



Reliability and validity of 4-metre gait speed in COPD

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ABSTRACT In community-dwelling older adults, usual gait speed over 4 m (4MGS) consistently predicts greater risk of adverse health outcomes. The aims of the present study were to assess the reliability of the 4MGS and the relationship with established health outcome measures in chronic obstructive pulmonary disease (COPD).

Test-retest and interobserver reliability of the 4MGS were measured in 80 and 58 COPD patients, respectively. In 586 COPD patients, the 4MGS, as well as forced expiratory volume in 1 s (FEV₁), the incremental shuttle walk (ISW), Medical Research Council (MRC) dyspnoea scale and St George's Respiratory Questionnaire (SGRQ) were measured. Participants were stratified according to "slow" (<0.8 m·s⁻¹) or "normal" 4MGS (≥0.8 m·s⁻¹).

Intra-class correlation coefficients for test-retest and interobserver reliability were 0.97 and 0.99, respectively. There was a significant positive correlation between 4MGS with ISW ($\rho=0.78$; $p<0.001$) and a negative correlation with MRC dyspnoea scale and SGRQ ($\rho=-0.55$ and -0.44 ; $p<0.001$ for both). COPD patients with slow 4MGS had significantly reduced ISW and higher MRC dyspnoea scale and SGRQ than those with preserved walking speed, despite similar FEV₁ % predicted.

The 4MGS is reliable in COPD, correlates with exercise capacity, dyspnoea and health-related quality of life, and has potential as a simple assessment tool in COPD.



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The 4-metre gait speed test is reliable and valid as a simple assessment tool in chronic obstructive pulmonary disease <http://ow.ly/kMHvX>

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Introduction

Usual gait speed measured over 4 m (4MGS) has been recommended as a potentially useful marker of multisystemic wellbeing in community-dwelling older adults [1]. A slow 4MGS is a consistent risk factor for disability, cognitive impairment, nursing home admission, falls and cardiovascular and all-cause mortality [1–4] in older adults who report no functional limitation. Moreover, it is reliable and quick to perform [5, 6]. 4MGS is also an established marker of exercise capacity in the elderly [7] and has been shown to correlate with other measures of function [8]. An expert working group recently identified the 4MGS as the most appropriate functional test for interventional trials in frail older adults [9]. A slow gait speed in the elderly is typically defined as a walking speed $<0.8 \text{ m}\cdot\text{s}^{-1}$ [1, 4], which corresponds to a reduction in the median life expectancy for most ages [4].

Most studies of 4MGS have been in community-dwelling older adults, a proportion of whom are likely to have respiratory disease. However, the 4MGS has not been validated specifically in a chronic obstructive pulmonary disease (COPD) population. The use of a reliable, validated and easy to perform assessment tool to evaluate functional performance and predict adverse outcomes in COPD is attractive. Although field walking tests such as the 6-min walk test and incremental shuttle walk (ISW) test are well validated, they show a learning effect and require space, which limits widespread use in some clinical settings.

Therefore, the aims of this study were to assess the reliability of the 4MGS and its association with established outcome measures of exercise capacity, dyspnoea and health-related quality of life in COPD. A further aim was to describe the clinical characteristics of COPD patients with a slow 4MGS in comparison to those with preserved 4MGS.

Methods

Subjects

Patients diagnosed with COPD according to Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines [10] were recruited from outpatient respiratory clinics at Harefield Hospital (Harefield, UK). Exclusion criteria included unstable cardiac disease, exacerbation within the preceding 4 weeks, being unable to walk 4 m or a predominant neurological limitation to walking (*e.g.* significant hemiplegia). All participants gave informed consent and the study was approved by the West London and the London–Camberwell St Giles Research Ethics Committees (11/H0707/2 and 11/LO/1780, respectively).

Measurement of 4MGS

4MGS was measured by one of seven trained operators. All operators followed the gait speed component of the Short Physical Performance Battery (SPPB) protocol available from the National Institute on Aging (www.grc.nia.nih.gov/branches/ledb/sppb/). To perform the test, a flat unobstructed course was identified, either in a clinic assessment room or hospital corridor, and 4 m marked out with tape. A walk was demonstrated to each participant prior to starting the test, but participants themselves did not perform a practice walk. The participant was positioned with the toes just touching the start line. The following standardised instructions were given: “This is our walking course. I want you to walk to the other end of the course at your usual speed, just as if you were walking down the street to go to the shops. Walk all the way past the other end of the tape before you stop. Ready...begin”. Timing with a stopwatch started when the participant began to move, not on the command “begin”. Timing was stopped when the participant’s first foot completely crossed the 4-m line. The walk test was repeated without rest and the faster of the two times was used to calculate the 4MGS, expressed in $\text{m}\cdot\text{s}^{-1}$. Participants were allowed to use their normal walking aids (*e.g.* cane). Oxygen users were provided with extra long tubing connected to a concentrator or immovable cylinder.

