# Validation of 4-meter-gait-speed test and 5-repetitions-sit-to-stand test in patients with pulmonary fibrosis: a clinimetric validation study

*Ada E.M. Bloem[1], Marcel Veltkamp[2, 3], Martijn A. Spruit[4, 5, 6], Jan W.H. Custers[1], Eric W.P. Bakker[7], Hanneke M. Dolk[2, 3], Jan C. Grutters[2, 8]*

[1] University of Applied Sciences Utrecht, Institute of Movement Studies, Faculty of Health Care, Utrecht, The Netherlands; [2] Interstitial Lung Diseases Center of Excellence, Department of Pulmonology, St Antonius Hospital, Nieuwegein, The Netherlands; [3] Division of Heart and Lungs, University Medical Center Utrecht, Utrecht, The Netherlands; [4] Department of Research and Education, CIRO+, Center of Expertise for Chronic Organ Failure, Horn, The Netherlands; [5] Department of Respiratory Medicine, Maastricht University Medical Center, NUTRIM School of Nutrition and Translational Research in Metabolism, Maastricht, The Netherlands; [6] REVAL - Rehabilitation Research Center, BIOMED - Biomedical Research Institute, Faculty of Medicine and Life Sciences, Hasselt University, Diepenbeek, Belgium; [7] Department of Clinical Epidemiology, Biostatistics, and Bioinformatics, Academic Medical Center, Amsterdam, The Netherlands; [8] Division of Heart and Lungs, University Medical Center Utrecht, Utrecht, The Netherlands

**Abstract.** *Background and objective:* Patients with pulmonary fibrosis (PF) have a clear exercise intolerance. The 4-meter-gait-speed (4MGS) test and the 5-repetitions-sit-to-stand (5STS) test are easy, inexpensive and reliable measures of functional performance. Both tests have been validated in healthy adults and patients with chronic obstructive pulmonary disease. 4MGS test and 5STS test have not been studied in patients with PF. *Methods:* In this cross-sectional clinimetric validation study 51 PF patients conducted in random order the 4MGS test, 5STS test and the 6-min walk test (6MWT) on a single day. Additionally, body weight, height, lean body mass, health-related quality of life, disease severity, handgrip strength, dyspnoea and leg fatigue were assessed. The setting was a tertiary referral center for Interstitial Lung Diseases. *Results:* Patients had a diagnosis of idiopathic pulmonary fibrosis (IPF, 37%), PF other than IPF (47%), or unclassified (16%). Patients walked 453±111m in six minutes. Moreover, it took the patients 2.0±0.5s to walk 4 m, and 12.0±3.8s for the 5STS test. The 4MGS test (r = 0.77; p<0.01) and the 5STS test (r = -0.41; p<0.01) correlated significantly with the distance walked in 6MWT. Indeed, 4MGS combined with handgrip strength and Medical Research Council dyspnoea grade could explain 75% of the variance in 6MWD. *Conclusions:* 4-meter-gait-speed and 5-repetitions sit-to-stand are significantly and independently correlated with the 6-minute walk distance in patients with pulmonary fibrosis. Indeed, 4-meter-gait-speed test may serve as a simple initial field test to assess exercise performance in patients with pulmonary fibrosis. *(Sarcoidosis Vasc Diffuse Lung Dis 2018; 35: 317-326)*

**Key words:** exercise and pulmonary rehabilitation; pulmonary fibrosis; 6-minute walk test; gait

## Introduction

Interstitial lung diseases (ILD) are a group of more than 150 different disorders characterized by inflammation of the lung parenchyma or interstitium often followed by the occurrence of pulmonary fibrosis (PF). Patients with PF complain about exertional dyspnoea, exercise intolerance and reduced quality of

life (1). As the disease progresses, patients become severely limited in their activity. Poor exercise tolerance is associated with reduced quality of life and poor survival (2, 3). Measures of exercise capacity or exercise-induced oxygen desaturation (EID) obtained from maximal and sub-maximal exercise tests are good predictors of survival in patients with PF (4-6). Measuring the exercise capacity in patients with PF is a well-accepted and important element of clinical management.

