



Functional tests for adults with asthma: validity, reliability, minimal detectable change, and feasibility

Joice Mara de Oliveira , Thamyres Spositon , Alcindo Cerci Neto , Fatima Mitsie Chibana Soares , Fabio Pitta & Karina Couto Furlanetto

To cite this article: Joice Mara de Oliveira , Thamyres Spositon , Alcindo Cerci Neto , Fatima Mitsie Chibana Soares , Fabio Pitta & Karina Couto Furlanetto (2020): Functional tests for adults with asthma: validity, reliability, minimal detectable change, and feasibility, Journal of Asthma, DOI: [10.1080/02770903.2020.1838540](https://doi.org/10.1080/02770903.2020.1838540)

To link to this article: <https://doi.org/10.1080/02770903.2020.1838540>

 View supplementary material 

 Published online: 06 Nov 2020.

 Submit your article to this journal 

 Article views: 57

 View related articles 

 View Crossmark data 



Functional tests for adults with asthma: validity, reliability, minimal detectable change, and feasibility

Joice Mara de Oliveira, MSc, PT^{a,b} , Thamyres Spositon, MSc, PT^{a,b}, Alcindo Cerci Neto, PhD, MD^c,
Fatima Mitsie Chibana Soares, MSc, MD^c, Fabio Pitta, PhD, PT^{a,b} , and Karina Couto Furlanetto, PhD, PT^{a,b} 

^aResearch and Postgraduate Center, Pitágoras-Unopar University (UNOPAR), Londrina, Paraná, Brazil; ^bLaboratory of Research in Respiratory Physiotherapy (LFIP), State University of Londrina, Londrina, Paraná, Brazil; ^cDepartment of Medicine, State University of Londrina (UEL), Londrina, Paraná, Brazil

ABSTRACT

Objective: To verify the validity, reliability, learning effect, Minimal Detectable Change (MDC), and feasibility of four functional tests (4-Meter Gait Speed [4MGS], Timed Up-and-Go [TUG], Sit-To-Stand [STS], and Short Physical Performance Battery [SPPB]) for adults with asthma.

Methods: In this cross-sectional study, fifty-two subjects with stable asthma underwent three sets of different functional tests protocols (4MGS, TUG, STS, SPPB) in a random order by two raters. For validation analysis, tests were compared with a sex-age matched control group without asthma and correlated with the Six Minute Walking Test (6MWT), and peripheral muscle strength, as well as with quality of life and asthma control questionnaires. Intra-rater and inter-rater reliability, MDC, and feasibility were verified.

Results: Adults with asthma presented worse results than controls in the functional tests, except for SPPB. All functional tests were significantly correlated with 6MWT ($0.45 < r < 0.67$) and peripheral muscle strength ($0.32 < r < 0.63$), but not with quality of life and asthma control ($0.02 < r < 0.17$). The tests presented good to excellent intra-rater Intraclass Correlation Coefficients ($ICC \geq 0.75$ for all). In all tests, a considerable learning effect and variability of measurement was observed, therefore, the best of two measurements should be used. MDC ranged from 15 to 31% and all tests were performed in a short time, small space, and without clinical adverse events.

Conclusion: Different protocols of 4MGS, TUG, STS, and SPPB are valid, reliable, and feasible to assess the functional capacity of adults with asthma. These tests are quick and practical new alternatives for assessing functional capacity in this population.

ARTICLE HISTORY

Received 6 August 2020
Revised 1 October 2020
Accepted 13 October 2020

KEYWORDS

Asthma; physical functional performance; motor activity; exercise test; validity and reliability; feasibility study

Introduction

Asthma is a chronic respiratory disease that affects approximately 300 million people in the world (1), and is characterized by chronic airway inflammation that causes respiratory symptoms and variable expiratory airflow limitation, which may vary over time and in intensity (2). A few studies have suggested that people with asthma, especially those with moderate to severe or difficult-to-control asthma, but even those with mild asthma, seem to have reduced functional capacity (3–7).

The most commonly used field test to assess functional capacity in chronic respiratory disease is the Six Minute Walking test (6MWT) (8–10). However, despite being both cheap and easy to perform, the 6MWT

requires a considerable space (11) (*i.e.* 30-meter corridor), which might be an important barrier. Alternatively, other functional tests considered cheaper, faster and requiring smaller spaces were developed to assess functional capacity, such as the 4-Meter Gait Speed (4MGS), Timed Up-and-Go (TUG), Sit-to-Stand (STS), and Short Physical Performance Battery (SPPB) (8).

The 4MGS reflects mobility and is related to important health outcomes as mortality in elderly people (12). Moreover, people with severe and/or difficult to control asthma generally use corticosteroids (13), and when combined with physical inactivity, this can cause atrophy and loss of muscle strength (5). Therefore, the use of the STS may also be important since this test also reflects lower limb strength in several populations (14,15). Finally, TUG and SPPB,

CONTACT Karina Couto Furlanetto  ka_furlanetto@hotmail.com  Research and Postgraduate Center of Pitágoras, Unopar University (UNOPAR), Rua Marselha 591, Jardim Piza, Londrina, Paraná 86041-140, Brazil.

 Supplemental data for this article can be accessed at [publisher's website](#).

© 2020 Taylor & Francis Group, LLC

besides assessing functional capacity, also reflects balance, which is known to be impaired in people with asthma (16,17).

Despite the abovementioned functional tests' advantages and their extensive use in several populations, few studies have used them to assess adults with asthma (18–20). Moreover, measurement properties regarding these tests (4MGS, TUG, STS, and SPPB) have not been investigated in adults with asthma. Therefore, the aims of this study were as follows: (1) to investigate the convergent, divergent and discriminative (i.e. known groups) validity of the 4MGS, TUG, STS and SPPB in adults with asthma; (2) to assess the intra and inter-rater reliability (3) to determine the Minimal Detectable Change (MDC), and (4) to verify the learning effect and the feasibility of these functional tests in this population.

Methods

Sample

Patients with diagnosis of asthma treated by the Department of Pneumology of the University Hospital outpatient service were invited to participate in the study. Furthermore, flyers were distributed in basic health care units of the city of Londrina (Brazil) to publicize the study aiming at recruiting patients with asthma with different severities. People with diagnosis of asthma according to the Global Strategy for Asthma Management and Prevention (GINA) (2) were included. Inclusion criteria were as follows: 18 years or more; to be under medical treatment for at least 6 months; clinical stability (*i.e.* no exacerbation symptoms or increment in asthma medication for at least 30 days); and absence of limiting cardiovascular and/or musculoskeletal disease. Exclusion criteria were as follows: inability to perform the tests; exacerbation or changes in asthma medication in the assessment period; diagnosis of other pulmonary disease(s); and to decline continuation in the assessments for any reason. The study was approved by Pitágoras-Unopar University Ethics Committee (number 3.060.314) and all participants signed an informed consent.