Test-retest and interobserver reliability

80 COPD patients underwent 4MGS measurement by the same operator on two occasions 24–48 h apart. 58 patients had 4MGS measured simultaneously by two observers on the same occasion.

Cross-sectional study

4MGS was measured in a convenience sample of 586 COPD patients. Further measurements included the ISW expressed in metres and % predicted [11, 12], St George’s Respiratory Questionnaire (SGRQ) [13], Medical Research Council (MRC) dyspnoea scale [14] and spirometry. These were performed by other investigators to ensure that the operators who measured 4MGS were blinded to these results. Comorbidities were recorded on the Charlson Index [15] and the recently validated COPD-specific comorbidity test index [16]. The participants were then stratified according to 4MGS, with “slow” walkers defined as a 4MGS $<0.80 \text{ m}\cdot\text{s}^{-1}$ and “preserved” defined as a 4MGS of $\geq 0.80 \text{ m}\cdot\text{s}^{-1}$, as recommended by expert consensus groups [1, 17].

Data analysis

Data analyses and graphical presentations were performed using GraphPad Prism 5 (GraphPad Software, San Diego, CA, USA) or SPSS version 19 (IBM, Armonk, NY, USA). Single measure intra-class correlation coefficients (ICCs) of consistency and random effect were calculated with 95% confidence intervals to examine test-retest and interobserver reliability. Measurement variability was determined by calculating the standard error of measurement (SEM) and percentages of the standard errors of the measurements (SEM %). Bland–Altman plots were plotted to demonstrate the 95% limits of agreement. Spearman’s rank correlation was used to quantify the association between 4MGS and other measures. Between-group differences were assessed using unpaired t-tests or Mann–Whitney U-tests for nonparametric data. A p-value <0.05 was considered significant.

Results

Reliability

The 4MGS showed excellent test-retest and interobserver reliability, with ICC values of 0.97 (95% CI 0.95–0.98) and 0.99 (95% CI 0.98–0.99), respectively. Measurement variability was low, with SEM 1.4% for interobserver and 1.5% for test-retest reliability. Similarly, no systematic variability was demonstrated with narrow limits of agreement between occasions (0.135 to -0.125) or observers (0.047 to -0.067) (fig. 1). Mean difference between test occasions was $0.005 \text{ m}\cdot\text{s}^{-1}$ and between observers was $-0.01 \text{ m}\cdot\text{s}^{-1}$.

Cross-sectional measurement of 4MGS

Baseline characteristics are shown in table 1. Sixty-seven, thirty-three and four patients used a walking aid only, ambulatory oxygen only or both, respectively. There was a strong positive correlation between 4MGS and ISW (table 2 and fig. 2a). Inspection of figure 2a shows a curvilinear relationship (second-order polynomial) between 4MGS and ISW (goodness of fit: $R^2=0.59$) with the curve flatter at low ISW values, suggesting a floor effect to the ISW. 4MGS was also negatively correlated with age, MRC dyspnoea scale and SGRQ (activity and impact domains, total score in fig. 2b). There was a weak but statistically significant relationship with forced expiratory volume in 1 s (FEV1) % pred ($\rho=0.10$; $p=0.01$) (fig. 2c) and body mass index (BMI) ($\rho=-0.09$; $p=0.03$).

Clinical characteristics related to slow gait speed

193 patients had a slow 4MGS and 393 had preserved 4MGS. Participants with slow 4MGS were slightly older and had higher BMI, but there were no differences in sex distribution or FEV1 % pred. However, large deficits in exercise capacity and health status were observed in the slow 4MGS group in ISW distance and SGRQ total score (table 3).

Discussion

We have demonstrated that usual 4MGS shows excellent test-retest and interobserver reliability in COPD. Furthermore, in a cohort of stable COPD patients, 4MGS was significantly correlated with measures of exercise capacity, health status and dyspnoea, supporting concurrent validity for the measure. Stratification according to “slow” 4MGS identified significant impairment in exercise capacity and poor health-related quality of life.