The 6-Minute-Walk Test (6MWT) is one of the most widely used clinical tests in patients with PF, as it plays a key role in evaluating functional exercise capacity and assessing prognosis (7, 8). Nevertheless, there are some disadvantages with the 6MWT. First, the 6MWT is generally carried out in a hospital corridor and the length of the corridor can be an issue (i.e., ≥30m) (7). Secondly, it may also be time-consuming as repeat walks are needed due to the learning effect (9). In regular clinical practice it is not a routine test every time patients with PF visit the medical outpatient consultation. Therefore, there is an increasing demand for reliable and easy to perform physical tests to provide clinicians with a first impression about the patients with PF functional exercise performance (10-14).

In respiratory medicine, the 4-Meter-Gait-Speed test (4MGS) and 5-Repetitions-Sit-To-Stand test (5STS) are relatively new tests. Both tests require little space, time, equipment or training to measure, which makes them attractive measures of functional exercise performance for routine clinical use (15). Clinimetric properties of the 4MGS and 5STS were reported to be adequate in patients with Chronic Obstructive Pulmonary Diseases (COPD) (10, 13, 15-17). However, clinimetric measurement properties of these tests in patients with PF are still unknown to our knowledge.

Therefore, the main research question was: What is the validity of the 4MGS and the 5STS, for assessing functional exercise performance in patients with PF?

The sub question was: Can these performance tests, alone or with other office-available tests, contribute to explain the variances in the distance walked in 6MWT in patients with PF?

## Method

This cross-sectional clinimetric validation study was undertaken on outdoor patients, visiting a tertiary referral center for ILD in the Netherlands, from June to December 2015. Participants were asked to perform three exercise performance tests, namely 4MGS, 5STS and 6MWT, on the one-day visit of the patient to the PF-specialized pulmonologist. This study was approved by the Medical research Ethics Committees United (MEC-U;NL51679.100.15/PT-PF)

Patients (age ≥18 year) with a confirmed PF diagnosis (1, 18), visiting the Outpatient Pulmonary Clinic of the ILD Centre and who met the in- and exclusion criteria for 6MWT (7) were eligible to participate. Eligible patients were invited by an ILD-physician (MV) using an invitational letter. Subsequently the principle researcher (AB) contacted patients who responded (telephone, e-mail, return form). At the one-day visit two researchers executed the exercise tests.

All patients were instructed at start of the visit about the study procedure and give written informed consent before first test (Figure 1: flow chart overview of the study design).

The following patient data and lung function test values were extracted from the electronic patients files (dated for this specific one-day visit): age (year), gender (m/f), height (m), body weight (kg), forced vital capacity (L, %predicted), forced expiratory volume in 1 second (L, %predicted), diffusion capacity (mmol/min/kPa, %predicted), smoking status (packed-year) and medication.

