


# Reliability and validity of the Glittre-ADL test to assess the functional status of patients with interstitial lung disease

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Hellen Fontão Alexandre<sup>1,2</sup>, Katerine Cristhine Cani<sup>1,3</sup>,  
Juliana Araújo<sup>1,4</sup> and Anamaria Fleig Mayer<sup>1,2,4</sup> 

## Abstract

The study objective was to investigate the reliability and validity of the ADL-Glittre test (TGlittre) to assess the functional status of patients with interstitial lung disease (ILD). Twenty-one individuals with ILD participated (age:  $63 \pm 11$  years; DLCO:  $51.0 \pm 12.6\%$  predicted), evaluated with body plethysmography, Saint George Respiratory Questionnaire, modified Medical Research Council dyspnea scale, six-minute walk test (6MWT) and monitoring of physical activity of daily living. Two TGlittre were performed, with an interval of 30 minutes between them. The TGlittre demonstrated high test-retest reliability, with an intraclass correlation coefficient of 0.90 (95%CI: 0.75–0.96;  $p < 0.001$ ). Nineteen patients (90.5%) performed better on the second test (mean difference between TGlittre 1 and 2:  $-0.57 \pm 0.96$  minute;  $p = 0.001$ ), with a learning effect of 11.6%. The time in TGlittre correlated with 6MWT ( $r = -0.70$ ;  $p = 0.002$ ) and with the total energy expenditure in physical activity of daily living ( $r = -0.52$ ;  $p = 0.02$ ). In %predicted, TGlittre and 6MWT also correlated ( $r = -0.50$ ;  $p = 0.04$ ). Correlations were observed between TGlittre and pulmonary function variables ( $r = -0.47$  to  $-0.57$ ;  $p = 0.01$  to  $p = 0.04$ ). There was no difference in the physiological response between TGlittre 1 and 2, and between TGlittre and 6MWT ( $p > 0.05$ ). In conclusion, the TGlittre is reliable and valid for assessing functional status of patients with ILD.

## Keywords

Lung diseases, interstitial, activities of daily living, physical functional performance, outcome assessment, health care, reproducibility of results, exercise test.

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<sup>1</sup> Núcleo de Assistência, Ensino e Pesquisa em Reabilitação Pulmonar (NuReab), Universidade do Estado de Santa Catarina (UDESC), Florianópolis, SC, Brazil

<sup>2</sup> Programa de Pós-Graduação em Fisioterapia, Centro de Ciências da Saúde e do Esporte (CEFID), Universidade do Estado de Santa Catarina (UDESC), Florianópolis, SC, Brazil

<sup>3</sup> Programa de Pós-Graduação em Ciências Médicas, Universidade Federal de Santa Catarina (UFSC), Florianópolis, SC, Brazil

<sup>4</sup> Programa de Pós-Graduação em Ciências do Movimento Humano, Centro de Ciências da Saúde e do Esporte (CEFID), Universidade do Estado de Santa Catarina (UDESC), Florianópolis, SC, Brazil

## Corresponding author:

Anamaria Fleig Mayer, Departamento de Fisioterapia. Núcleo de Assistência, Ensino e Pesquisa em Reabilitação Pulmonar (NuReab), UDESC. Rua Pascoal Simone, 358, CEP 88080-350, Florianópolis, SC, Brazil.

Email: [anamaria.mayer@udesc.br](mailto:anamaria.mayer@udesc.br)



## Introduction

In interstitial lung disease (ILD), dyspnea and peripheral muscle fatigue are the main manifestations responsible for exercise intolerance.<sup>1</sup> This condition, together with physical inactivity and disease exacerbation, negatively impacts the activities of daily living (ADL) and functional status.<sup>1-3</sup> The latter has already been identified as a predictor of mortality<sup>4</sup> and disease severity.<sup>5</sup> Thus, its evaluation is indispensable<sup>3,6</sup> and can be performed using exercise tests, which provide a global perspective of functional capacity and must be chosen according to their characteristics.<sup>1</sup> The 6-minute walk test (6MWT) is widely used since it is valid, reproducible, and correlates with other outcomes.<sup>7,8</sup> The step test<sup>9</sup> and the sit-to-stand test<sup>10,11</sup> are also feasible; however, they require greater standardization to support its clinical practice use in ILD.

