Functional Tests in Chronic Obstructive Pulmonary Disease, Part 2: Measurement Properties

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Abstract

Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality worldwide and an important cause of disability and handicap. For a thorough patient-centered outcome assessment and comprehensive management of the disease, measures of lung function, exercise capacity, and health-related quality of life, but also of functional capacity in activities of daily life, are necessary. In Part 2 of this seminar series, we discuss the main functional tests to assess upper and lower body functional capacity in patients with COPD to help clinicians substantiate their choice of functional outcome measures in COPD. In agreement with the International Classification of Functioning, Disability and Health to assess functional capacity representative of daily life activities, this review focuses on functional tests that include components such as changing and maintaining body positions, walking, moving, and climbing, as well as carrying, moving, and handling objects. We review the validity, reliability, and responsiveness of these tests. With 11 links to the International Classification of Functioning, Disability and Health framework addressing several upper and lower body components of functional activities, the Glittre Activities of Daily Life test seems to be the most promising and comprehensive test to evaluate functional capacity in activities of daily life. The links between functional capacity tests and real participation in daily life, as well as with important clinical outcomes such as morbidity and mortality, need further investigation. More studies are also recommended to document minimal detectable changes, minimal clinically important differences, and normative values for these functional tests.

Keywords: chronic obstructive pulmonary disease; patient outcome assessment; functional capacity; International Classification of Functioning, Disability, and Health

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In the first section of this two-part *Annals* seminar series, we delineated the background, rationale, and utility of functional tests to track limitations in daily life activities of patients with chronic obstructive pulmonary disease (COPD). This second part is devoted to reviewing, describing, and critiquing functional tests that have been developed to assess upper and lower body functional capacity. We focus on outcome measures that are relevant to physical functional activities, as referred to in the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) Chapter 4, "Mobility" (1), and the Brief and Comprehensive ICF Core Sets for COPD (2–4). These include maintaining a standing position, changing the basic body position, walking and moving, and carrying, moving, and handling objects (1).

Part 2 is intended to help health care professionals choose among functional outcome measures and tests to be used in the clinical evaluation of patients with COPD by providing detailed information on the methodological aspects of the various tests. The measurement properties of the tests are also discussed (*see* Table 1 for definitions of properties), and the most promising functional tests for practical application in COPD management are highlighted. Readers can also refer to Table 2 and Table 3, in which we link the different functional tests described in this article with the ICF's activity and participation categories.

Maintaining a Standing Position

Recent studies have shown that balance and postural control are impaired in patients with COPD, resulting in a fear of falling

Table 1. Measurement properties and definitions

Measurement Properties	Definition
Longitudinal change	Ability to detect clinically significant changes over time
Minimal clinically important difference (MCID)	The smallest change necessary to show a significant change for the patient
Minimal detectable change (MDC)	The smallest change that can be detectable statistically superior to the standard error of measurement
Reliability	Ability to give similar results in the same context, on various occasions and without random errors.
Internal consistency	Correlation between elements that should measure the same concept in the same test or questionnaire
Interrater/observer agreement (or reliability)	Ability of more than one evaluator to repeat the same measure with the same participants in the same context, on different occasions, and to obtain similar results
Intrarater/observer agreement (or reliability)	Ability of one evaluator to repeat the same measure with the same participants in the same context, and to obtain the same results
Test-retest reliability	Ability to give the same results with repeated assessments, in the same conditions, in different moments
Standard error of measurement (SEM)	Quantification of reliability in the same unit as the original measure; represents standard deviation of errors of measurements for a given test.
Validity	Ability of a test, instrument, or questionnaire to measure what it was designed to measure, without systematic errors.
Concurrent validity	Level of association of results obtained with test, instrument, or questionnaire and those obtained with the reference test, instrument, or questionnaire.
Construct validity	Level of association of results obtained with two tests that reflect the same phenomenon
Convergent validity	Ability to give highly correlated results with another test, instrument, or questionnaire that measures a similar construct
Criterion validity	How well-related a measure is to the reference measure (gold standard)
Discriminative validity	Ability to distinguish results that are obtained by two groups with different characteristics
Specificity	Ability of a test to accurately identify patients without the condition of interest
Sensitivity	Ability of a test to accurately identify patients with the condition of interest

(5, 6) and an increased risk for falls (7). One frequently used functional outcome measure for functional balance and postural control in COPD management is the Berg Balance Scale (BBS).