In order to verify the discriminative validity, retrospective data from non-asthmatic people who participated in another study aimed at creating reference values for functional tests in adults were also analyzed. These people presented forced expiratory volume in the first second/forced vital capacity ratio (FEV_1/FVC) $\geq 70\%$ and healthy condition based on physical examination and medical history. The control sample was matched by sex and age and performed the functional

tests in the same protocols as people with asthma. Data collection occurred between April 2018 and June 2019.

Design and outcomes

In this cross-sectional study, people with asthma were assessed in three different days. In the first day (visit 1), participants underwent anthropometric measurements, lung function assessment (Spirometer MicroLab 3500, Care Fusion®, Ireland), the first set of functional tests (see more details further) and completed the scales of self-reported comorbidities (21), Asthma Control Test (ACT) (22), Asthma Quality of Life Questionnaire (AQLQ) (23), and Hospital Anxiety and Depression Scale (HADS) (24). After three days (visit 2), participants underwent blood collection for biomarkers analysis (total Immunoglobulin E [IgE] and eosinophil), followed by the second and third sets of functional tests. Finally, eight days later (visit 3), participants performed two 6MWT in a 30-meter corridor according to the ERS/ATS guidelines (11) as well as peripheral muscle strength tests. Quadriceps strength was measured on the preference limb by a strain gauge (EMG System Brazil®) during a maximal voluntary isometric contraction sitting with stabilized trunk and knee flexion at 60° (25). A dynamometer (Jamar®, United States of America) was used to assess handgrip strength in the dominant hand, with the patient in the seated position with shoulders in a neutral position and elbow flexioned at 90° (26). Both muscle strength tests were performed three times each and the best result was chosen for the analysis.

Functional tests

Eight protocols of functional tests were performed three times by each patient. The test–retests were performed three days apart with the same rater (intra-rater) (visit 1 and visit 2), and a different rater performed the tests again on visit 2, 30 min after the retest (inter-rater reliability). The sequence of tests was randomized, except for the balance component of SPPB, which was always the first test to avoid possible effects by other tests on balance measurement. At the beginning of each test and each set of functional tests, heart rate and subjective sensation of dyspnea were assessed. During the set, the next test just started when dyspnea symptoms returned to baseline levels or heart rate reduced to baseline values considering a variation lower than 10%. Each test was similarly explained and demonstrated by raters to the participants immediately before starting.

4-Meter gait speed

In this test, the participants walk in a 4 m corridor with a cone in the edges. They were positioned with the toes just touching the start line and were instructed to walk in a usual pace (4MGS_usual) in the command “go” until overpass the cone, and also in a fast-pace walking mode, with an instruction to walk as fast as possible without run (4MGS_max) (12). A stopwatch started when the participant began to move and stopped when the participant’s first foot completely crossed the cone, with the result in seconds. The two protocols were performed separately in a randomized order. The 4MGS_usual was performed twice without rest and the faster of the two times was chosen for analysis (27), and it was considered as the walking speed component of SPPB (28).

Timed up-and-go

In TUG test, the participants should stand up from a chair (seat in 46 cm high) in the command “go”, walk in a 3 meters distance, turn around a cone positioned in the edge, walk back to the chair and sit down again. The stopwatch started when the participant’s back left the chair in the word go and ended when the participant’s back was positioned against the chair in full sit down position, with the result also in seconds (29). Once again, two protocols of this test were performed, with participants walking at their usual pace (TUG_usual) and at the fastest possible pace (TUG_max).

Sit-To-Stand

Sit-To-Stand test was performed in 3 different protocols: the one of 5 repetitions (STS_5r), 30 s (STS_30s), and 1 min (STS_1min). For all protocols, the participants started seated on a chair (with a seat of 46 cm high), with their feet flat on the floor and their arms crossed on the chest. In the first protocol, they were encouraged to fully stand up and sit down landing firmly as fast as possible five times without using the arms. In the STS_5r protocol, the stopwatch started on the command “go” and stopped at the end of the completed fifth stand, with results in seconds (15). In STS_30s and STS_1min protocols, the participants should stand up and sit down as many times as possible for 30 s and 1 min, respectively, with results in number of repetitions. The stopwatch stopped when the time was completed and only the fully stand ups was counted (30). Participants were allowed to rest during the test; however, the time in the stopwatch kept running. The STS_5r protocol was considered as the sitting and rising component of SPPB (28).

Short physical performance battery

The SPPB consists of three components: balance assessment, walking speed at usual pace, and sitting and rising in the chair 5 times. For balance, participants were instructed to remain 10 s in three standing positions while they look to a fixed point in the wall. The positions were feet together side-by-side, semi-tandem (the toes of one foot aligned with the mid-point of the other foot), and tandem (one foot in front of the other, with the heel of the front foot in contact with the toes of the back foot) (28). In the semi-tandem and tandem positions, the participants preference to choose which foot they would always put behind were considered. Components of walking speed and sitting and rising protocols were explained above in the 4-Meter Gait Speed and Sit-to-Stand sections, respectively (8). Each component is scored from 0 to 4, with a total of 12 points (the higher the score the better) (8,28).

Data analysis

Data were expressed as absolute and relative frequency, mean $\pm$ standard deviation (SD) or median [interquartile range 25–75%], as appropriate. Data distribution was verified by the Shapiro–Wilk test. Mann–Whitney test was used to investigate discriminative validity by comparing the functional tests results between asthmatic and control subjects, using the best of two assessments for both. Pearson and Spearman coefficients were used to investigate convergent and discriminant validity. For the convergent validity the functional tests should correlate at least moderately with 6MWT and peripheral muscle strength; moreover, for divergent validity, weak to no correlations ($r < 0.40$) with mental health outcomes and disease control were expected.

Regarding reliability, Wilcoxon or Student’s *t*-test were used to compare the performance between tests pairwise of the sets. To assess the relative reliability, we used a single measure of Intraclass Correlation Coefficients (ICC) of absolute agreement and random (for intra-rater) or mixed effects (for inter-rater) with 95% confidence intervals. ICC values were interpreted according to the following cutoff points: <0.50 = poor reliability; 0.50 – 0.75 = moderate reliability; 0.75 – 0.90 = good reliability; >0.90 = excellent reliability (31). For absolute reliability, the variability measurement was determined by calculating the absolute and relative standard error of measurement (SEM and SEM% respectively), the absolute

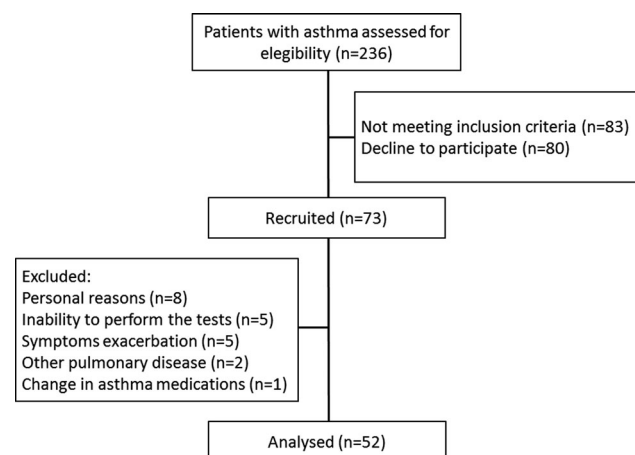


Figure 1. Flowchart of the study for asthma group.