These tests focus on assessing a single task using the lower limbs, such as walking, ascending/descending steps, and standing/sitting. An alternative involving multiple tasks is the Glittre-ADL test (TGlittre), which consists of a standardized ADL circuit that, in addition to the tasks mentioned above, includes upper limb movements, squats, and/or trunk inclination.<sup>12</sup> Therefore, the TGlittre can provide a more detailed functional status assessment since ADL are performed using different body segments.<sup>12</sup> Also, it is known that upper limb muscle dysfunction contributes to functional limitation in ILD, but to a lesser extent than the lower limbs.<sup>2,5</sup> Initially developed for COPD, the TGlittre differentiates the functional status of healthy individuals,<sup>13</sup> correlates with physical activities of daily living (PADL),<sup>14</sup> induces similar physiological overload to the 6MWT<sup>15</sup> and has also proved to be valid in other populations.<sup>16-19</sup>

Given the limitation of valid tests for the assessment of functional status, the TGlittre emerges as an alternative for ILD patients; however, its applicability needs to be investigated. Thus, the present study aimed to investigate the reliability and validity of the TGlittre to assess the functional status of patients with ILD.

## Methods

This cross-sectional study was approved by the Human Research Ethics Committee of the Santa Catarina State University (UDESC) (CAAE: 02360 518.3.3001.0121). Patients with ILD of both sexes, referred from health services in Florianópolis,

participated in the study, with prior consent. The following inclusion criteria were adopted: diagnosis of ILD by a pulmonologist, based on clinical, radiological, and functional criteria, and confirmed by lung biopsy and/or computed tomography<sup>3</sup>; age between 18 and 80 years; and clinical stability in the last month to the protocol. As exclusion criteria, were adopted: associated comorbidities that made evaluations unfeasible; participation in pulmonary rehabilitation program in the last 6 months; current or ceased smoking in less than 6 months; and disease exacerbation during the protocol.

## Study design

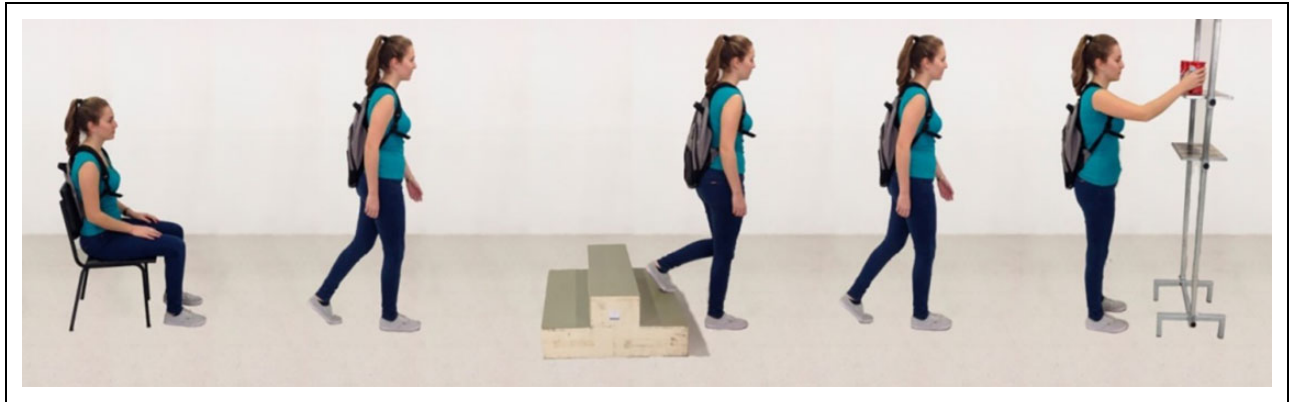
There were 5 days of evaluation. On the first, anamnesis was conducted, data regarding anthropometry and lung function were collected, and both the Saint George Respiratory Questionnaire (SGRQ) and the modified Medical Research Council (mMRC) were applied. On the second day, the patients performed two TGlittre (TGlittre 1 and TGlittre 2), with an interval of 30 minutes in between. Right after, were instructed to use an accelerometer for 2 days at home. On the last day, two 6MWTs (30-minute interval) were performed.