Patients were asked to fill out the MOS 36-Item Short-Form Health Survey (SF-36) to assess generic health status (19-21), and the Medical Research Council (MRC) for situational perception of breathlessness (21, 22). Additionally, rest heart rate (HRrest, beats-per-minute; Nellcor N-20), blood pressure (BP, mmHg), body mass index (BMI, weight/length$^2$), body fat percentage (fat%weight, Omron HBF 306) (23), transcutaneous oxygen saturation (SpO2; %; Nellcor-N-20), and the ratings for perceived exertion for dyspnoea and leg fatigue for short-term intensity (0-10 modified Borg scale) (24) were obtained. Peak heart rate (HRpeak) was defined as 210-(0.63*Age). A low fat-free mass index (FFMI: FFM/height$^2$) was based on BMI-specific
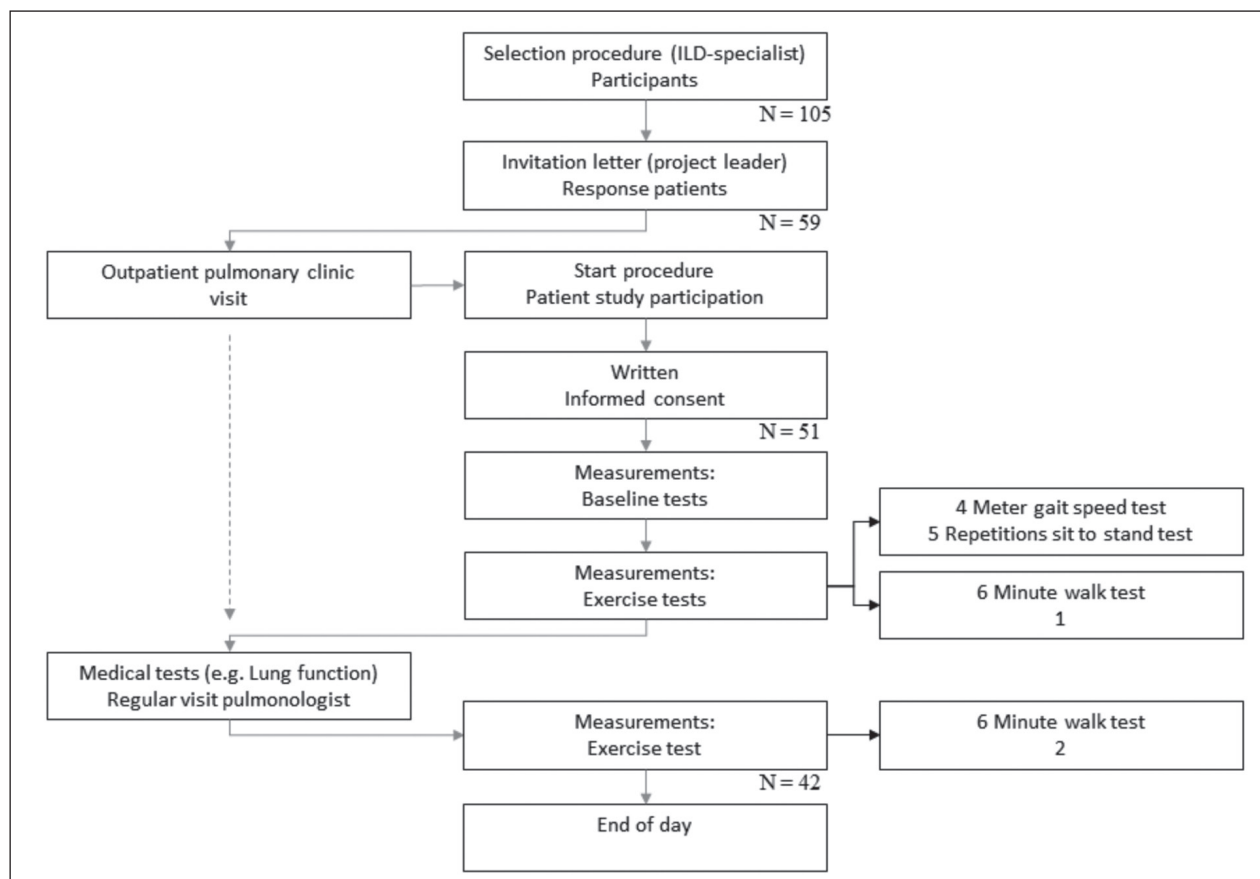
**Fig. 1.** Flow chart overview of the study design with main procedures

and gender-specific cut points as derived from the UK Biobank, classifying a FFMI below the fifth percentile as low (25). The maximal isometric grip strength of the right hand (HGS, kg) was measured with a Jamar hand-grip dynamometer (protocol American Society of Hand Therapy) (26, 27). Percentage of predicted was calculated using normative data of Spruit et al. (28).

Subsequently, the exercise tests were performed. Patients were randomly assigned to start the battery of functional exercise tests with either the two performance tests, 4MGS (first) and 5STS, followed by the 6MWT, or the other way around. Interval time for the second 6MWT was at least one hour.

Exercise tests were performed with continuous monitoring of $SpO_2$ and HR; each test started from resting values HR and SpO2. For time measurements a stopwatch (HiTRAX-GO) and a sim-

ple timer (Eurochron Dual-Timer) were used. Tests were performed on a flat hard surface, a safety chair was placed near to test area. Before tests, exercise protocols were explained to the patient. The dyspnoea and leg fatigue scores were assessed before and directly after each test. Tests were supervised by one of two trained physiotherapists, who walked slightly behind the patient during the 6MWT to avoid setting the walking pace. Oxygen desaturation was defined as $SpO_2$ ≤88% and/or a decrease of >4% (29, 30). Patients were not stopped during exercise testing when SpO2 was <80%, as this also occurs during daily activities (29). If a patient was on long-term oxygen therapy, oxygen was given at their standard flow rate or as prescribed by a physician; the cylinder was carried by the assessor. Directly after finishing the test patients were asked to sit (chair) to recover. Three minutes recovery time was measured for SpO2

and HR (a failure of HR recovery to reduce by at least 13 bpm after 1 minute, HRR1, or 22 bpm after 2 minutes of recovery, HRR2) (31). All necessary safety procedures were be taken into account according to the ERS/ATS Technical Standard (7). If a patient was unable to perform an exercise test according to test protocol, that test was excluded for statistical analysis.