BBS

The BBS measures balance via 14 different functional tasks, including maintaining a body position (sitting or standing), transferring oneself, retrieving objects from the floor, and standing on one foot. With this test, the risk of falling can be quantified by evaluating the balance while completing several functional tasks. A score of 0–4 is used for each functional task. The total score is the sum of the scores for 14 tasks (*see* Appendix E1 and Appendix E2, panel A, in the online supplement). A score above 45/56 indicates a low probability of falling in daily life (8), whereas a score below 45/56 indicates the need for further investigation, in terms of requiring walking devices or assistance (9).

The BBS takes 15–20 minutes. For generally healthy elderly subjects, the BBS is highly specific (96%) for identifying individuals at risk of falling. The normative score ranges between 53 and 55 (10). Some validation studies on the BBS have shown high levels of interrater (8, 11) and intrarater agreement (intraclass coefficient correlation [ICC], 0.98 [11]), as well as concurrent validity with measures of postural sway (9).

Lower BBS scores in patients with moderate to severe COPD indicate an increased fall risk (12), with a significant correlation between the frequency of falls/stumbles and COPD (13). In patients with COPD, the BBS was found to be sensitive enough to indicate fall risk factors (12); however, more prospective studies are necessary to validate the cutoff values for predicting falls.

BBS scores are correlated significantly with the severity of airflow limitation (12), dyspnea, leg fatigue, hypoxemia, oxygen desaturation, and the distance walked during the 6-minute walk test (6MWT) (13). Although a minimal detectable change (MDC) has yet to be established for patients with COPD in the same way that it has been among healthy elderly people (14), a difference of between 3.5 and 6.2 points in the BBS score may discriminate accurately between COPD fallers (⩾1 fall per year) and nonfallers (no self-reported fall in the preceding 12 mo) (5, 15).

A small but significant improvement in BBS score was recorded after 6 weeks of pulmonary rehabilitation in a small study involving 29 patients with COPD (mean change, 2.8 ± 2.8; $P = 0.001$) (16). However, a significant mean increase of 5.4 points (95% confidence interval [CI], 2.1–8.6 points; $P < 0.01$) from a baseline score of 45.6 ± 5.8 has been reported via the BBS in patients with COPD after 6 weeks of pulmonary rehabilitation, when paired with specific balance training consisting of various modalities such as stance, transition and gait exercises, and functional strengthening (17). The BBS may thus be considered responsive to specific balance training in COPD, showing changes that are above the proposed MDC for this parameter. In healthy elderly people, various balance training parameters, such as training frequency, period, and volume can affect the posttraining improvement seen in balance tests such as the BBS, as well as on the magnitude of the reduction of the fall risk (18).

Readers can refer to a randomized controlled trial (17) for more details on

Table 2. Functional tests links to ICF A&P categories (d410-d429 changing and maintaining body positions)

Tests	D410 Changing Basic Position				D415 Maintaining a Body Position		D420 Transferring Oneself
	d4103 Sitting	d4104 Standing	d4105 Bending	d4106 Shifting the Body's Center of Gravity	d4153 Maintaining a Sitting Position	d4154 Maintaining a Standing Position	d4200 Transferring Oneself while Sitting
BBS	X	X	X	X	X	X	X
TUG	X	X					
5STS	X	X					
6MWT							
ESWT							
4MGS							
3MST							
6MST							
SCPT							
6PBRT					X		
UULEX					X		
GST	X	X	X			X	
Glittre	X	X	X				
SPPB	X	X				X	

Definition of abbreviations: 3MST = 3-minute constant rate step test; 4MGS = 4-m gait speed; 5STS = five-repetition sit-to-stand; 6MST = 6-minute step test of free cadence; 6MWT = 6-minute-walk test; 6PBRT = 6-minute pegboard and ring test; A&P = activities and participation; BBS = Berg Balance Scale; ESWT = endurance shuttle walk test; GST = grocery shelving task; ICF = International Classification of Functioning, Disability and Health; SCPT = Stair Climb Power Test; SPPB = short physical performance battery; TUG = timed up and go; UULEX = unsupported upper limb exercise test.

balance training in COPD and to a systematic review and meta-analysis for further reading on the effects of balance training on balance performance in healthy elderly people (18).