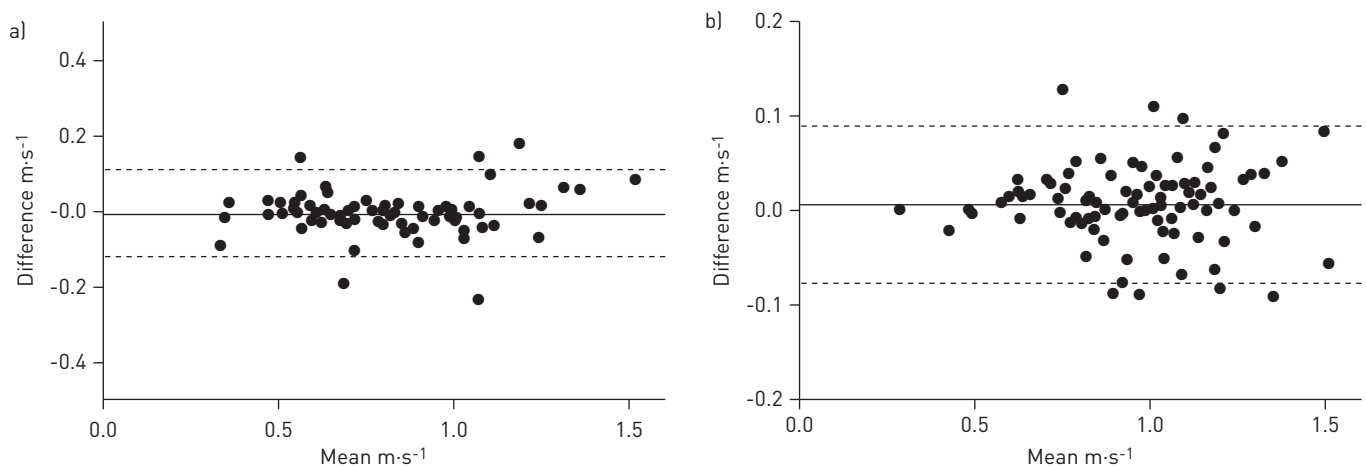


FIGURE 1 Bland–Altman plots for a) test-retest and b) interobserver reliability.

TABLE 1 Baseline characteristics of study subjects

Subjects	586
Age years	70 (63–76)
Sex male/female	372/214
Height m	1.67 (1.58–1.73)
Weight kg	73.0 (61.8–86.9)
Body mass index kg·m⁻²	26.8 (23.2–31.2)
FEV₁ % predicted	46 (29–61)
MRC dyspnoea score	3 (2–4)
ISW test m	190 (100–293)
ISW test % predicted	31 (16–49)
SGRQ	
Symptoms	68.6 (52.4–81.2)
Activity	72.8 (59.5–87.3)
Impact	37.1 (24.5–52.8)
Total	53.7 (41.4–66.4)
Charlson index	1 (1–2)
COTE index	0 (0–1)
Exacerbations in previous year	2 (1–3)
Hospital days in previous year	0 (0–4.25)
Gait speed m·s⁻¹	0.89 (0.74–1.05)

Data are presented as n or median (interquartile range). FEV₁: forced expiratory volume in 1 s; MRC: Medical Research Council; ISW: incremental shuttle walk; SGRQ: St George's Respiratory Questionnaire; COTE: chronic obstructive pulmonary disease-specific comorbidity test.

Critique of the method

Although gait speed has been reported over a variety of distances, most investigators currently believe that 4 m is optimal for a field test [18], balancing a distance short enough to be feasible in most clinical settings, but long enough to ensure measurement accuracy. Test-retest reliability for 4MGS is better than that reported over an 8-foot course [19] and as reliable as over 6 m [20]. A 4-m course has also been shown to be feasible in 90% of households [21], allowing the possibility of using the 4MGS as a tool in community- or home-based studies. Consistent with this, in our study, we observed very high ICCs for both test-retest and interobserver reliability. Our results were perhaps towards the better end of those previously reported [8, 19, 20], and this may reflect differences in patient populations. It is important to note that reliable 4MGS

TABLE 2 Spearman's rank correlation (ρ) to compare the relationship between 4-m gait speed and other health outcome measurements

	ρ	p-value
Age	-0.21	<0.001
Height	0.03	0.40
Weight	0.01	0.86
BMI	-0.09	0.03
FEV₁ % predicted	0.10	0.01
MRC dyspnoea score	-0.55	<0.001
ISW test	0.78	<0.001
ISW test % predicted	0.72	<0.001
SGRQ		
Symptoms	-0.15	0.007
Activity	-0.51	<0.001
Impact	-0.38	<0.001
Total	-0.44	<0.001
Charlson index	-0.12	0.004
COTE index	-0.09	0.03

BMI: body mass index; FEV₁: forced expiratory volume in 1 s; MRC: Medical Research Council; ISW: incremental shuttle walk; SGRQ: St George's Respiratory Questionnaire; COTE: chronic obstructive pulmonary disease-specific comorbidity test.