(MDC) and relative (MDC%) values of MDC at 95% confidence interval. The learning effects of each functional test were also calculated. The formulas used are the following (32,33):

$$\text{SEM} = \text{SD of } 1^{\text{st}} \text{ and } 2^{\text{nd}} \text{ tests} * \sqrt{(1 - \text{ICC})}$$

$$\text{SEM\%} = (\text{SD of } 1^{\text{st}} \text{ and } 2^{\text{nd}} \text{ tests} / \text{mean of } 1^{\text{st}} \text{ and } 2^{\text{nd}} \text{ tests}) * 100$$

$$\text{MDC} = 1.96 * \text{SEM} * \sqrt{2}$$

$$\text{MDC\%} = (\text{MDC} / \text{mean of } 1^{\text{st}} \text{ and } 2^{\text{nd}} \text{ tests}) * 100$$

$$\text{Learning Effect} = 2^{\text{nd}} \text{ test} - 1^{\text{st}} \text{ test}$$

$$\text{Learning Effect\%} = ([2^{\text{nd}} \text{ test} - 1^{\text{st}} \text{ test}] / 1^{\text{st}} \text{ test}) * 100$$

The 95% limits of agreement with Bland–Altman plots were also calculated to evaluate agreement

Table 1. Characteristics of the sample and comparisons between the asthma group and the control group.

	Asthma (n = 52)	Controls (n = 52)	p Value
Anthropometric data			
Sex (men/woman)	20/32	22/30	0.691
Age (years)	47 [38–58]	47 [33–63]	0.733
Height (m)	1.63 ± 0.10	1.65 ± 0.11	0.255
Weight (kg)	71 [61–87]	68 [60–79]	0.097
Body mass index (kg/m ²)	28 [24–33]	24 [22–27]	0.002
Lung function			
FEV ₁ (L)	2.22 ± 0.71	3.17 ± 0.95	<0.0001
FEV ₁ (%predicted)	73 ± 17	99 ± 12	<0.0001
FEV ₁ /FVC (%)	72 [65–77]	84 [81–88]	<0.0001
Comorbidities			
Charlson Index (points)	1 [1–2]	0 [0–0]	<0.0001
Mental health			
HADS anxiety (points)	8 [4–10]	5 [3–7]	0.003
HADS depression (points)	6 [2–9]	4 [2–6]	0.004
Exercise capacity			
6MWT (m)	553 ± 92	612 ± 79	0.001
6MWT (%predicted)	98 ± 13	105 ± 10	0.003
Peripheral strength			
Quadriceps strength (Kgf)	18 [15–25]	NA	NA
Handgrip strength (Kgf)	28 [24–40]	NA	NA
Systemic outcomes			
IgE (IU/mL)	80.6 [12.9–332.4]	NA	NA
Eosinophil (cells/mcL)	286 [167–432]	NA	NA
Asthma medications			
ICS dose (mcg-d)	490 [123–490]	NA	NA
LABA dose (mcg-d)	24 [12–24]	NA	NA
Asthma control			
ACT (points)	21 [17–23]	NA	NA
General exacerbations (n/%)	37/71	NA	NA
Exacerbation with hospitalization (n/%)	8/15	NA	NA
Level of dyspnea			
mMRC (points)	1 [0–2]	NA	NA
Quality of life			
AQLQ (points)	5.1 [4.2–5.8]	NA	NA

Data are presented as absolute or relative value, mean ± SD or median [interquartile range 25%–75%]. FEV₁: forced expiratory volume in the 1st second; FVC: forced vital capacity; HADS: Hospital Anxiety and Depression Scale; 6MWT: Six-Minute Walking Test; Kgf: Kilograms force; IgE: Immunoglobulin E; ICS: inhaled corticosteroids; LABA: Long Action B₂-Agonist (equivalent dose for Beclometasone) [34]; ACT: Asthma Control Test; General exacerbations: number of participants who had asthma exacerbation in the last year; Exacerbation with hospitalization: number of participants who were hospitalized due to asthma exacerbation in the last year; mMRC: modified Medical Respiratory Council; AQLQ: Asthma Quality of Life Questionnaire; NA: not applicable. p Values: comparisons between Asthma group vs Control group.

Bold values highlight statistically significant results.

Table 2. Comparisons of functional testes performed by people with asthma and controls (discriminative validity).

Functional tests	Asthma (n = 52)	Controls (n = 52)	p Value
SPPB (points)	12 [11–12]	12 [12–12]	0.259
4MGS_usual (s)	4.14 [3.48–4.68]	3.52 [3.11–4.12]	0.002
4MGS_max (s)	2.96 [2.64–3.36]	2.56 [2.32–2.89]	<0.0001
STS_5r (s)	8.91 [7.71–10.83]	7.81 [6.90–9.31]	0.008
STS_30s (repetitions)	14 [12–18]	17 [15–19]	0.006
STS_1min (repetitions)	28 [24–33]	35 [30–40]	<0.0001
TUG_usual (s)	9.40 [8.27–11.17]	7.98 [7.15–9.52]	<0.0001
TUG_max (s)	7.05 [6.20–8.22]	5.89 [5.21–7.11]	<0.0001

The best of the first two functional tests were considered in both groups. Data are presented as absolute value or median [interquartile range 25%–75%]. SPPB: Short Physical Performance Battery; 4MGS_usual: 4-Meter Gait Speed usual; 4MGS_max: 4-Meter Gait Speed maximum; STS_5r: 5-repetitions Sit-To-Stand; STS_30s: 30-s Sit-To-Stand; STS_1min: 1-min Sit-To-Stand; TUG_usual: Timed Up-and-Go usual; TUG_max: Timed Up-and-Go maximum.

Bold values highlight statistically significant results.

Table 3. Correlations of functional tests and other outcomes in people with asthma for convergent and divergent validities.