Changing Body Position

Changing body position from a sitting to a standing position is a common functional daily activity (19) that is necessary for autonomy. The most frequently used and investigated tests in patients with COPD are the timed up and go (TUG) test and the five-repetition sit-to-stand test (5STS).

Timed Up and Go Test

The TUG test measures a person's mobility, including both static and dynamic balance, by assessing the time it takes to rise from a chair, walk 3 m, turn around, walk back to the chair, and sit down (Appendix E1 and Appendix E2, panel B).The TUG test is widely used in clinical and research settings because of its moderate to excellent reliability in various conditions (20–25), the minimal use of equipment, and its easy administration (26), and because it incorporates various functional components essential for independent living (27). It correlates with mobility and strength) (28–30) and can differentiate fallers (⩾1 self-reported fall in the preceding year) from nonfallers (no self-reported fall in the last 12 mo) (28). Normative data stratified by decade and sex for people older than 60 years has been established in a small study by Steffen and colleagues (10).

In patients with COPD, fallers took 3.1 seconds longer to complete the test than nonfallers (15). In a study that pooled patients with severe and very severe COPD, chronic heart failure, or chronic renal failure (20), the within-day test-retest reliability was excellent (ICC among three trials, 0.94; 95% CI, 0.92–0.96; $P < 0.0001$), with a possible learning effect between the first and second trial (20). One study involving 60 patients with COPD (mean forced expiratory volume in 1 second [FEV_1], 65 ± 22% of predicted value) reported a MDC of 1.84 seconds and excellent inter- and intrarater reliability, with an ICC of 0.99 and 0.92, respectively (31). A significant reduction of 1.5 seconds ($P = 0.003$) in TUG performance was found after 6 weeks of pulmonary rehabilitation in patients with COPD, suggesting the TUG is a responsive evaluation tool (16). However, to our knowledge, there are no existing studies that have determined longitudinal change of the TUG test in patients with COPD.

5STS

The 5STS is the most recently documented alternative for assessing the ability to change from a sitting to a standing position repeatedly. This test provides an overall assessment of lower limb muscle function, with a focus on the quadriceps, by measuring the fastest time taken to stand five times from a chair with arms folded across the chest (*see* Appendix E1 and Appendix E2, panel C).

The 5STS has good test-retest reliability (32, 33) and validity, as well as a significant correlation with TUG tests results and gait speed in healthy community-dwelling populations (34). Reference values are available (35); however, the studies examined for this article contained many methodological differences (the chair height varied between 43 and 48 cm, for example, and the start/end points for time completion varied).

The 5STS demonstrates excellent test-retest and interobserver reliability, with ICCs of 0.97 (95% CI, 0.95–0.99) and 0.99 (95% CI, 0.99–1.00), respectively, without any significant difference in 5STS time being noted in the test-retest (36). Patients with COPD took 21% longer than healthy subjects to complete the 5STS test (37). A cross-sectional study involving 475 patients with COPD reported a positive association between a slower 5STS time, the health-related quality of life, and the Medical Research Council's dyspnea scores, as well as a negative correlation between 5STS time and exercise capacity (as measured

Table 3. Functional tests links to ICF A&P categories (d430-d449 carrying, moving and handling objects; d450-d469 walking and moving)