To assess lung function, a body plethysmography was used<sup>20</sup> (Master Screen Body, Jaeger®, Germany). Predicted lung function values were calculated<sup>21</sup> and the carbon monoxide diffusing capacity (DLCO) was also assessed.<sup>22</sup>

The SGRQ assessed the health-related quality of life.<sup>23</sup> Total and domain scores were obtained: symptoms, activity, and psychosocial impact. Values above 10% represent an altered quality of life, and higher scores indicate a worse outcome.<sup>23</sup>

The mMRC was used to assess the degree of dyspnea.<sup>24</sup> The higher the score, the greater the dyspnea on exertion.<sup>24</sup>

The TGlittre consists of a 10-meter circuit in which the individual starts from a sitting position, walks, goes up and down two interposed steps and walks again until reaching a shelf, individually adjusted according to the height of the shoulder and waist.<sup>12</sup> Three objects of 1 kg each positioned on the top shelf must be moved one by one to the bottom shelf, then to the floor, back to the bottom shelf, and finally back to the top shelf. Once this task was completed, the individual should return the entire circuit in the opposite direction and sit on the chair, finishing one lap; immediately afterward, another lap is started<sup>12</sup> (Figure 1).



**Figure 1.** TGlittre's ADL circuit (Source: author's own files).

The patients were instructed to complete five laps in the shortest time, using a backpack with 2.5 kg (for women) or 5 kg (for men).<sup>12</sup> Two TGlittre were performed, always by the same evaluator and with an interval of 30 minutes in between to allow the cardiorespiratory parameters and symptoms (dyspnea and fatigue) to return to baseline. Before and after, and at the end of each lap, heart rate (HR), SpO<sub>2</sub>, and the sensation of dyspnea and lower limb fatigue were verified.<sup>25</sup> Blood pressure (BP) was assessed at the beginning and end of tests. The test was interrupted, for safety reasons, in the presence of adverse events, SpO<sub>2</sub> < 80% and/or HR > 85% of maximum (allowing the return when SpO<sub>2</sub> ≥ 85% and/or a reduction of 10 bpm from the highest reached), or even when the patient deemed necessary for recovery. Reliability was calculated using the time in TGlittre 1 and 2, while the TGlittre with the lowest time was used in the remaining analyses. The predicted values were calculated,<sup>26</sup> with a longer time represents a greater functional limitation.<sup>12</sup>

All patients were instructed to use a triaxial accelerometer (DynaPort MiniMod; McRoberts BV<sup>®</sup>) during 2 consecutive days to monitor the PADL.<sup>27</sup> Measurements were performed at home and started immediately after waking up, for 12 hours daily counted from their placement.<sup>28</sup> The variables used for data analysis consisted of the averages of the 2 days of use: time in moderate and vigorous activities and time in sedentary behavior (≥3.0 and <1.5 metabolic equivalent of task, respectively), movement intensity, energy expenditure, and number of steps.<sup>28,29</sup>

The 6MWT assessed functional capacity.<sup>30</sup> In a 30-meter flat corridor, marked by cones positioned 0.5 meter from the beginning and end of the course,<sup>30,31</sup> two tests were performed with an interval

of 30 minutes to allow the cardiorespiratory parameters to return to baseline. Before and after, as well as during every minute, HR, SpO<sub>2</sub>, dyspnea, and lower limb fatigue were assessed.<sup>25</sup> BP was assessed before and after the test. The longest distance covered (in meters and the percentage of predicted values)<sup>32</sup> was included in data analysis. The greater the distance, the better the functional capacity.<sup>30</sup>

### Sample size

The GPower software, version 3.1.9.2, (Kiel, Germany) was used. Considering an intraclass correlation coefficient (ICC) of >0.75,  $\alpha = 0.05$ , and  $\beta = 0.10$  for reliability analyzes, an optimal sample size of 14 patients was estimated.<sup>33</sup> Adopting a correlation coefficient of 0.70 for the construct validity hypothesis, an estimated sample size of 17 patients was obtained.<sup>33</sup> Nevertheless, considering a sample loss of 20%, an optimal sample size of 21 patients was estimated.

### Statistical analysis

The SPSS program, version 20.0 (IBM Corporation) was used. Data normality was verified with the Shapiro-Wilk test. Paired t test or Wilcoxon were used to compare the performance and interruption time in TGlittre, physiological response (HR, SpO<sub>2</sub>, BP), dyspnea, lower limb fatigue, and variations ( $\Delta$  final—initial;  $\Delta$  recovery—final) between the two tests and between TGlittre and 6MWT. Relationships between the TGlittre performance and the other instruments, between the time spent on the first TGlittre and the variation between test and retest, as well as between the physiological variables in the TGlittre and 6MWT were assessed using the Pearson's or Spearman's correlation coefficients. The two-way