4MGS is a performance measure of functional mobility and gait speed (10, 32). The patient was instructed to 'walk as quickly as possible' 4 meters (moving start); space to accelerate and to decelerate was 2 meter, before/after the set distance. The distances (0-2-6-8 meter) were marked with tape stripes on the floor. The test was performed three times (interval period 2 minutes). The fastest time to complete the 4-meter walk was used for analysis. Reference values are based on gender, age and height (33).

5STS is a performance measure of functional mobility and lower limb muscle strength (15, 34). Patients sat with arms folded across chest, in upright position against the back (chair height 45 cm). Patients were asked to stand up and sit down 5 times, as quickly as they could without any form of assistance. The test was performed twice (interval period 2 minutes). The quickest time measured was used for further analysis. Normative values: the times for 5-repetitions can be considered worse for exceeding the following values: 11.4 s (60 to 69 years), 12.6 s (70 to 79 years), and 14.8 s (80 to 89 years) (11).

The 6MWT procedure was conform the Official ERS/ATS Technical Standard (7). Briefly, 6MWT took place in a quiet 30-meter corridor and only standardized instructions and encouragement were given. Patients were instructed to walk as far as they could without running; they were permitted to slow down or stop to rest if needed. Reasons to stop the test were experienced chest pain, intolerable dyspnoea, diaphoresis, leg cramps and/or vertigo. The 6MWT was performed twice, with a minimal interval of one hour. The best 6MWD was used for further analysis (30, 35). If a patient was not able to complete a second 6MWT, the result of the first test was used for analysis. Walking distance will be compared with the mean distance%predicted compared to healthy elderly persons (36). Data on the reproducibility of the 6MWT was published before (9).

*Outcome measures*

The primary outcome measures were the main outcomes of the two performance tests, gait speed in 4MGS (m/s) and the time to raise from a chair five times in 5STS (s), and the distance covered in 6MWT (m).

Secondary outcomes included the patient characteristics (gender, age, disease classification, lung function and diffusion capacity, use of supplemental oxygen, BMI, FFMI, MRC, HR, SpO2, BP, SF-36) and measurement outcomes from strength and exercise testing (HGS, HRpeak, CR, Lowest SpO2, Borg scores of dyspnoea and leg fatigue, recovery time for HR and SpO2)

*Data analysis*

SPSS software (version 23) was used for statistical analysis. Patients' characteristics are presented with appropriate measures of central tendency and dispersion. Numerical data were tested for normality by mean-median ratio, SD-mean ratio, and judging histogram (37). Test-retest reliability was calculated by intraclass correlation coefficient (ICC) of single measures and absolute agreement with random effect (95%CI; p<0.05). The correlation between the 4MGS (m/s) and the 6MWD (m), and the correlation between the time to complete the 5STS (s) and the 6MWD (m), were calculated by Pearson's r or when the assumptions are violated by Spearman's rho. In case of missing values, cases were excluded pairwise. The range for what constitutes a low, moderate or high correlation was respectively $0.3 \leq r < 0.5$, $0.5 \leq r < 0.7$ and $0.7 \leq r < 1.0$ (38). A multivariable model was conducted to assess the associations between independent in univariate analysis significant variables and the dependent variable 6MWD. The level of significance was set on P<0.05.

## Results

After invitation (n=105) 59 patients (56%) responded, whereby 8 Patients (13.6%) were excluded (excluded for 6MWT). The study sample consisted of 51 elderly patients with PF, of which 75% were men. The most common diagnosis was Idiopathic PF (37%). Generally, patients were overweight, had

to stop for breath after walking about 100 yards or after a few minutes on level ground, had an impaired spirometry and diffusion capacity, had a slightly im-paired HGS (12% of the patients had a HGS <5 per-centile) and a clearly impaired generic quality of life (Table 1 and 2).