	6MWT	Quadriceps strength	Handgrip strength	AQLQ	ACT
SPPB					
<i>r</i>	0.61	0.39	0.50	−0.14	0.02
<i>p</i> value	<0.0001	0.006	<0.0001	0.309	0.907
4MGS_usual					
<i>r</i>	−0.64	−0.30	−0.52	0.02	−0.14
<i>p</i> value	<0.0001	0.040	<0.0001	0.881	0.341
4MGS_max					
<i>r</i>	−0.67	−0.44	−0.63	0.07	−0.02
<i>p</i> value	<0.0001	0.002	<0.0001	0.624	0.866
STS_5r					
<i>r</i>	−0.56	−0.34	−0.49	−0.08	−0.13
<i>p</i> value	<0.0001	0.018	<0.0001	0.581	0.344
STS_30s					
<i>r</i>	0.45	0.34	0.43	0.11	0.13
<i>p</i> value	0.001	0.020	0.002	0.429	0.375
STS_1min					
<i>r</i>	0.48	0.32	0.41	0.08	0.09
<i>p</i> value	<0.0001	0.028	0.003	0.598	0.514
TUG_usual					
<i>r</i>	−0.62	−0.43	−0.49	0.14	0.02
<i>p</i> value	<0.0001	0.002	<0.0001	0.324	0.876
TUG_max					
<i>r</i>	−0.61	−0.40	−0.49	0.06	−0.17
<i>p</i> value	<0.0001	0.005	<0.0001	0.688	0.243

ACT: Asthma Control Test; AQLQ: Asthma Quality of Life Questionnaire; SPPB: Short Physical Performance Battery; 4MGS_usual: 4-Meter Gait Speed usual; 4MGS_max: 4-Meter Gait Speed maximum; STS_5r: 5-repetitions Sit-To-Stand; STS_30s: 30-s Sit-To-Stand; STS_1min: 1-min Sit-To-Stand; Rep: repetitions; TUG_usual: Timed Up-and-Go usual; TUG_max: Timed Up-and-Go maximum; 6MWT: Six-Minute Walking Test.

Bold values highlight statistically significant results.

between the trials. *p* Values <0.05 was considered significant.

Results

Of the 236 patients with asthma assessed for eligibility, 73 complied with inclusion criteria and 52 were analyzed. Reasons for exclusions are shown in Figure 1. Regarding the controls, data from 52 subjects matched by age and sex with the 52 asthmatic subjects were taken from another database (unpublished data). The majority of patients with asthma were composed of middle-aged and overweight women with limited

pulmonary function. Regarding the treatment levels, 39% of the patients were at step 5, 37% at step 4, 12% at step 3, 4% at step 2, and 8% at step 1, according to GINA (2,34). The asthma group had a prevalence of 48% of rhinitis, 44% of sinusitis, 35% of gastroesophageal reflux, and 8% obstructive sleep apnea. People with asthma had a median of 2[0–3] exacerbations in the last year. Other characteristics of the two groups are described in Table 1 and the results of the best functional test are shown in Table 2.

Regarding discriminative validity, patients with asthma had worse performance in the functional tests compared to controls, except for SPPB which was not

Table 4. Results of the three sets of functional tests and relative reliability in people with asthma.

Functional tests	Test	Retest	Inter-rater	ICC intra-rater	ICC inter-rater
SPPB (points)	12 [10–12]	12 [11–12]	12 [11–12]	0.75 (0.56–0.86)	0.75 (0.56–0.86)
4MGS_usual (s)	4.53 [3.82–4.96]	4.25 [3.48–4.76]*	4.06 [3.72–4.55] [†]	0.86 (0.73–0.92)	0.58 (0.26–0.76)
4MGS_max (s)	3.07 [2.72–3.88]	3.05 [2.81–3.50]	3.12 [2.78–3.72]	0.83 (0.70–0.90)	0.46 (0.08–0.68)
STS_5r (s)	9.79 [8.10–11.52]	9.42 [7.92–11.05]	9.20 [7.53–11.37] [†]	0.84 (0.72–0.90)	0.86 (0.75–0.92)
STS_30s (repetitions)	14 [11–16]	14 [12–17]*	14 [12–16] [†]	0.91 (0.81–0.95)	0.86 (0.73–0.93)
STS_1min (repetitions)	25 [22–29]	27 [23–33]*	27 [23–32] [†]	0.87 (0.73–0.93)	0.80 (0.62–0.89)
TUG_usual (s)	9.86 [8.93–11.69]	9.58 [8.40–11.42]	9.17 [8.50–10.69] [†]	0.90 (0.82–0.94)	0.76 (0.56–0.87)
TUG_max (s)	7.27 [6.41–8.56]	7.45 [6.44–8.35]	7.47 [6.75–8.13]	0.91 (0.84–0.95)	0.83 (0.70–0.90)

Functional tests results presented as median [interquartile range 25%–75%]; ICC presented as absolute value (95% Confidence Interval). SPPB: Short Physical Performance Battery; 4MGS_usual: 4-Meter Gait Speed usual; 4MGS_max: 4-Meter Gait Speed maximum; STS_5r: 5-repetitions Sit-To-Stand; STS_30s: 30-s Sit-To-Stand; STS_1min: 1-min Sit-To-Stand; TUG_usual: Timed Up-and-Go usual; TUG_max: Timed Up-and-Go maximum; ICC: Intraclass Correlation Coefficient.

*Statistically significant difference ($p < 0.05$) between the 1st and 2nd sets of functional tests (intra-rater).

[†]Statistically significant difference ($p < 0.05$) between the 1st and 3rd sets of functional tests (inter-rater).

There were no differences between retest and inter-rater tests ($p > 0.05$ for all).

Table 5. Standard error of measurement (SEM), minimal detectable change (MDC), and learning effect of functional tests in subjects with asthma.

Functional tests	SEM ^a	SEM%	MDC ^a	MDC%	Learning effect ^a	Learning effect (%)
SPPB (points)	0.61	11	1.68	15	0.15 ± 1.09	2.0 ± 11.5
4MGS_usual (s)	0.33	20	0.91	21	−0.14 ± 0.52	2.7 ± 10.3
4MGS_max (s)	0.28	21	0.79	24	−0.07 ± 0.53	0.4 ± 14.3
STS_5r (s)	1.11	28	3.07	31	−0.52 ± 2.02	3.4 ± 17.5
STS_30s (repetitions)	1.31	30	3.64	25	1.14 ± 2.31	8.7 ± 15.8
STS_1min (repetitions)	2.88	29	7.99	29	1.85 ± 6.10	6.8 ± 25.2
TUG_usual (s)	0.60	19	1.67	16	−0.15 ± 1.16	1.3 ± 11.8
TUG_max (s)	0.50	22	1.37	18	−0.07 ± 0.98	0.2 ± 13.1

^aSEM, MDC, and learning effect presented as units of measurement of each test; SEM%, MDC%, and learning effect (%) presented as percentage. Values based on the first two sets of functional tests. SEM: standard error of measurement; MDC: minimal detectable change; SPPB: Short Physical Performance Battery; 4MGS_usual: 4-Meter Gait Speed usual; 4MGS_max: 4-Meter Gait Speed maximum; STS_5r: 5-repetitions Sit-To-Stand; STS_30s: 30-s Sit-To-Stand; STS_1min: 1-min Sit-To-Stand; TUG_usual: Timed Up-and-Go usual; TUG_max: Timed Up-and-Go maximum.

statistically different (Table 2). Most of the correlations between the functional tests and 6MWT and peripheral muscle strength were moderate, what features the convergent validity. None of the functional tests had significant correlations with quality of life (measured by AQLQ) neither with the level of asthma control (assessed by ACT), which contemplates the divergent validity (Table 3).