Tests	D430 Lifting and Carrying Objects			D440 Fine Hand Use			D445 Hand and Arm Use			D450-d469 Walking and Moving			D455 Moving around
	d4300 Lifting	d4301 Carrying in the hands	d4303 Carrying on shoulders, hip and back	d4305 Putting down objects	d4400 Picking up	d4401 Grasping	d4403 Releasing	d4452 Reaching	d4458 Hand and arm use, other specified*	d4500 Walking short distances	d4501 Walking long distances	d4503 Walking around obstacles	d4551 Climbing
BBS					X				X				X
TUG										X		X	
5STS													
6MWT											X	X	
ESWT											X	X	
4MGS										X			
3MST													X
6MST													X
SCPT													X
6PBRT					X		X	X					
UULEX	X			X		X							
GST	X					X	X						
Glittre ADL-test	X		X	X		X	X	X		X			X
SPPB									X	X			

Definition of abbreviations: 3MST = 3-minute constant rate step test; 4MGS = 4-m gait speed; 5STS = five-repetition sit-to-stand; 6MST = 6-minute step test of free cadence; 6MWT = 6-minute-walk test; 6PBRT = 6-minute pegboard and ring test; A&P = activities and participation; BBS = Berg Balance Scale; ESWT = endurance shuttle walk test; GST = grocery shelving task; ICF = International Classification of Functioning, Disability and Health; SCPT = Stair Climb Power Test; SPPB = short physical performance battery; TUG = timed up and go; UULEX = unsupported upper limb exercise test.

by the Incremental Shuttle Walk Test [ISWT]), and a negative relationship between 5STS time and lower limb muscle strength, suggesting excellent convergent validity (36).

The 5STS time was reduced significantly (−1.4 s) in 239 patients with COPD after outpatient pulmonary rehabilitation (36). This was correlated with changes in ISWT distance (36) (r = 0.13; $P < 0.05$). On the basis of the results of the study, the authors suggest there is a minimal clinically important difference, ranging from 1.3 to 1.7 seconds. The 5STS therefore seems to be reliable and responsive to pulmonary rehabilitation, in addition to being a time-efficient, low-cost, and simple test, with no apparent learning effect (36). Patients who were unable to attempt or complete the test had significantly reduced exercise capacity and quadriceps strength, thus indicating good discriminative validity for the 5STS for patients with COPD (36).

Variations of the 5STS are sometimes used. For example, some studies have assessed the time to perform 10 full stands from a sitting position (38), or the maximal number of full stands performed in 1 minute (39–41) or in 30 seconds (17, 42). Such variations have not been investigated as thoroughly, however, among patients with COPD.

The 1-minute sit-to-stand test shows promising results in this population, generates higher hemodynamic demand than the 5STS or its 30-second variation, and presents significant correlations with the 6MWT, the 4-m gait speed (4MGS), quadriceps muscle strength, and fat-free muscle mass (41, 43). The 1-minute sit-to-stand test is also responsive to pulmonary rehabilitation; an improvement of at least three repetitions is consistent with physical benefits after this intervention (anchor-based MDC of 2.5 repetitions) (41).

Walking and Moving

Field Walking Tests

The European Respiratory Society and American Thoracic Society recently published an official systematic review (44) of, and standard operating procedures (45) for, the measurement properties of the

6-minute walk distance test (6MWT), the ISWT, and the Endurance Shuttle Walk Test (ESWT). The methodological properties of these tests (Appendix E2) and the standard operating procedure (Appendix E1) are summarized here.

The 6MWT is a self-paced walking test, which measures the distance covered by an individual over the course of 6 minutes while walking back and forth on a 30-m flat course (*see* Appendix E2, panel D). The 6MWT has strong validity and reliability, with a large body of evidence to support its clinical and research use for a COPD population (46). Responsiveness to intervention has been confirmed after pulmonary rehabilitation (mean effect of 44 m [47]), but not after bronchodilation (48). Construct validity is supported by a large body of data (correlation coefficients 0.6–0.9 with measurements for maximal exercise capacity [$\dot{V}O_2$ peak and peak work capacity] and 0.4–0.9 with physical activity) (44). The relationships with respiratory function and health-related quality of life are of weak to moderate strength, with correlation coefficients of 0.10–0.59 and 0.03–0.65, respectively (44). The 6MWT has good reliability (ICC, 0.82–0.99), despite a clear learning effect when two or more tests are conducted (44). Reference values based on age and sex for healthy adults are available for the test (49). The median estimate for the MDC is 30 m in most recent studies of patients with COPD (45).