**Table 1.** Patient characteristics (N=51)

| Variables | Values |
|---|---|
| Male (%) | 37 (73) |
| Age, years* (IQR) | 68 (63-74) |
| Pulmonary Fibrosis, | |
| Idiopathic Pulmonary Fibrosis (%) | 19 (37) |
| Other than Idiopathic Pulmonary Fibrosis, | |
| Extrinsic Allergic Alveolitis (%) | 9 (18) |
| Smoking related (%) | 2 (4) |
| Connective tissue related (%) | 13 (26) |
| Unclassified (%) | 8 (16) |
| Body mass index, kg/m² | 27.4±4.6 |
| Fat free mass index, kg/m² | 18.5±2.2 |
| Body fat percentage, % of weight | 30.8±6.5 |
| Number of patients with low FFMI (%) | 10 (20) |
| Medical research council dyspnoea grade* (IQR) | 3 (2 -3) |
| SpO$_2$ at rest, sat% | 97±2 |
| Supplemental oxygen, yes (%) | 11 (22) |
| HRrest, bpm | 76±12 |
| Systolic blood pressure at rest, mmHg | 131±16 |
| Diastolic blood pressure at rest, mmHg | 85±10 |
| Walking aid, yes (%) | 6 (12) |
| SF-36 PCS, points* (IQR) | 32.6 (25.8-38.0) |
| SF-36 MCS, points* (IQR) | 49.3 (43.0-56.5) |
| | |
| FVC, L | 2.9±0.9 |
| FVC, % predicted | 79.7±21.5 |
| FEV$_1$, L | 2.3±0.7 |
| FEV$_1$, % predicted | 81.5±21.4 |
| DLCOcSB, mmol/min/kPa | 4.0±1.6 |
| DLCOcS, % predicted | 46.1±16.4 |
| PF severity, Mild-Moderate/severe**, N (%) | 29/22 (57/43) |
| Smoking status (n=50) | |
| Never smoker | 14 (28%) |
| Former smoker | 35 (69%) |
| Current smoker | 1 (2%) |
| Smoking pack-year*/*** (n=28, IQR) | 20 (10-27) |
| Medication (n=50) | |
| Blood pressure decrease | 20 (10%) |
| Heart frequency decrease | 8 (16%) |
| Oral corticosteroids | 24 (48%) |

Data are presented as mean (SD) unless otherwise stated
 * Median
** Mild-Moderate (FVC/FEV1 % pred (<80%) ≥50%, DLCOc (<80%) ≥40%), Severe (FVC/FEV1 % pred <50%, DLCOc <40%)); Classification Pulmonary Fibrosis According to National Institute For Health and Care Excellence (NICE) (48)
*** Pack-year=quantification of cigarette smoking, (number of cigarettes smoked per day/20) * number of years smoked. (1 pack has 20 cigarettes)
Abbreviations: N=number, %=percentage, IQR=interquartile range, kg/m²=kilogram per square length in meters, FFMI=fat-free index, SpO2=peripheral capillary oxygen saturation, HRrest=heart rate at rest, bpm=beats per minute, mmHg =millimeters of mercury, SF-36=short-form health survey 36 questions, PCS=physical component score, MCS=mental component score, FVC=forced vital capacity, FEV$_1$=forced expiratory volume in 1 second, L=litre, DLCOcSB=diffusion capacity to carbon monoxide corrected single breath, mmol/min/kPa=mmol CO per minute per kilopascal, PF=Pulmonary Fibrosis, SD=standard deviation

**Table 2.** Strength and exercise testing

| Variables | Values |
|---|---|
| HGS Right hand highest value, Kg | 35±13 |
| HGS Right hand normative value <P5, N (%)[1] | 6 (12) |
| | |
| 6MWT | |
| Distance, m | 453±117 |
| Distance, % predicted[2] | 70.7±15.8 |
| Mean speed, m/s | 1.26±0.33 |
| Lowest SpO$_2$ , % | 85±7 |
| Distance saturation product, m·% | 382±104 |
| HRpeak, bpm | 128±18 |
| HRpeak, % predicted | 77±11 |
| Chronotropic response, bpm | 53±32 |
| Borg dyspnoea score end, points* (IQR) | 4 (3/7) |
| Borg leg fatigue score end, points* (IQR) | 3 (1/4) |
| | |
| 4MGS test | |
| Time, s | 2.0±0.5 |
| Mean speed, m/s | 2.1±0.5 |
| Lowest SpO$_2$, % | 96±2 |
| HRpeak, bpm | 92±11 |
| HRpeak, % predicted | 55±7 |
| | |
| Borg dyspnoea score end, points* (IQR) | 1 (0.5/2) |
| Borg leg fatigue median score end, points* (IQR) | 0.5 (0/2) |
| | |
| 5STS test | |
| Time, s | 12.0±3.8 |
| Lowest value SpO$_2$, % | 96±2 |
| HRpeak, bpm | 91±14 |
| HRpeak, % predicted | 54±8 |
| Borg dyspnoea score end, points*** (IQR) | 2 (0.5/3.8) |
| Borg leg fatigue score end, points*** (IQR) | 1.5 (0/3) |