**Table 1.** Characterization data of the sample of 21 individuals with ILD.

Variables	Mean $\pm$ SD	
Age (years)	63.2 $\pm$ 11.4	
BMI (kg/m <sup>2</sup> )	27.5 $\pm$ 5.30	
	Absolute	%predicted
<b>Lung Function</b>		
FEV <sub>1</sub> (L) and (%pred)	2.12 $\pm$ 0.66	78.0 $\pm$ 20.8
FVC (L) and (%pred)	2.56 $\pm$ 0.87	74.7 $\pm$ 21.2
VC (L) and (%pred)	2.62 $\pm$ 0.87	78.9 $\pm$ 23.2
TLC (L) and (%pred)	3.98 $\pm$ 1.07	73.2 $\pm$ 16.8
DLCO (mmol/min*kPa) and (%pred)	4.42 $\pm$ 1.33	51.0 $\pm$ 12.6
6MWT (m) and (%pred)	437 $\pm$ 89.8	79.5 $\pm$ 14.6
	Mean $\pm$ SD	
mMRC	I [I]*	
SGRQ		
Total	43.5 $\pm$ 17.7	
Symptoms	44.5 $\pm$ 18.6	
Activity	57.5 $\pm$ 18.6	
Impact	37.0 $\pm$ 19.9	
PADL		
Time in moderate and vigorous activities (min)	84.7 $\pm$ 33.3	
Time in sedentary behavior (min)	536 $\pm$ 70.6	
Steps (number/day)	5292 $\pm$ 1993	
Walking movement intensity (m/s <sup>2</sup> )	1.90 $\pm$ 0.43	
Energy expenditure walking (Kcal)	320 $\pm$ 138	
Total energy expenditure (Kcal)	1310 $\pm$ 300	

SD: standard deviation; BMI: body mass index; kg: kilogram; m: meters; %predicted: percentage of predicted; FEV<sub>1</sub>: forced expiratory volume in 1 second; L: liters; %pred: % of predicted; FVC: forced vital capacity; VC: vital capacity; TLC: total lung capacity; DLCO: carbon monoxide diffusing capacity; mmol: millimoles; min: minutes; kPa: kilopascals; 6MWT: 6-minute walk test; mMRC: modified Medical Research Council scale; SGRQ: Saint George Respiratory Questionnaire; PADL: physical activity of daily living; s: seconds; Kcal: kilocalories.

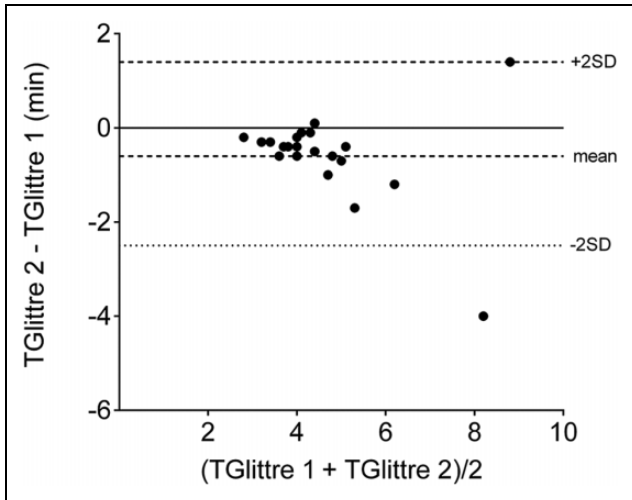
\*Results presented in median [interquartile range].

ICC, with mixed effects and a single measure, was adopted to assess the reliability, and values were interpreted as low (<0.40), moderate ( $\leq$ 0.75), and high (>0.75).<sup>34</sup> The Bland-Altman plot was used to assess the agreement between the two TGlitre. The standard error of measurement (SEM) and the minimum detectable difference (MDD) were calculated,<sup>35</sup> as well as the learning effect in the TGlitre [ $100\% - \frac{\text{TGlitter1} \times 100}{\text{TGlitter2}}$ ]. Validity was tested with the hypothesis of a correlation coefficient of  $\geq$ 0.70 between the time in the TGlitre and both the distance walked in the 6MWT and the PADL variables.

