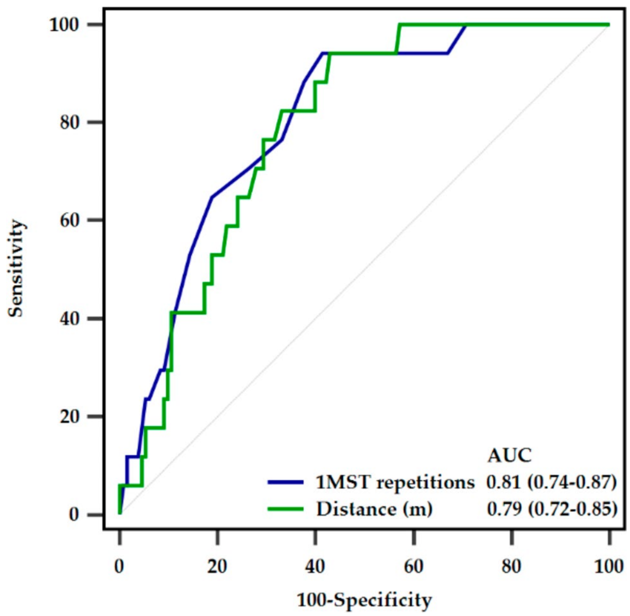

Fig. 2 The cutoff values of 1MSTS repetitions of 23 and 6MWT distances of 416 m using ROC curve analysis to predict 18-month mortality in patient with F-ILD. AUC, Area under curve

Unlike previous studies investigating the correlation between 1MSTS and 6MWT in terms of oxygen desaturation in pulmonary fibrosis patients [18, 20, 21], the most important finding of this study is identifying the cut-off points for predicting eighteen-month survival in F-ILD patients using 1MSTS repetitions and 6MWT distance. Although only 17 patients (11.3%) in this cohort died within eighteen months after undergoing these tests, we found that a 6MWT distance of less than 416 m can serve as predictors of eighteen-month mortality with good sensitivity and fair specificity. Furthermore, we found that 1MSTS repetitions of 23 or fewer have similar predicting power with 6MWT distance of less than 416 m, also have a good sensitivity and similar specificity. Although previous study had revealed the positive correlation between the distance of 6MWT and the repetitions of 1MSTS [20, 21, 38], there were no evidence of clear cutoff point in those 2 parameters to predict 18 months mortality in patients with F-ILD. Our study is the first to find out the specific cutoff point to predict 18 months mortality in patients with F-ILD, whether by 6MWT or 1MSTS. W We also performed Kaplan-Meier Curve Analysis for the cutoff point of 1MSTS and 6MWT and revealed a significant difference, which strengthened the clinical value of those 2 cutoff points (Additional Figs. 1, 2 and 3). While larger-scale studies are needed to confirm these findings, this discovery enhances the potential role of 1MSTS as a supplementary tool for functional assessment in F-ILD and the predictor of short-term mortality risk.

There are several limitations to this study. First, it was conducted in a single center with only 150 patients, limiting its sample size and generalizability. Second, we excluded F-ILD types other than IPF and CTD-ILD, which restricts the applicability of our findings to other F-ILD types. Third, the etiology of CTD-ILD included systemic sclerosis, rheumatoid arthritis, Sjogren's syndrome, and idiopathic inflammatory myopathies, making subgroup analysis based on different CTD-ILD etiologies challenging. Fourth, there were only seventeen deceased patients in this cohort, which is a small number to achieve sufficient statistical power. However, we still found significant differences in the parameters of 1MSTS and 6MWT between the alive and deceased groups, indicating the importance of these indicators. In the future, multi-center studies with larger sample sizes will be required to confirm the findings of this study. Additionally, considering that 1MSTS may impose a slightly lower load than the 6MWT, regular and frequent use of the 1MSTS and comparing the differences between subsequent exams should be considered.