Data are presented as mean (SD) unless otherwise stated
[1] 1=Low <P5 (percentile score) (28)
[2] References Troosters et al, 1999 (36)
* Median
Abbreviations: N=number, %=percentage, IQR=interquartile range, HGS=hand grip strength, Kg=kilograms, 6MWT=six minute walk test, m=meter, m/s=meter per second, SpO2=peripheral capillary oxygen saturation, m·%=product of distance walked and lowest oxygen saturation, HRpeak=Heart Rate Peak, bpm=beats per minute, 4MGS=4 meter gait speed, s=second, 5STS=5 repetitions sit-to-stand, HRpeak=heart rate peak, SD=standard deviation

Research question 1

Mean walk time 4MGS (2.1±0.5 m/s) was comparable with healthy elderly subjects; 17 patients (33,3%) walked slower than reference value (33). Mean time in 5STS was 12±4 s, thereby 47% of the patients scored worse than might be expected based on age (11). Test-retest reliability (ICC) of 4MGS and 5STS were 0.95, 95% CI 0.92-0.97, p<0.01 and 0.87, 95% CI 0.63-0.94, p<0.01, respectively. Both tests, 4MGS and 5STS, showed an increase in HR (respectively 15±8 bpm and 13±10 bpm), which fully recovered after 2 minutes rest. In both tests no EID was observed.

On average, the 6MWD was moderately impaired with a mean distance %predicted of 71±16% (453 m; range 145-690 m; Table 2). During 6MWT, an increase in HR (50±18 bpm, p<0.01) and a decrease in SpO2 (-12±7%, p<0.01) were observed. Direct after completing the 6MWT, 24 patients (47%) had a limited HR recovery (HRR1 -11±17bpm, HRR2 -21±17bpm; p<0.01). The lowest mean SpO$_2$ was 85±7%, 31 patients (61%) had an oxygen de-

saturation of ≤88%, 40 patients (78%) had a desaturation of >4%. After 3 minutes rest $SpO_2$ was fully recovered (SpO2rest 97±2%, SpO2-recovery-3min 96±3%, p>0.05), but not HR (HRrest 79±13 bpm, HR-recovery-3min 90±16 bpm, p<0.01).

6MWD was associated with 4MGS (r=0.77; p<0.05) and 5STS time (r=-0.41; p<0.05) (Figure 2).

Table 3 summarizes the correlations between the exercise tests and other outcome parameters. In brief, 6MWD correlated best with HGS and the degree of dyspnoea (r=0.65, and r=-0.62, respectively; both p<0.01). The same was true for the 4MGS: r=0.57, and r=-0.40, respectively (both p<0.01).
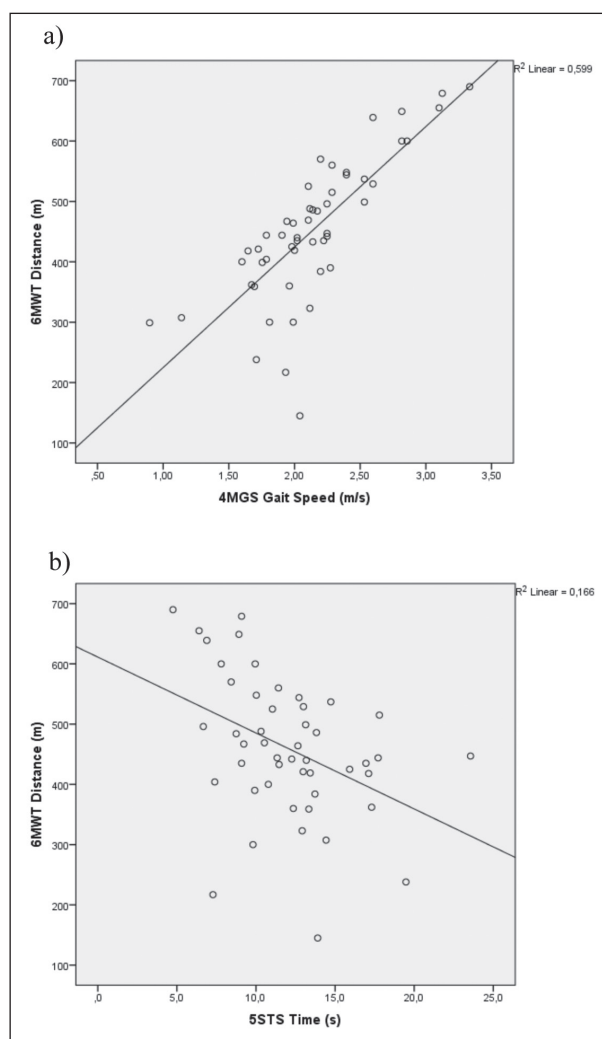