## Results

Twenty-eight patients were eligible. Of these, seven were excluded: one for hallux amputation, one for

significant cardiac symptoms, four interrupted the protocol (two due to exacerbation and two due to the COVID-19 pandemic) and one for not fit the sample's severity profile, characterizing as an outlier (forced vital capacity: 21%pred; shortest time in TGlitre: 15.9 minutes; average interruption time at TGlitre: 8.77 minutes; longer distance in the 6MWT: 198 meters). The total sample was composed of 21 patients with ILD, 14 female (66.7%), with a diagnosis time of  $5.85 \pm 3.53$  years. Considering the etiology of the pulmonary condition, 12 (57.1%) had ILD secondary to rheumatic disease, three (14.3%) idiopathic pulmonary fibrosis, two (9.5%) ILD due to hypersensitivity and two (9.5%) usual interstitial pneumonia. Another 2 patients (9.5%) had no definite cause for ILD. None had emphysema or other respiratory comorbidities. Also, one patient (4.5%) was a long-term oxygen therapy user and performed all tests



**Figure 2.** Bland-Altman distribution graph for the two TGlitter performed by individuals with ILD. Mean =  $-0.6$  min;  $+2$  SD =  $1.4$  min; and  $-2$  SD =  $-2.5$  min.

receiving the same flow of oxygen supplementation prescribed to him to use at home in daily life. The baseline characteristics are shown in Table 1.

The TGlitter showed high reliability, with ICC of  $0.90$  (95%CI:  $0.75$  to  $0.96$ ;  $p < 0.001$ ). The patients spent less time to complete the second test compared with the first ( $4.36 \pm 1.44$  minutes *versus*  $4.93 \pm 1.70$  minutes, respectively;  $p = 0.001$ ), with a mean difference of  $-0.57 \pm 0.96$  minute (Figure 2). The patients reached  $140 \pm 38.3\%$  of the time spent on the best test. Nineteen (90.5%) performed better on the second test, with a learning effect of 11.6%. Relationship was observed between the time spent on TGlitter 1 and the time variation between test and retest ( $r = -0.45$ ;  $p = 0.04$ ). SEM and MDD corresponded to  $0.55$  and  $1.51$  minute, respectively. On average, the sample reduced the time spent in the first three laps when performing the TGlitter 2 ( $p < 0.001$  to  $p = 0.03$ ) (Table 2).

There were interruptions in the tests of six patients (28.6%). During the TGlitter 1, two interruptions (33.3%) were due to oxygen desaturation, three (50%) performed by the patient, and one (16.7%) due to oxygen desaturation and by the patient. In TGlitter 2, three (50%) interrupted due to  $SpO_2 < 80\%$ , two (33.3%) due to self-reported limitation, and one (16.7%) for both reasons. The average interruption time was  $24.7 \pm 78.9$  and  $21.5 \pm 43.9$  seconds in TGlitter 1 and 2, respectively, with a moderate reliability (ICC:  $0.70$ ; 95%CI:  $0.93$  to  $0.99$ ;  $p < 0.001$ ) and no significant difference between them ( $p > 0.05$ ).

For the validity, 17 patients performed the 6MWT (four were excluded due to protocol interruption), and 19 performed the PADL (two were excluded due to lack of accelerometer data). The time spent to complete the TGlitter correlated with the distance in the 6MWT, both in meters ( $r = -0.70$ ;  $p = 0.002$ ; power:  $0.96$ ) and in percentage of predicted ( $r = -0.50$ ;  $p = 0.04$ ; power:  $0.69$ ). A relationship between the TGlitter performance and total energy expenditure ( $r = -0.52$ ;  $p = 0.02$ ; power:  $0.77$ ) were also observed (Figure 3), but not with other PADL variables ( $p > 0.05$ ).

Taking into account the other variables, the sample size was 21 patients. The TGlitter performance correlated with forced expiratory volume in 1 second ( $r = -0.57$ ;  $p = 0.01$ ), forced vital capacity ( $r = -0.49$ ;  $p = 0.03$ ), and vital capacity ( $r = -0.47$ ;  $p = 0.04$ ), all expressed in liters. No relationships were observed with dyspnea and quality of life.

### Physiological behavior during the TGlitter

The physiological behavior was similar between the two TGlitter (ICC:  $0.70$  to  $0.95$ ;  $p = 0.01$  to  $p < 0.001$ ). Lower limb fatigue was significantly higher during the third and fourth laps of the TGlitter 2 compared with TGlitter 1 (1 [2.5] *versus* 2 [3.5]; and 1 [3.5] *versus* 3 [4.5]; expressed as median [interquartile range];  $p = 0.04$  and  $p = 0.02$ ; respectively) (ICC:  $0.89$ ; 95%CI:  $0.70$  to  $0.96$ ; and ICC:  $0.92$ ; 95%CI:  $0.79$  to  $0.97$ ; respectively,  $p < 0.001$ ), while a higher systolic BP was found during the TGlitter 1 recovery compared with TGlitter 2 ( $122 \pm 13.2$  mmHg *versus*  $116 \pm 11.2$  mmHg;  $p = 0.03$ ) (ICC:  $0.79$ ; 95%CI:  $0.45$  to  $0.92$ ;  $p = 0.001$ ). No significant differences were observed in the other physiological variables.