The ISWT differs from the reality of daily life because standardized and incremental speed increases are imposed during the test (45). The ISWT is often used to assess cardiopulmonary maximal exercise capacity and has been shown to elicit physiological responses in ways that are similar to results for incremental tests on stationary bicycles and treadmills (45).

The ESWT requires patients to maintain a predetermined walking pace (based on their maximal performance during a previous ISWT) while walking back and forth between two cones set on a flat 10-m course (45, 50). This walking pace should be maintained until exhaustion, to a maximum of 20 minutes (*see* Appendix E1 and Appendix E2, panel E). The ESWT also provides reliable measurements for dyspnea, with good repeatability in the modified Borg dyspnea score when the test is repeated (45) and no significant learning effect among patients with COPD.

The main outcome is most frequently reported as time in minutes and seconds, but can also be expressed as distance completed in meters (45). There is a lack of research on the relationship between the ESWT and clinical outcomes such as survival and readmission (45). The MDC may be specific to the context or intervention, and a change after bronchodilation of 65 seconds (95% CI, 45–85 s) or 85 m (95% CI, 60–115 m), representing 13–15% of the baseline, is likely to be detected by patients (45). The ESWT has a good responsiveness to treatment, with a standard error of measurement of between 0.52 and 1.27 (44). However, because the ESWT requires the execution of an ISWT beforehand to set the speed, it is a rather time-consuming functional capacity test (50).

Gait Speed Tests

The 4MGS test measures the walking speed by recording the fastest time of either of two recorded trials for walking 4 m at one's usual speed (Appendix E1 and Appendix E2, panel F). In patients with COPD, the 4MGS has been validated (51), with the results showing good test-retest and interobserver reliability (ICC, 0.97 [95% CI, 0.95–0.98] and 0.99 [95% CI, 0.98–0.99], respectively) (52), low measurement variability without systematic variability (standard error of measurement: interobserver, 1.4%; test-retest, 1.5%) (52), a strong positive correlation with the ISWT (51, 52) and 6MWT (53), and responsiveness to pulmonary rehabilitation (a significant increase of 0.08 m/s; effect size, 0.4) (51). The MCID varies between 0.08 meters per second (95% CI, 0.05–0.10 m/s) in patients who reported "feeling better" after pulmonary rehabilitation and 0.11 meters per second (95% CI, 0.09–0.13 m/s) in patients who achieved the MCID in the ISWT (51).

The 4MGS test, the maximal 4MGS, and the related 10-m gait speed and maximal 10-m gait speed tests have proven useful for stable patients with COPD (54). A considerable difference (0.1 m/s) between gait speeds measured with longer (10-m) and shorter (4-m) courses suggests, however, that adherence to only one protocol of gait speed measurement is preferable in longitudinal studies, in which the test is to be performed on several occasions (55).

Stair Climbing Tests

Among various available stair-step tests (56–60), the 3-minute constant rate step test, the 6-minute step test, and the stair climb power test have been validated for patients with COPD (Appendix E1). In the 3-minute test, patients are asked to step up with one foot after the other on to the first stair of the step, and then to step down to the floor again, one foot after the other. The rate of the movement is imposed by an audio signal, and it should be maintained for the 3-minute duration of the test (Appendix E2, panel G). The primary outcome is dyspnea. The test shows excellent reproducibility for monitoring dyspnea (ICC, 0.91) (60), as well as detecting improvements in activity-related dyspnea after bronchodilation (61) and enabling the presence and severity of breathlessness/ventilatory limitations when patients are faced with climbing or descending stairs to be assessed (60).