Regarding reliability, the comparisons between test–retest and inter-rater tests are described in Table 4. Only 4MGS_usual, STS_30s and STS_1min were different between test and retest (intra-rater), while 4MGS_usual, STS (the 3 protocols) and TUG_usual were statistically different between inter-rater tests. Table 4 also shows that all functional tests presented good intra-rater reliability, with high ICC values (≥ 0.75). Inter-rater reliability was also good except for both 4MGS_usual and 4MGS_max. Values of SEM, MDC, and learning effect are provided in Table 5. The random measurement error and systematic error in test retest (intra-rater) and inter-rater assessments can be visualized on the Bland–Altman plots (supporting information Figures S1 and S2, respectively).

All functional tests required small spaces, cheap equipment, and had short duration. Moreover, there were no important clinical adverse events during or

after the tests. Among all of them, the 4MGS was the test which required the larger space – 4 meters for the actual test plus approximately 1 m after the cone for the walking deceleration. The more time-consuming test was the SPPB, which took approximately 4 min for instructions and performance of its 3 components.

Discussion

Validity

This is the first study to investigate different measurement properties of the 4MGS, TUG, STS, and SPPB in adults with asthma, and the sample size agrees with Cosmin recommendations (minimum of 50) (35). All functional tests have shown to be valid to assess functional capacity in this population, using three specific types of validation which encompass the construct validity class. The comparison of functional tests between people with and without asthma showed the SPPB as the only test that did not differ between groups. This possibly happened because of a ceiling effect due to the scoring system of this test, which only goes up to 12 points and seems to be easily reached by people without important physical impairments, such as

people with mild asthma, who were also included in this study. Noteworthy, this is the first study to compare and show that most of the functional tests were significantly worse in people with asthma, which means they can discriminate groups of subjects who are supposed to be different (discriminative validity). Even the 6MWT, despite reflecting a preserved exercise capacity, presented worse results in people with asthma. This is in agreement with a recent clinical trial, which showed that a group of asthmatics also presented a normal range of 6MWT in terms of predicted values (36).

The present study also showed mild-to-moderate correlations between functional tests, 6MWT and peripheral muscle strength, which characterizes the convergent validity (37). The 4MGS, TUG, and STS tests have been shown to correlate with 6MWT and peripheral muscle strength in other populations (15,38,39). For instance, Puhan et al. found a moderate correlation ($r=0.45$) between the 1-min STS and handgrip strength in people with Chronic Obstructive Pulmonary Disease (14).

To complete the validation component, as expected, mental health and level of asthma control were not significantly correlated with functional tests in the present study, what proves that these instruments have different constructs and that the functional tests do not measure other aspects than those intended (divergent validity) (40).

Reliability and agreement

The ICCs showed good-to-excellent reliability in almost all functional tests, including those with statistical differences in the comparison between sets. Only the 4MGS protocols presented poor-to-moderate inter-rater ICC. The ICC is the most used test to assess reliability, since it reflects both degree of correlation and agreement between the measurements (31). Therefore, we tend to conclude that all tests present good intra-rater reliability but the 4MGS does not seem to be reliable inter-rater. The inter-rater reproducibility of this test should be better studied in future studies; meanwhile we suggest that the same rater applies this test in a reassessment condition in clinical practice.

The MDC represents the minimal amount of change that can be considered as the “real” difference, so that is not likely to be due to chance variation in measurement (41). The smaller the MDC, the more reliable are the measurements, although there is no cutoff point to establish a good MDC% (41). In this study, MDC values were smaller than the variability of measurement

for all tests (see 95% limits of agreement in [supporting information Figure S1](#)) and a considerable learning effect was observed, which was larger in STS_30s and STS_1min tests (9% and 7%, respectively). These findings suggest that the best of two measurements should be used as the result in all tests.

Moreover, in the present study, the MDC% of the functional tests ranged from 15 to 31%, which is consistent with previous studies. Mesquita et al. (33) showed a MDC of 14% for TUG_usual in patients with Chronic Obstructive Pulmonary Disease, while 16% was found in the present study. Another study reported absolute values of SEM and MDC for patients undergoing hemodialysis that are similar to the ones found in the present study for the SPPB (SEM: 0.72 vs 0.61; MDC: 1.7 vs 1.7, respectively) and TUG_usual (SEM: 1.24 vs 0.60; MDC: 2.9 vs 1.7, respectively) (42).

Feasibility

Even the functional tests that used the largest space and were more time-consuming in the present study (4MGS and SPPB, respectively), still require smaller space and were less time-consuming than other tests, such as the 6MWT. Moreover, all the investigated functional tests are easy to perform since they require few and accessible equipment and use familiar movements. Because of these characteristics, patients might be more comfortable and confident with these simple tests than with more time-consuming and challenging tests such as the Incremental Shuttle Walk Test. In a recent study, people with asthma slightly improved at each Incremental Shuttle Walk Test until the third repetition, probably because initially they were afraid of exacerbating (43). Finally, all the investigated functional tests have shown to reflect the functional capacity and peripheral muscle strength in adults with asthma, and our hypothesis were confirmed. This topic is an area for future research and these tests can be easily used in the clinical practice.

Study limitations

Although the Cosmin recommendations consider a sample size above 50 subjects as acceptable, it is known that a sample above 100 subjects is considered as optimum. Therefore, it is reasonable to consider that sample size is a limitation in the present study, although we believe this limitation did not substantially influence the results. Another limitation is the large variability in disease severity; on the other hand,

a heterogeneous sample may increase the external validity of the study.

Conclusion

In general, the functional tests 4MGS, TUG, STS, and SPPB showed to be valid, reliable, and feasible to assess adults with asthma, and MDCs of these tests were provided. These functional tests should be performed twice because of the learning effect and the variability of the measurements in this population. These functional tests are a quick and practical alternative for assessing functional capacity in this population.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