No significant differences were found between 6MWT and TGlitter. When the variables were analyzed at the end of the test and during the TGlitter recovery, they all correlated to their correspondents in the 6MWT ( $r = 0.47$  to  $0.84$ ;  $p < 0.001$  to  $p = 0.04$ ), except for dyspnea and  $SpO_2$  in the last lap and the sixth minute of the 6MWT ( $p > 0.05$ ). When considering the final  $\Delta$ , HR and lower limb fatigue were correlated between TGlitter and 6MWT ( $r = 0.60$ ;  $p = 0.01$ ;  $r = 0.92$ ;  $p < 0.001$ ; respectively), as well as lower limb fatigue in  $\Delta$  recovery ( $r = 0.53$ ;  $p = 0.03$ ).

**Table 2.** Comparison between total times and laps times spent on TGlittre 1 and TGlittre 2.

	TG1ittre 1 (Mean ± SD)	TG1ittre 2 (Mean ± SD)	Δ TG1ittre (Mean ± SD)	p
Total time (min)	4.93 ± 1.70	4.36 ± 1.44	-0.57 ± 0.96	0.001*
Time (%pred)	161 ± 51.0	143 ± 46.6	-18.0 ± 29.8	0.001*
Lap 1 (s)	55.1 ± 14.4	47.0 ± 10.5	-8.14 ± 6.19	<0.001*
Lap 2 (s)	52.5 ± 14.5	46.3 ± 8.83	-6.14 ± 6.91	<0.001*
Lap 3 (s)	71.8 ± 79.0	55.1 ± 33.2	-16.0 ± 81.2	0.03*
Lap 4 (s)	57.1 ± 22.3	57.6 ± 24.0	1.21 ± 14.4	0.17
Lap 5 (s)	55.0 ± 15.3	55.9 ± 26.0	1.48 ± 20.9	0.05

TG1ittre: Glittre-ADL Test; SD: standard deviation; Δ: TG1ittre2 – TG1ittre1; p: significance level; min: minutes; %pred: percentage of predicted; s: seconds.

\*Statistic difference ( $p < 0.05$ ).

## Discussion

The present study demonstrated that the TG1ittre was reliable and valid for assessing functional status in ILD, showing high test-retest reliability and relationships with both the distance covered in the 6MWT and energy expenditure in the PADL. Also, the TG1ittre correlated with lung function, indicating that more severe patients spend more time to complete the test. The physiological changes induced during the TG1ittre test and retest were similar, and the same behavior was observed between the TG1ittre and 6MWT. Most patients showed superior performance in the second TG1ittre, with a learning effect of 11.6%.

The high test-retest reliability found in the TG1ittre demonstrates its consistency during the application of two tests on the same day and with an interval of 30 minutes. The ICC value found is close to that presented by two other studies that investigated the TG1ittre reliability in COPD patients (ICC of 0.97 and 0.96).<sup>36,37</sup> The TG1ittre also proved to be reliable in other populations, with ICCs ranging between 0.84 and 0.93.<sup>16,18,19,38</sup>