**Fig. 2.** Correlations between a) 4-meter gait speed test (4MGS) and 6-minute walk distance (6MWD) and b) 5 repetitions sit-to-stand test (5STS) and 6-minute walk distance (6MWD)
Abbreviations: M=meters, 6MWT_M= 6-minute walk test maximum (best of two tests on one day), ms=meter per second, s=second

Research question 2

Multivariable linear regression models were fit for predicting 6MWD, including all variables which were statistically significant in univariate correlation (Table 3). The final model, equation 6MWD=184.6+138.6*4MGS(m/s)+2.0*HGS(Kg, right hand)−35.2*MRC (R=0.87, $R^2$=0.75; backward regression), showed that 4MGS (p<0.01), HGS (p<0.05), and MRC dyspnoea grade (p<0.01) were associated with 6MWD (collinearity: VIF<3) (Table 4 Regression coefficients). These three variables could explain 75% of the variance in 6MWD in patients with PF.

## Discussion

The present study has two main findings: 1) 4MGS and 5STS time have good and moderate correlations with 6MWD, respectively; and 2) 75% of variance in the 6MWD can be explained by combining three office-available tests that can easily be performed during an outpatient consultation (i.e., 4MGS, HGS and MRC dyspnoea).

Our findings show a significant correlation between 6MWD with simple functional performance tests in a well-defined group of patients with PF. This is in line with previous results obtained in patients with chronic lung diseases, like COPD and ILD (13, 32, 39, 40). Besides, in patients with PF the 6MWD has been identified as an independent predictor of mortality (18, 41, 42). So, measurements of functional exercise capacity are important in clinical management and the finding that 4MGS may serve as a simple surrogate for 6MWD is therefore probably of clinical importance.

Despite the significant correlations of the 4MGS and 5STS with the 6MWD, they are not a replacement of the 6MWT. Physical performance and physical activity are both part of the domain physical functioning. In the bigger concept of exercise capacity all three tests highlight different components. The 5STS is a very short test which especially requires muscle strength from the lower limbs. 4MGS and 6MWT are tests that require the same physical performance, namely walking. Only 4MGS represents a very short capacity test out of mainly the anaerobic energy system. Besides, the simple performance tests set a less limited stress on the cardiopulmonary system than the

**Table 3.** Relationship between the results of 4MGS, 5STS, 6MWT and other outcome parameters

Pearson and Spearman rank correlation coefficient

| Variables | 4MGS | 5STS | 6MWT |
|---|---|---|---|
| | r | r | r |
| Age (yr) | -0,55** | 0,22 | -0,47** |
| Resting blood pressure diastolic (mmHg) | 0,30* | -0,08 | 0,26 |
| Resting blood pressure systolic (mmHg) | 0,23 | 0,05 | 0,16 |
| BMI (kg/m²) | -0.01 | 0,10 | 0,09 |
| Body fat percentage (% weight) | -0,36* | 0,31* | -0,42** |
| Fat free mass (kg) | 0,24 | 0,01 | 0,42** |
| FVC (L) | 0,10 | 0,02 | 0,38** |
| FEV1 (L) | 0,17 | -0,06 | 0,41** |
| Lung function: DLCOcSB (mmol/min/kPa) | 0,23 | -0,12 | 0,40** |
| PCS of SF-36 | 0,39** | -0,23 | 0,48** |
| MCS of SF-36 | -0,05 | -0,09 | -0,02 |
| MRC dyspnoe grade | -0,40** | 0,18 | -0,62** |
| HGS right hand highest value (kg) | 0,57** | -0,24 | 0,65** |
| Baseline heart rate (bpm) | 0,04 | 0,01 | -0,25 |
| Heart rate end (bpm) | 0,14 | 0,07 | 0,22 |
| Baseline SpO2 (%) | 0,17 | -0,11 | 0,34* |
| SpO2 end (%) | 0,08 | 0.00 | 0,10 |
| Baseline dyspnoe, Borg score | -0,33* | 0,14 | -0,43** |
| Dyspnoe end, Borg score | -0,32* | 0,23 | -0,09 |
| Baseline leg fatigue, Borg score | -0.19 | -0,02 | -0,18 |
| Leg fatigue end, Borg score | -0,32* | 0,18 | 0,14 |