ORCID

Joice Mara de Oliveira  <http://orcid.org/0000-0003-3387-2940>

Fabio Pitta  <http://orcid.org/0000-0002-3369-6660>

Karina Couto Furlanetto  <http://orcid.org/0000-0002-7496-7228>

References

1. The Global Asthma Report 2018. Auckland, New Zealand: Global Asthma Network, 2018. Available from: www.globalasthmanetwork.org [accessed 26 August 2019].
2. Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention, 2019. Available at: www.ginasthma.org [accessed 26 August 2019].
3. Weatherald J, Loughed MD, Taillé C, Garcia G. Mechanisms, measurement and management of exertional dyspnoea in asthma. *Eur Respir Rev* 2017; 26(144):170015.
4. Vermeulen F, Garcia G, Ninane V, Laveneziana P. Activity limitation and exertional dyspnea in adult asthmatic patients: what do we know? *Respir Med* 2016;117:122–130. doi:10.1016/j.rmed.2016.06.003.
5. Ramos E, de Oliveira LV, Silva A, Costa I, Corrêa JC, Costa D, Alves V, Donner CF, Stirbulov R, Arena R, et al. Peripheral muscle strength and functional capacity in patients with moderate to severe asthma. *Multidiscip Respir Med* 2015;10(1):3.
6. Cordova-Rivera L, Gibson PG, Gardiner PA, Powell H, McDonald VM. Physical activity and exercise capacity in severe asthma: key clinical associations. *J Allergy Clin Immunol Pract* 2018;6(3):814–822.
7. Marcon A, Girardi P, Ferrari M, Olivieri M, Accordini S, Bombieri C, Bortolami O, Braggion M, Cappa V, Cazzoletti L, et al. Mild asthma and chronic bronchitis seem to influence functional exercise capacity: A multi-case control study. *Int Arch Allergy Immunol* 2013; 161(2):181–188. doi:10.1159/000345137.
8. Bui KL, Nyberg A, Maltais F, Saey D. Functional tests in chronic obstructive pulmonary disease, part 2: measurement properties. *Ann Am Thorac Soc* 2017; 14(5):785–794. doi:10.1513/AnnalsATS.201609-734AS.
9. Spruit MA, Pitta F, Garvey C, ZuWallack RL, Roberts CM, Collins EG, Goldstein R, McNamara R, Surpas P, Atsuyoshi K, et al. Differences in content and organisational aspects of pulmonary rehabilitation programmes. *Eur Respir J* 2014;43(5):1326–1337. doi:10.1183/09031936.00145613.
10. Moreira GL, Donária L, Furlanetto KC, Paes T, Sant'Anna T, Hernandez NA, Pitta F. GOLD B-C-D groups or GOLD II-III-IV grades: which one better reflects the functionality of patients with chronic obstructive pulmonary disease? *Chron Respir Dis* 2015;12(2):102–110. doi:10.1177/1479972315573528.
11. Holland AE, Spruit MA, Troosters T, Puhan MA, Pepin V, Saey D, McCormack MC, Carlin BW, Sciurba FC, Pitta F, et al. An official European respiratory society/American thoracic society technical standard: field walking tests in chronic respiratory disease. *Eur Respir J* 2014;44(6):1428–1446. doi:10.1183/09031936.00150314.
12. Kim H-J, Park I, Lee HJ, Lee O. The reliability and validity of gait speed with different walking pace and distances against general health, physical function, and chronic disease in aged adults. *J Exerc Nutr Biochem* 2016;20(3):46–50.
13. Freitas PD, Xavier RF, McDonald VM, Gibson PG, Cordova-Rivera L, Furlanetto KC, de Oliveira JM, Carvalho-Pinto RM, Cukier A, Stelmach R, et al. Identification of asthma phenotypes based on extrapulmonary treatable traits. *Eur Respir J* 2020;2000240. doi:10.1183/13993003.00240-2020.
14. Puhan MA, Siebeling L, Zoller M, Muggensturm P, ter Riet G. Simple functional performance tests and mortality in COPD. *Eur Respir J* 2013;42(4):956–963. doi:10.1183/09031936.00131612.
15. Jones SE, Kon SSC, Canavan JL, Patel MS, Clark AL, Nolan CM, Polkey MI, Man WDC. The five-repetition sit-to-stand test as a functional outcome measure in COPD. *Thorax* 2013;68(11):1015–1020.
16. Cunha ÂGJ, Nunes MPT, Ramos RT, Carvalho-Pinto RM, Boffino CC, Martins FC, Tanaka C. Balance disturbances in asthmatic patients. *J Asthma* 2013;50(3): 282–286. doi:10.3109/02770903.2012.750668.
17. Almeida V, Guimaraes F, Moco V, Ferreira A, Menezes S, Lopes A. Is there an association between postural balance and pulmonary function in adults with asthma? *Clinics* 2013;68(11):1421–1427.
18. Freitas Canuto F, Silva SM, Malosá Sampaio LM, Stirbulov R, Ferrari Corrêa JC. Neurophysiological and functional assessment of patients with difficult-to-control asthma. *Rev Port Pneumol* 2012;18(4): 160–165.
19. Mancuso CA, Choi TN, Westermann H, Briggs WM, Wenderoth S, Charlson ME. Measuring physical activity in asthma patients: two-minute walk test, repeated chair