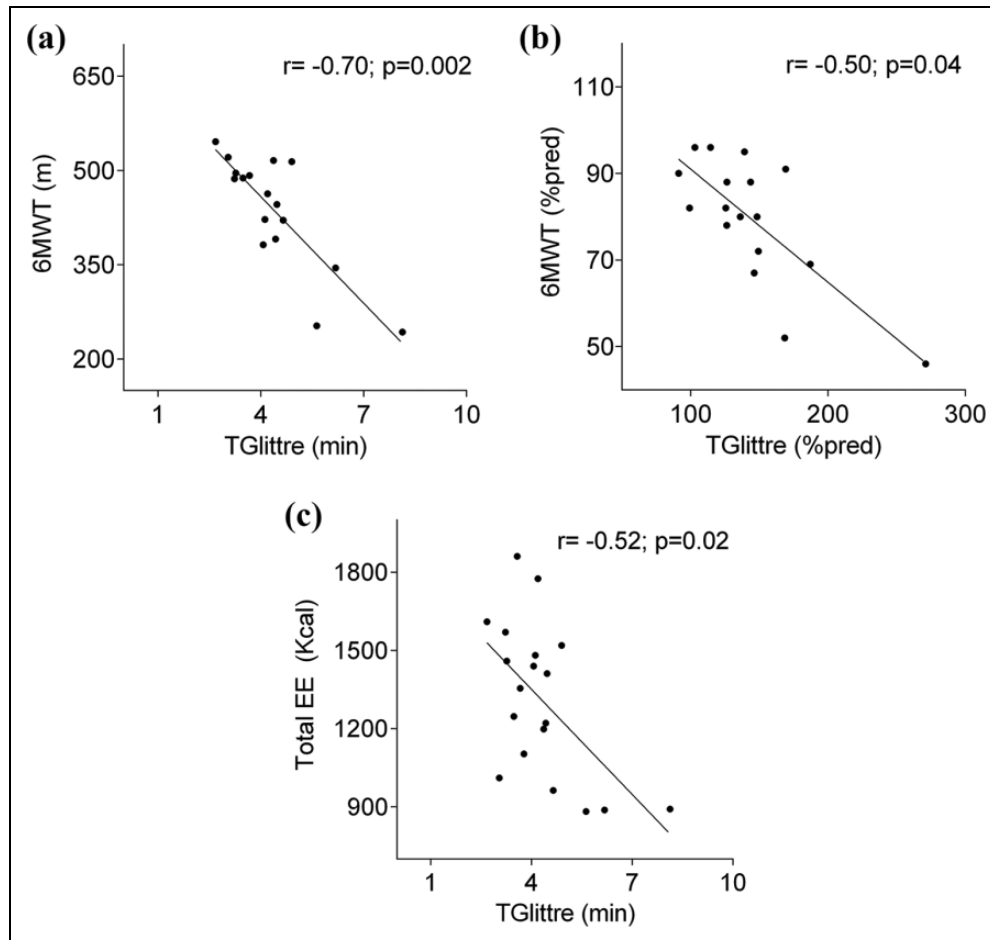
Given the scarcity of standardized tests, no “gold standard” field test is present for the functional evaluation of ILD patients. Among the most used, the 6MWT is the one that best reflects the everyday life of this population, being highly standardized in chronic respiratory diseases (ICC of 0.82 to 0.99)<sup>31</sup> and idiopathic pulmonary fibrosis (ICC of 0.82),<sup>7</sup> values similar to those of the TG1ittre. Correlations between the TG1ittre and the 6MWT were observed both in absolute and percentage of predicted values, taking into account the validity hypothesis, and also in studies including other populations.<sup>12,13,18,19</sup> An alternative test for patients with ILD is the five-repetitions sit-to-stand test, which proved to be reliable (ICC of 0.87).<sup>10</sup> Taking into account only the applicability of

the 6MWT and five-repetitions sit-to-stand tests, both could be used to assess functional status; however, their characteristics need to be considered.<sup>6</sup> These tests partially evaluate functional limitation since include only one activity<sup>9,10</sup> in a wide range of ADL that are usually limited by the disease. Conversely, the TG1ittre simulates a daily situation involving multiple tasks and different body segments, chosen because they are often problematic for those who present ADL limitations.<sup>12,13</sup> Furthermore, an advantage is that the 10-meter circuit requires less physical space for its execution compared with the 6MWT.<sup>30</sup>

The correlation between the TG1ittre performance and total energy expenditure found in the study suggests that this test can reflect the energy expenditure of ILD patients in an ADL context. However, correlations with other PADL variables were expected, such as those found by Karloh et al.<sup>14</sup> in COPD, since the TG1ittre mimics everyday life. This fact can be attributed to a possible type II error and should be better investigated in future studies with larger sample sizes.

Our results also showed that the time to complete the TG1ittre correlated with lung function, indicating that more severe patients had a worse performance, which was already expected and related to more intense exercise intolerance, as in COPD. Conversely, Skumlien et al.<sup>12</sup> also observed correlations between the TG1ittre performance and both the activities domain score of the SGRQ and dyspnea. Although dyspnea is the main symptom for ADL limitation in ILD and COPD, no relationships were found. Even though dyspnea has been assessed by different instruments when considering these studies, future analyses with a larger sample size must be conducted to confirm these findings.