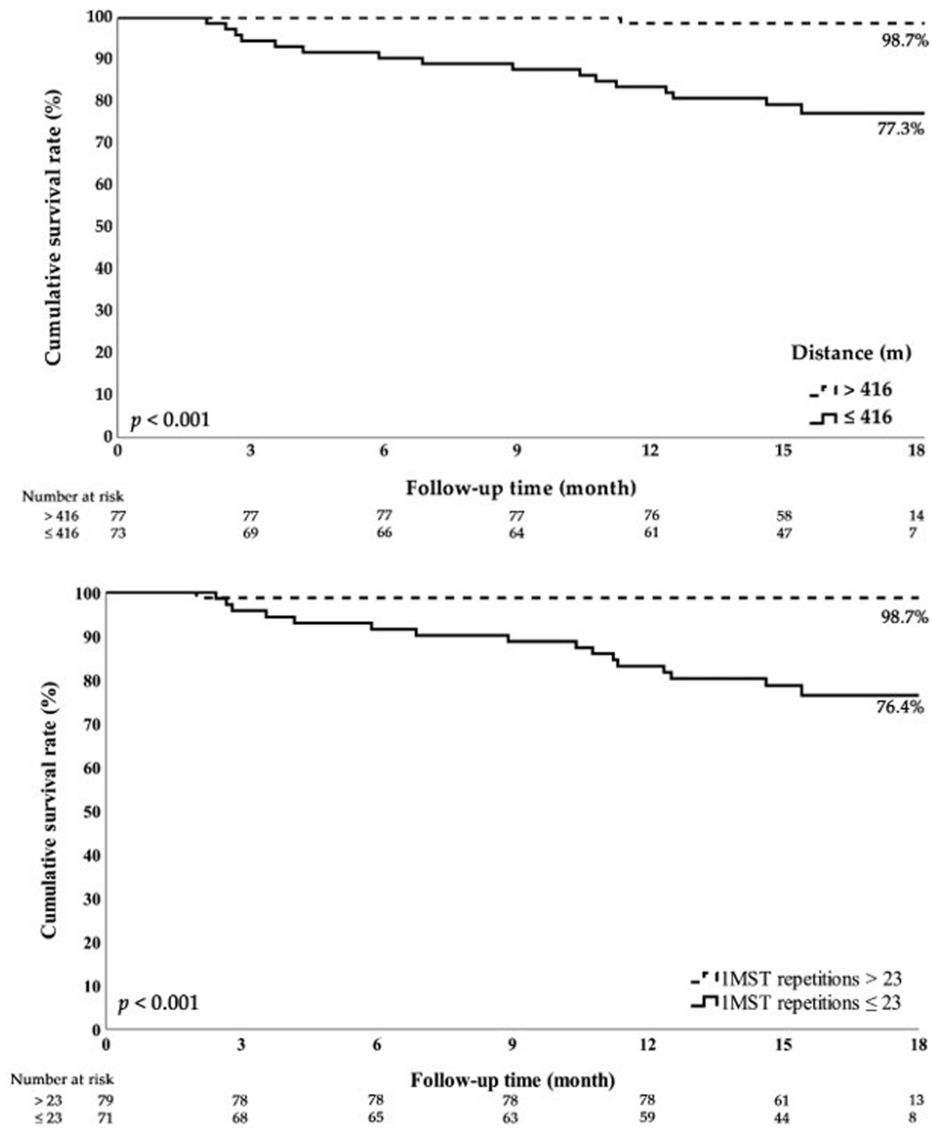

Fig. 3 Kaplan-Meier curve analysis of 18-month mortality using a cutoff value of 416 m for the 6MWT distance and a cutoff value of 23 repetitions for 1MSTS

Conclusion

Our findings show that the repetitions of 1MSTS can significantly predict eighteen-month mortality as 6MWT distance does, and the repetitions of 1MSTS also correlates with the GAP score, mMRC scale, and 6MWT distance. A cutoff of 1MSTS ≤ 23 repetitions can have similar sensitivity and specificity as 6MWT distances ≤ 416 m while predicting eighteen months mortality, with an AUC of 0.807 and 0.789, respectively. This highlights 1MSTS as a potential supplementary tool for functional assessment and short-term mortality risk in F-ILD. Future multi-center studies are needed to confirm these findings.

Abbreviations

6MWT	Six-minute walking test
6MWD	Six-minute walking distance
CI	Confidence interval
CCI	Charlson Comorbidity Index
CTD-ILD	Connective tissue disease-associated interstitial lung disease
DL_{CO}	Diffusion capacity for carbon monoxide
FVC	Forced vital capacity
GAP	Gender-Age-Physiology
IPF	Idiopathic pulmonary fibrosis
IQR	Interquartile range
MDD	Multidisciplinary discussion
mMRC	Modified Medical Research Council
PFT	Pulmonary function test
REGILD	Registry of Interstitial Lung Disease
ROC	Receiver operating characteristic

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12890-025-03521-3 .

Supplementary Material 1: Fig. 1- Bland-Altman analysis showed agreement between 1-MSTS repetitions and 6MWT distance.

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

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Author contributions
M.-Y. T, K-T. H, and P.-K. F were responsible for conducting the research and data review. Y.-H.Y and C.-Y.H were responsible for data collection and statistical analysis. M.-Y. T, C.-Y. H and P.-K. F were responsible for data coding and interpretation of the results. M.-Y. T, and P.-K.F. was responsible for the study design, along with interpretation of the results and preparation of the manuscript. All authors discussed the results and contributed to the preparation of the final manuscript. All authors read and approved the final manuscript.

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Data availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethical approval
Ethics approval and consent to participate: This study was conducted in compliance with the Declaration of Helsinki and approved by the Ethics Committee of Taichung Veterans General Hospital (IRB number: CE18325B; date of approval: December 18, 2018). All patients signed an informed consent form.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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