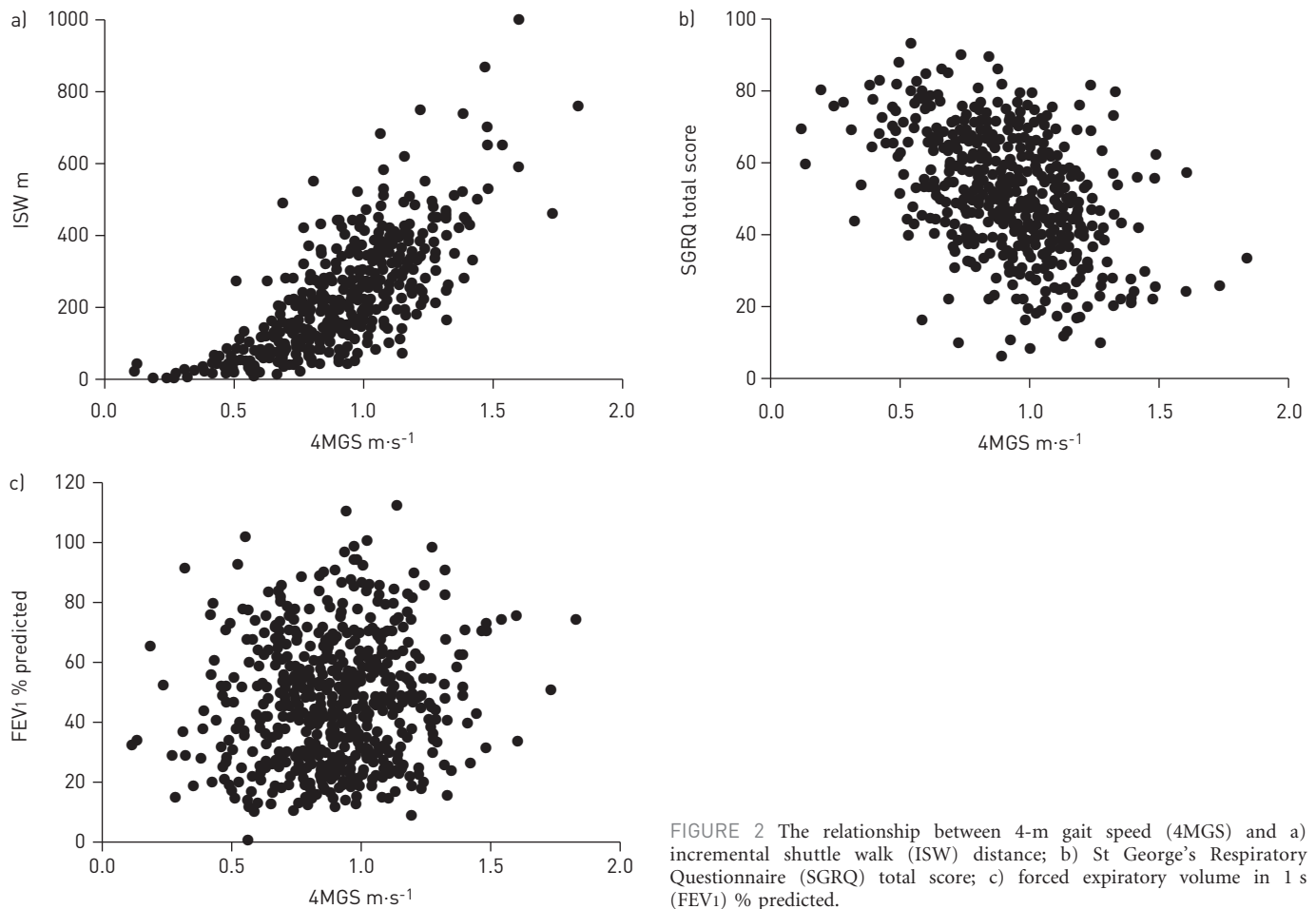


FIGURE 2 The relationship between 4-m gait speed (4MGS) and a) incremental shuttle walk (ISW) distance; b) St George's Respiratory Questionnaire (SGRQ) total score; c) forced expiratory volume in 1 s (FEV1) % predicted.

measurements can be made even by nonprofessional staff [6] and good reliability has been shown in frail patients or those with cognitive dysfunction [19, 20].