- rise test, and self-reported energy expenditure. *J Asthma* 2007;44(4):333–340. doi:[10.1080/02770900701344413](https://doi.org/10.1080/02770900701344413).
20. Majewski M, Dąbrowska G, Pawik M, Rożek K. Evaluation of a home-based pulmonary rehabilitation program for older females suffering from bronchial asthma. *Adv Clin Exp Med* 2015;24(6):1079–1083. doi:[10.17219/acem/31679](https://doi.org/10.17219/acem/31679).
21. Porsbjerg C, Menzies-Gow A. Co-morbidities in severe asthma: clinical impact and management. *Respirology* 2017;22(4):651–661. doi:[10.1111/resp.13026](https://doi.org/10.1111/resp.13026).
22. Roxo JPF, Ponte EV, Ramos DCB, Pimentel L, D'Oliveira Júnior A, Cruz AA. [Portuguese-language version of the Asthma Control Test]. *J Bras Pneumol* 2010;36(2):159–166. doi:[10.1590/s1806-37132010000200002](https://doi.org/10.1590/s1806-37132010000200002).
23. Silva L. d, Silva L. d. Validation of asthma quality of life questionnaire (Juniper) to brazilian portuguese. *Rev AMRIGS* 2007;51:31–37.
24. Ciprandi G, Schiavetti I, Rindone E, Ricciardolo FLM. The impact of anxiety and depression on outpatients with asthma. *Ann Allergy Asthma Immunol* 2015;115(5):408–414.
25. Gagnon D, Nadeau S, Gravel D, Robert J, Bélanger D, Hilsenrath M. Reliability and validity of static knee strength measurements obtained with a chair-fixed dynamometer in subjects with hip or knee arthroplasty. *Arch Phys Med Rehabil* 2005;86(10):1998–2008. doi:[10.1016/j.apmr.2005.04.013](https://doi.org/10.1016/j.apmr.2005.04.013).
26. Roberts HC, Denison HJ, Martin HJ, Patel HP, Syddall H, Cooper C, Sayer AAA. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age Ageing* 2011;40(4):423–429. doi:[10.1093/ageing/afr051](https://doi.org/10.1093/ageing/afr051).
27. Kon SSC, Patel MS, Canavan JL, Clark AL, Jones SE, Nolan CM, Cullinan P, Polkey MI, Man WDC. Reliability and validity of 4-metre gait speed in COPD. *Eur Respir J* 2013;42(2):333–340.
28. Puthoff ML. Research corner outcome measures in cardiopulmonary physical therapy: short physical performance battery. *Cardiopulm Phys Ther J* 2008;19:17–22.
29. Marques A, Cruz J, Quina S, Regêncio M, Jácome C. Reliability, agreement and minimal detectable change of the Timed Up & Go and the 10-meter walk tests in older patients with COPD. *COPD* 2016;13(3):279–287. doi:[10.3109/15412555.2015.1079816](https://doi.org/10.3109/15412555.2015.1079816).
30. Morita AA, Bisca GW, Machado FVC, Hernandez NA, Pitta F, Probst VS. Best protocol for the sit-to-stand test in subjects with COPD. *Respir Care* 2018;63(8):1040–1049.
31. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med* 2016;15(2):155–163.
32. de Vet HCW, Terwee CB, Knol DL, Bouter LM. When to use agreement versus reliability measures. *J Clin Epidemiol* 2006;59(10):1033–1039. doi:[10.1016/j.jclinepi.2005.10.015](https://doi.org/10.1016/j.jclinepi.2005.10.015).
33. Mesquita R, Wilke S, Smid DE, Janssen DJA, Franssen FME, Probst VS, Wouters EFM, Muris JWM, Pitta F, Spruit MA. Measurement properties of the Timed Up & Go test in patients with COPD. *Chron Respir Dis* 2016;13(4):344–352.
34. III Consenso Brasileiro no Manejo da Asma. Definição, epidemiologia, patologia e patogenia. *J Pneumol* 2002;28:4–5. Available from: https://s3-sa-east-1.amazonaws.com/publisher.gn1.com.br/jornaldepneumologia.com.br/pdf/Suple_163_52_cons_asma_2002_s03.pdf [accessed 29 November 2019].
35. Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, Bouter LM, de Vet HC. COSMIN checklist manual. COSMIN initiative, 2012. Available from: www.cosmin.nl [accessed 2 September 2019].
36. Zampogna E, Paneroni M, Cherubino F, Pignatti P, Rudi M, Casu G, Vitacca M, Spanevello A, Visca D. Effectiveness of a pulmonary rehabilitation program on persistent asthma stratified for severity. *Respir Care* 2019;64(12):1523–1530.
37. Souza AC, Alexandre NMC, Guirardello EB. Psychometric properties in instruments evaluation of reliability and validity. *Epidemiol Serv Saude* 2017;26(3):649–659. doi:[10.5123/S1679-49742017000300022](https://doi.org/10.5123/S1679-49742017000300022).
38. Hwang R, Morris NR, Mandrusiak A, Mudge A, Suna J, Adsett J, Russell T. Timed up and go test: a reliable and valid test in patients with chronic heart failure. *J Card Fail* 2016;22(8):646–650.
39. Bisca GW, Morita AA, Hernandez NA, Probst VS, Pitta F. Simple lower limb functional tests in patients with chronic obstructive pulmonary disease: a systematic review. *Arch Phys Med Rehabil* 2015;96(12):2221–2230. doi:[10.1016/j.apmr.2015.07.017](https://doi.org/10.1016/j.apmr.2015.07.017).
40. Polit DF. Assessing measurement in health: beyond reliability and validity. *Int J Nurs Stud* 2015;52(11):1746–1753. doi:[10.1016/j.ijnurstu.2015.07.002](https://doi.org/10.1016/j.ijnurstu.2015.07.002).
41. Polit DF. Getting serious about test-retest reliability: a critique of retest research and some recommendations. *Qual Life Res* 2014;23(6):1713–1720. doi:[10.1007/s11136-014-0632-9](https://doi.org/10.1007/s11136-014-0632-9).
42. de Villar LOP, Martínez-Olmos FJ, Junqué-Jiménez A, Amer-Cuenca JJ, Martínez-Gramage J, Mercer T, Segura-Ortí E. Test-retest reliability and minimal detectable change scores for the short physical performance battery, one-legged standing test and timed up and go test in patients undergoing hemodialysis. *PLoS One* 2018;13:1–16.
43. Majd S, Hewitt SM, Apps LD, Murphy AC, Bradding P, Singh SJ, Green RH, Evans RA. Understanding the measurement properties of the incremental shuttle walk test in patients with severe asthma. *Respirology* 2019;24(8):752–757.

Online Supplement

Functional tests for adults with asthma: validity, reliability, Minimal Detectable Change and feasibility.