Considering the TG1ittre with the best performance, the ILD patients of our study performed in a longer



**Figure 3.** Correlations between time spent on TGlittre (minutes) and distance on 6MWT, in meters (a); performance on TGlittre (%predicted) and distance on 6MWT, in percentage of predicted (b); and between time spent on TGlittre (minutes) and total energy expenditure, in kilocalories (c).

time ( $\sim 4.5$  minutes) than healthy ( $2.62 \pm 0.34$  and  $3.03 \pm 0.30$  minutes).<sup>13,16</sup> In general, it is known that at least 2 minutes are required to complete the TGlittre without violating the protocol<sup>16</sup> and that adults without underlying diseases tend to perform it in a very close time. The impaired pulmonary function and gas exchange resulting from the ILD pathophysiology and other systemic impairments contribute to exercise intolerance and create a vicious cycle of functional capacity and symptom worsening.<sup>1,3</sup> Therefore, it is expected that these patients demand more time to perform the ADL, which reflects in a low performance during tests. Similar results are observed in COPD, which performs the TGlittre between 4 and 5 minutes,<sup>13,15</sup> and, on average, reaching 139% of the predicted time.<sup>26</sup>

Almost the entire sample performed better the second TGlittre, with an average reduction of 11.6% in time compared to the first test (approximately 1

minute), demonstrating a significant learning effect. Although as far as we know there is no cut-off point, it is interesting to perform two TGlittre on the same day so that the patient's performance is not underestimated. The improvement in performance observed in the retest is probably due to the familiarization with the first test, which makes the patient accustomed to the effort and safer during a second test.<sup>39</sup> In other studies, healthy and COPD patients showed minor learning effects (6.3 to 7%).<sup>12,16,36,37</sup> This difference can be explained by the greater oxygen desaturation observed in ILD patients during exercise,<sup>3</sup> which may interfere with the test performance. In parallel, another test that has a similar learning effect is the 6MWT, which is also recommended to be performed twice.<sup>31</sup> Jenkins and Cecins<sup>39</sup> analyzed the learning effect of different chronic respiratory diseases during the 6MWT and found that it is directly influenced by the diagnosis since patients with ILD and COPD had a greater



magnitude of change (+41 and +37 meters in the second 6MWT, respectively) than those with bronchiectasis and asthma (+22 and +19, respectively), especially as the former report higher levels of dyspnea in the first test.<sup>39</sup> Furthermore, the shortest time observed in the second TGlittre was mainly due to the reduced duration of the first three laps, a behavior similar to that found in COPD.<sup>15</sup> Our results also showed that a longer time in TGlittre 1 is associated with a shorter time variation between test and retest.

The physiological changes during the TGlittre were expected, in which the increased metabolic demand generated an equivalent adaptation. This behavior was similar in the two TGlittre, suggesting a similar physiological overload. Studies performed in COPD have also demonstrated the same response.<sup>13,15</sup> Conversely, the greater sensation of lower limb fatigue observed in the third and fourth laps of the TGlittre 2 was probably associated with the shorter time spent to complete the test. The lack of significant difference in the physiological variables between the TGlittre and 6MWT, together with the moderate to very strong correlations found, indicates that both tests promoted a similar physiological overload. According to results in COPD, the TGlittre induced higher oxygen consumption, but the cardiovascular and ventilatory responses were similar to those observed in the 6MWT.<sup>14</sup>

This is the first study investigating the TGlittre applicability in ILD, with a representative sample of several subtypes, demonstrating its reliability and validity. It cannot be ruled out that the sample size may have caused a type II error in some correlation analyses. However, this is a reflection of the low disease prevalence.<sup>3,40</sup> The evaluation of the PADL in just 2 days could be considered a limitation of the study. However, it was possible to find a correlation between the main study variable and the total energy expenditure, supporting the validity of TGlittre. Thus, this study provides a new tool that contributes to the assessment and management of functional status of patients, especially those with less severe disease. Further studies are suggested to investigate other measurement properties of the TGlittre to consolidate it as a functional assessment tool in this population and so that the results can be extrapolated to more severe patients.

In conclusion, the TGlittre is a reliable and valid tool for the assessment of functional status in ILD and can be used for this purpose. Due to the learning effect in this population, it is recommended to conduct two tests on the same day.

## Author contributions

All authors contributed substantially to the conception and design of the study, the collection, analysis, and interpretation of the data, the draft, review and the approval of the final version.

## Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## ORCID iD

Anamaria Fleig Mayer  <https://orcid.org/0000-0003-0320-4810>

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