We asked patients to walk at their usual or comfortable speed in line with most previous reports. Although some investigators have modified the test by assessing maximal walking speed [8, 18], much of the data on the prognostic value of gait speed have focused on usual speed, and there is no evidence to indicate that measurement of maximal walking speed is any more reliable than usual speed [8, 22]. However, we suspect that usual gait speed would be close to maximal speed in symptomatic severe COPD patients

Another consideration was the choice of gait speed cut-off. Several cut-off points for prediction of adverse health outcomes have been previously proposed. These have partly depended on the length of track, settings, the population being studied and the outcome of interest. For the 4MGS, "slow" is typically defined by expert consensus groups as a walking speed $<0.8 m \cdot s^{-1}$ [1, 17]. Recently, in a pooled analysis of nine cohort studies of older adults (totalling 34 485 individuals), years of remaining life for each sex and age increased as gait speed increased, with a gait speed of $0.8 m \cdot s^{-1}$ at the median life expectancy for most ages [4]. Future longitudinal studies are required to validate the predictive value of this 4MGS cut-off in COPD populations, although, given the large differences in health outcomes demonstrated in our study, this cut-off appeared to be discriminatory.

Significance of the findings

The 4MGS as a single item tool has not been previously reported in COPD. ROIG *et al.* [23] recently reported self-selected gait speed in 21 COPD patients over a 5-m course, demonstrating a 20% reduction in speed compared with age-matched controls. ILGIN *et al.* [24] described significant associations between gait speed and lung function parameters and health-related quality of life in COPD, although gait speed was calculated from 6-min walk distance rather than from a short course. ANDERSSON *et al.* [25] showed high test-retest reliability when measuring walking speed in 49 COPD patients, although the 30-m course may limit generalisation of the findings. EVANS *et al.* [26] demonstrated the validity of self-paced walking and

TABLE 3 A comparison between chronic obstructive pulmonary disease (COPD) patients with low or normal 4-m gait speed (4MGS)

	Gait speed		p-value
	Slow	Normal	
Subjects	193	393	
Age years	73 (64–78)	69 (63–75)	<0.001
Sex male/female	100/93	221/172	0.33
Height m	1.65 (1.58–1.74)	1.58 (1.41–1.67)	0.72
Weight kg	74.6 (61.0–89.0)	72.1 (62.0–86.0)	0.46
BMI kg·m⁻²	28.4 (23.9–32.5)	26.3 (23.0–30.2)	0.01
FEV₁ % predicted	46 (28–61)	46 (30–61)	0.37
MRC dyspnoea score	4 (4–5)	3 (2–4)	<0.001
ISW distance m	80 (40–120)	250 (160–350)	<0.001
ISW % predicted	14 (7–24)	41 (28–57)	<0.001
SGRQ			
Symptoms	71.5 (54.3–82.2)	67.8 (51.6–80.2)	0.11
Activity	85.8 (72.8–92.5)	66.3 (53.5–79.8)	<0.001
Impact	47.9 (32.1–58.4)	34.0 (22.3–47.1)	<0.001
Total	63.1 (48.9–71.6)	49.6 (38.7–61.1)	<0.001
Charlson index	1 (1–3)	1 (1–2)	0.02
COTE index	0 (0–1)	0 (0–1)	0.82
Exacerbations	2 (1–4)	2 (1–3)	0.77
Hospital days	1 (0–7)	0 (0–4)	0.004
Gait speed m·s⁻¹	0.67 (0.56–0.74)	0.99 (0.89–1.12)	<0.001

Data are presented as n or median (interquartile range), unless otherwise stated. BMI: body mass index; FEV₁: forced expiratory volume in 1 s; MRC: Medical Research Council; ISW: incremental shuttle walk; SGRQ: St George's Respiratory Questionnaire; COTE: chronic obstructive pulmonary disease-specific comorbidity test.

responsiveness to pulmonary rehabilitation in 37 COPD patients. Interestingly, although the test was performed in an enclosed, temperature-controlled 250-m flat corridor, the repeatability was similar to that of 4MGS observed in our study. In addition to the considerably larger sample size, our data adds to the current literature by demonstrating that 4MGS correlates significantly to health outcome measures commonly used in COPD.