Results

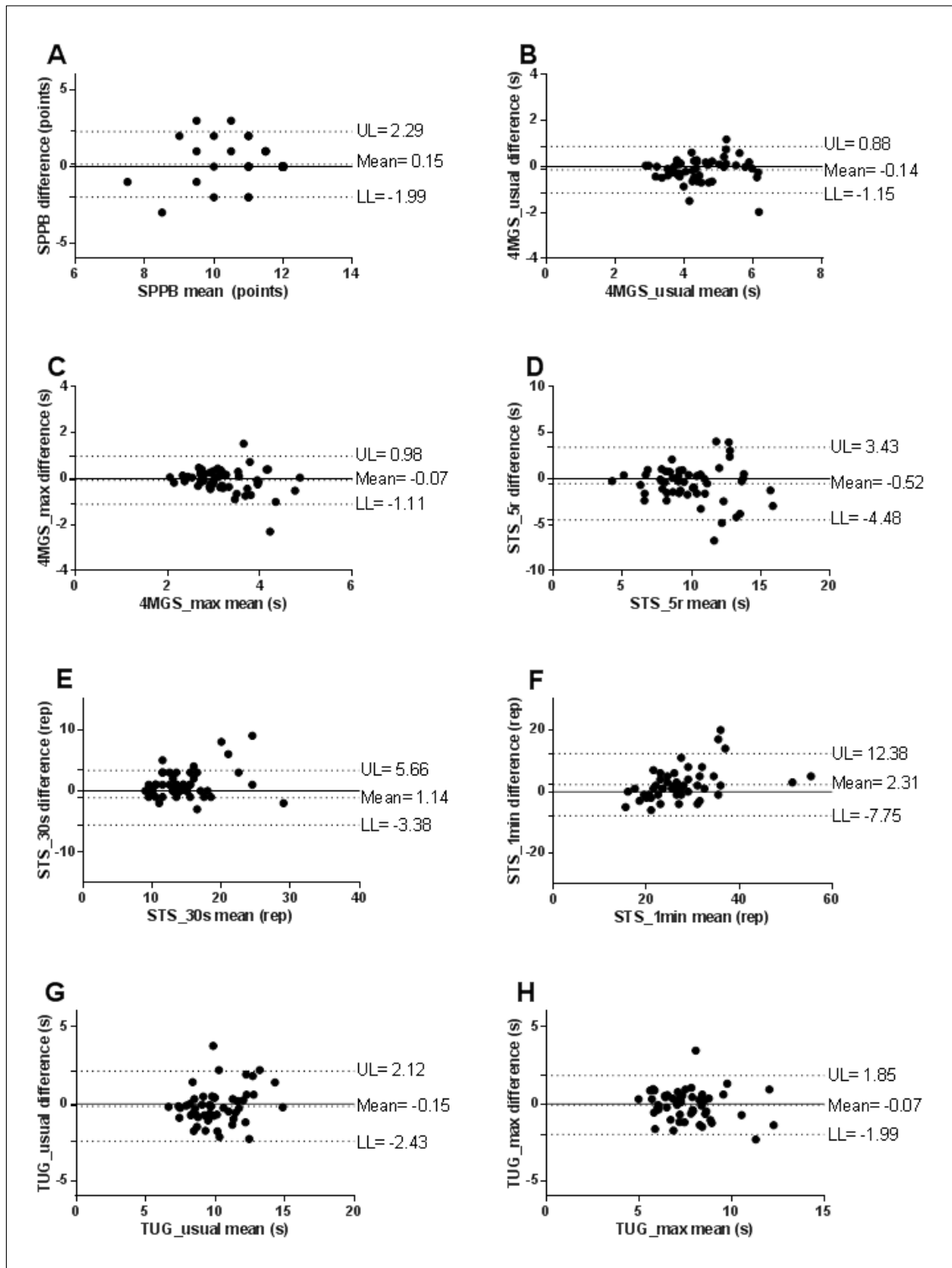


Figure S1. Bland and Altman plots of the difference against the mean of the first and second sets of functional tests (intra-rater). Mean: the average difference between the two

tests; UL: Upper limit of agreement; LL: Lower limit of agreement. (A) SPPB: Short Physical Performance Battery; (B) 4MGS_usual: 4-Meter Gait Speed usual; (C) 4MGS_max: 4-Meter Gait Speed maximum; (D) STS_5r: 5-repetitions Sit-To-Stand; (E) STS_30s: 30-seconds Sit-To-Stand; (F) STS_1min: 1-minute Sit-To-Stand; Rep: repetitions; (G) TUG_usual: Timed Up-and-Go usual; (H) TUG_max: Timed Up-and-Go maximum.

n=51 people analysed in STS_30s and STS_1min, and 52 people in the other tests.

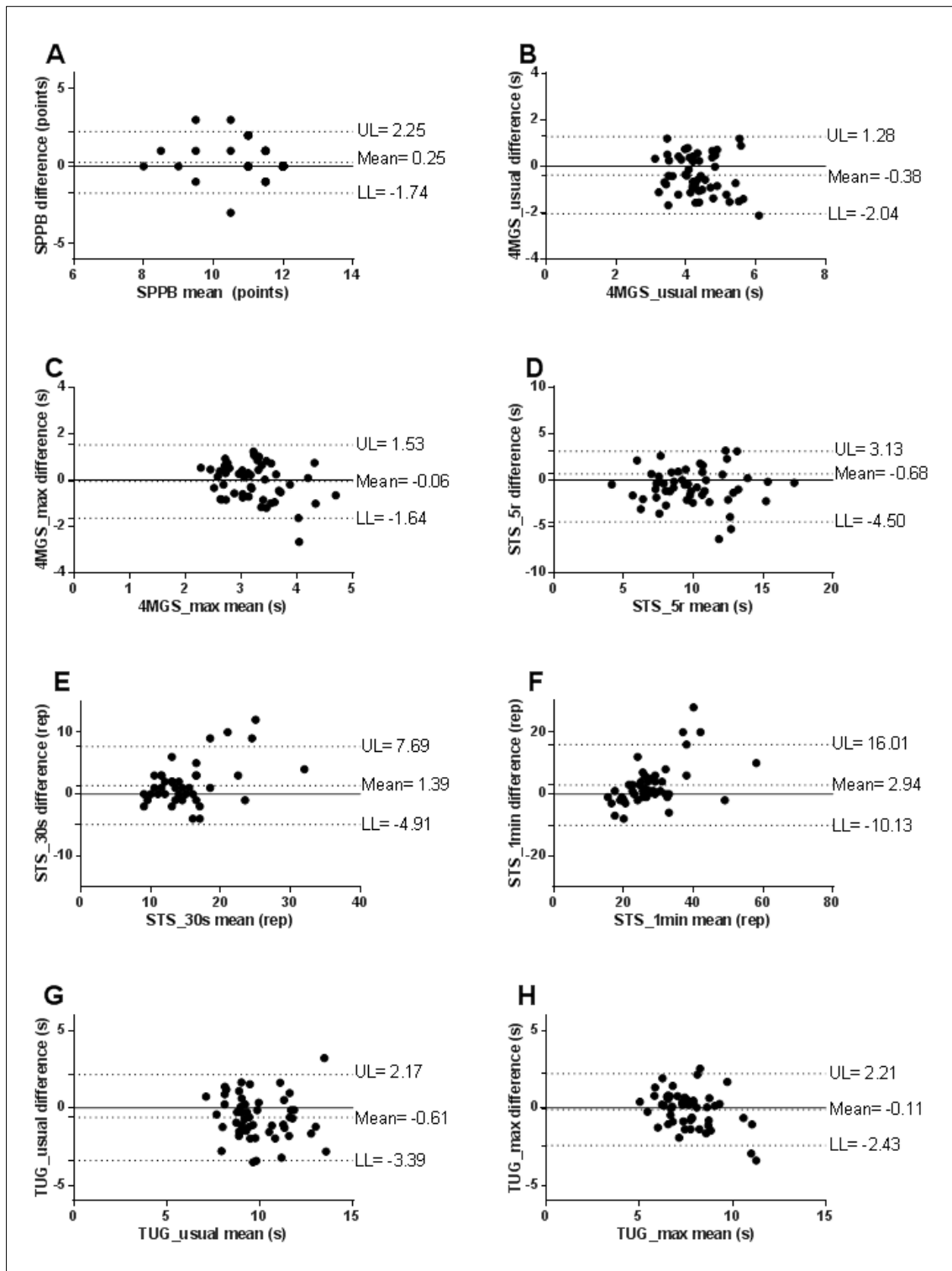


Figure S2. Bland and Altman plots of the difference against the mean of the first and third sets of functional tests (inter-rater). Mean: the average difference between the two tests; UL: Upper limit of agreement; LL: Lower limit of agreement. (A) SPPB: Short Physical Performance Battery; (B) 4MGS_usual: 4-Meter Gait Speed usual; (C)

4MGS_max: 4-Meter Gait Speed maximum; (D) STS_5r: 5-repetitions Sit-To-Stand; (E) STS_30s: 30-seconds Sit-To-Stand; (F) STS_1min: 1-minute Sit-To-Stand; Rep: repetitions; (G) TUG_usual: Timed Up-and-Go usual; (H) TUG_max: Timed Up-and-Go maximum.

n=51 people analysed in all the tests.