r: Pearson's and Spearman rank correlation coefficient
* 0,01<p≤0,05
** p≤0,01
Abbreviations: 4MGS=4 meter gait speed, 5STS=5 repetitions sit-to-stand, 6MWT=six minute walk test, yr=year, mmHg=millimeters of mercury, kg/m²=kilogram per square length in meters, %=percentage, kg=kilogram, BMI=Body Mass Index, kg/m²=kilogram per square length in meters, FVC=forced vital capacity, L=liter, FEV1=forced expiratory volume in 1 second, DLCOcSB=diffusion capacity to carbon monoxide corrected single breath, mmol/min/kPa=mmol CO per minute per kilopascal, PCS=physical component score, SF-36=short-form health survey 36 questions, MRC=Medical Research Council, bpm=beats per minute

**Table 4.** Regression coefficients

Coefficients
Dependent Variable: 6MWT Distance (m)

| Model | Unstandardized Coefficients | | Standardized Coefficients | t-value | p-value | 95,0% Confidence Interval for B | |
|---|---|---|---|---|---|---|---|
| | B | Standard Error | Beta | | | Lower Bound | Upper Bound |
| (Constant) | 184,609 | 59,507 | | 3,102 | ,003 | 64,756 | 304,463 |
| 4MGS Gait Speed (m/s) | 138,603 | 23,772 | ,536 | 5,831 | ,000 | 90,724 | 186,482 |
| HGS (Kg) Right Hand | 2,028 | ,859 | ,220 | 2,361 | ,023 | ,298 | 3,757 |
| MRC Dyspnoea Scale | -35,210 | 8,927 | -,324 | -3,944 | ,000 | -53,189 | -17,231 |

Abbreviations: 6MWT=six minute walk test, m=meter, 4MGS=4 meter gait speed, m/s=meter per second, HGS=hand grip strength, Kg=kilograms, 6MWT=six minute walk test, MRC=Medical Research Council

6MWT. First, the HRpeak and the lowest SpO2 in the performance tests were clearly different compared to the values obtained during the 6MWT. Indeed, the 6MWT is an endurance exercise capacity test, and given the fact that PF is a progressive fibrotic lung disease which affects diffusion capacity, probably patients may experience more limitations in their ability to perform an aerobic exercise test (5, 43, 44).

Second, in the 6MWT both the distance walked as EID have been found to predict mortality. The

composite of the product of distance and desaturation would predict mortality better than either measure alone (45-47). During the 4MGS and 5STS tests, however, no EID was observed. So, when healthcare professionals are interested in EID in patients with PF, the simple performance tests are insufficient. Indeed, one 6MWT needs to be performed to accurately determine the presence/absence of EID (9).

## LIMITATIONS OF THE STUDY

The current study sample was selective, as all patients were clinically stable outpatients with PF visiting a specialized ILD center for routine medical check-up. Indeed, during this one-day visit, patients were already asked to perform routine clinical tests, such as spirometry, chest-X-rays and blood drawing. Although patients started each exercise test from rest values (HR, SpO2), it may to some extent have affected the exercise performance.

The 4MGS test was restricted to the fast speed protocol only (instruction: 'walk as fast as possible'). There is no evidence to indicate that measurement of usual-walking speed is more reliable than maximal speed (10, 33).

Another limitation is the sample size, which prevented generation of more robust prediction models.

To conclude, the 4MGS and 5STS scores correlate respectively good and moderate with the 6MWD in patients with PF. These results suggest that very simple performance tests may serve as an easy first step to provide healthcare professionals with valuable information of functional status of patients with PF. In fact, the 4MGS together with simple measurements of HGS and dyspnoea score (MRC) will guide healthcare professionals in their decision to request also for an additional 6MWT. Obviously, the 6MWT provides additional information on EID which cannot be adequately determined suing the 4MGS and 5STS.

**Ethics approval:** The study received ethical approval from the Medical research Ethics Committees United (MEC-U; NL51679.100.15/PT-PF).

Informed consent was obtained from each participant in the study before data collection began.

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