The 4MGS is also noted to be a single component of the Short Physical Performance Battery (SPPB). Previous data on the SPPB in COPD have been described in a single cohort [27–29], demonstrating lower (worse) SPPB scores in COPD patients compared with age-matched healthy controls, and an association between increased lean-to-fat ratio and preserved lung function with higher SPPB scores. This cohort was restricted to 40–65 years of age and tended to have milder disease: 30% of patients were in the now-defunct GOLD stage 0 [27, 28]. Our patients were older and more typical of COPD patients seen in hospital practice. Furthermore, we demonstrated that just one component of the SPPB had a strong association with clinically relevant outcomes. The 4MGS is quicker to perform, and previous studies have shown that the 4MGS has similar associations and predictive abilities to the SPPB [6, 30].

The 4MGS has been frequently used in epidemiological studies of older adults due to its ease and speed of use. It has been shown to predict health status, functional decline, institutionalisation, onset of disability and mortality [1, 3, 18, 30]. Other investigators have used gait speed as a functional outcome measure [31], and expert working groups (including representatives from the US Food and Drug Agency) have identified the 4MGS as the most appropriate functional test for interventional studies in frail older adults and sarcopenia [9, 32]. The 4MGS has potential as an assessment tool in COPD. It is quick to perform, and cheap. Walking is familiar to the vast majority of adults, and the test is easy to understand; the 4MGS has been shown to be highly reliable even in people with cognitive dysfunction [20]. Furthermore, it requires little space, and the operator does not require any specialist training. These properties mean that the 4MGS could be adopted in almost any clinical environment (even at the bedside, or in primary care).

Our study demonstrated that 4MGS is reliable in COPD with excellent test-retest reliability. This is significant, particularly as current field tests of exercise capacity show a learning effect [11, 33] and some, like the 6-min walk test, require a 30-m course. Evidence of concurrent validity was demonstrated by showing significant associations with exercise capacity, health status and dyspnoea. By stratifying COPD

patients according to 4MGS, we showed that the slow walking speed clinical phenotype exhibited significant deficits in exercise capacity, increased dyspnoea and poor health status in comparison to those with preserved walking speed. Interestingly, despite large differences in these outcome measures (which exceeded the commonly agreed minimum clinically important differences), there was no significant difference in FEV1 % pred between the groups. Although 4MGS was shown to correlate negatively with age and BMI, it is unlikely that these were significant confounding factors for our results, given that there were still large differences in ISW % pred (which corrects for age and BMI). Furthermore, 4MGS was not simply a reflection of comorbidity burden; we showed no or very weak relationships between 4MGS and validated comorbidity indices. We propose that 4MGS, like exercise capacity, reflects global wellbeing and captures the multisystemic effects of disease severity in COPD rather than pulmonary impairment alone.

Limitations

The study population was selective in that most were GOLD stage II–IV and symptomatic hospital outpatients. Our results need to be corroborated in other COPD populations (e.g. hospitalised inpatients or milder asymptomatic patients) in different settings. As the current study was cross-sectional, we could not evaluate the prognostic value of 4MGS in COPD. Longitudinal studies are required to assess the ability of 4MGS to predict clinically useful end-points. Although 4MGS was shown to correlate significantly with ISW, it is important to stress that the tool is not a measure of peak exercise capacity. However, it is an indicator of functional impairment, particularly in frail older patients [9], and has been previously used as a functional outcome measure in interventional pharmacological trials [31]. The curvilinear relationship between ISW and 4MGS (fig. 2a) suggests that the 4MGS may have a particular role in the assessment of poorly functioning individuals (i.e. there was a wide range in 4MGS in patients with very low ISW values). Further studies are needed to test the responsiveness of 4MGS to intervention in COPD. 4MGS may also have a role in rapidly screening COPD patients for extrapulmonary manifestations prior to more complex objective measurement of the outcome of interest. We did not make measurements of muscle mass or function, but this seems likely to be a fruitful area of research in COPD, particularly as expert consensus groups in sarcopenia and cachexia already recommend 4MGS as a screening tool [17, 32].

In summary, our study confirms that 4MGS is feasible and reliable in COPD, and correlates with measures of exercise capacity and health status. This demonstrates the potential utility of 4MGS as a simple assessment tool of multisystem wellbeing in COPD.

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