The 6-minute step test of free cadence (Appendix E2, panel H) was built using the 6MWT canvas and the same standardized instructions. In this test, patients are instructed to step on and off a 20-cm-tall step as many times as possible in 6 minutes, using a free-step cadence. The results are correlated strongly with exercise capacity ($r = 0.734$ [59]), and the test has an excellent intrarater reproducibility (ICC $>$ 0.8 [58]). There is a cutoff value of 78 steps for determining which patients have low physical capacity (59), and a standard error and MDC of 4.8 and 11.1 steps, respectively (58). One advantage of this test over the 6MWT is that it may be used to assess functional capacity when long hallways are unavailable.

The stair climb power test, in which patients are instructed to ascend a 10-step flight of stairs as fast (and as safely) as they can (29, 62–64) (Appendix E2, panel I), is the most recent test used to assess leg muscle power (62). The scores for velocity, force, and power that are recorded via this test are associated more closely with mobility limitations than with muscle strength (65) The stair climb power test is strongly associated with eccentric quadriceps strength (29, 63) and has a high test-retest reliability (ICC, 0.90) in patients with COPD (63).

Carrying, Moving, and Handling Objects

For individuals with COPD, simple domestic activities of daily life that involve the arms can be impaired and induce symptoms, which may limit their independence in everyday life (66–69). In comparison with healthy control patients, patients with COPD experience worse dyspnea and hyperinflation during peak arm exercises, highlighting the importance of measuring upper extremity function in these individuals (70).The most frequently used and well-researched tests to assess the carrying, moving, and handling of objects in patients with COPD are the 6-minute pegboard and ring test (6PBRT), the unsupported upper-limb exercise test (UULEX), and the grocery shelving test (GST).

6PBRT

One functional upper extremity test that has received increased attention lately is the 6PBRT (71). The test measures isometric shoulder function by assessing the total number of rings moved back and forth between two sets of two pegs (one placed at shoulder level and another placed 20 cm above) in 6 minutes (Appendix E1 and Appendix E2, panel J).

The 6PBRT involves moving and handling objects and is performed with arms held, unsupported, at shoulder height. The test, which requires good finger dexterity, focuses on isometric shoulder flexion, even though a small dynamic movement is performed (72). The 6PBRT has excellent test-retest reliability ($r = 0.91$) (71) and convergent and discriminant validity; it is moderately correlated with different aspects of lung function ($r = 0.52$–0.71) (73). Furthermore, it appears to be responsive to change after limb muscle strength (standardized response mean, 1.8) (73) and limb muscle endurance training (mean group difference, 20 rings [95% CI, 3–37 rings]; effect size, 0.73 [74]).

Janaudis-Ferreira and colleagues (73) reported that the 6PBRT is moderately ($r = 0.41$) related to isometric shoulder muscle strength when measured at 90° of shoulder flexion in patients with COPD. Nyberg and associates (74) found, however, that although the 6PBRT is positively correlated with isokinetic shoulder flexion endurance ($r = 0.40$), it is negatively correlated with isokinetic shoulder muscle strength (results at approximately 30°–40°of shoulder flexion; $r = -0.45$). These apparently conflicting results could, to some extent, be explained by the different angles used to measure strength. Furthermore, the 6PBRT seems to be moderately related to activities of daily living, as measured subjectively via the Pulmonary Functional Status and Dyspnea Questionnaire (a questionnaire on upper extremity activity subdomains; $P = -0.49$) and objectively, using a wrist accelerometer ($r = 0.54$) (75).

UULEX

In contrast to the 6PBRT, the UULEX involves more dynamic movement and a larger upper extremity range of motion (76), mimicking frequently performed activities of daily living that require arm movements below and above shoulder height (Appendix E1 and Appendix E2, panel K).

The UULEX measures dynamic upper limb shoulder flexion endurance above and below shoulder height. In cases of COPD, the UULEX has an excellent test-retest reliability (ICC, 0.98) and is considered valid (76). It is correlated with oxygen consumption, pulmonary ventilation during exercise, tidal volume, muscle fatigue, and dyspnea ratings ($r = 0.58$–0.86) and is responsive to change after upper limb muscle strength training (standardized response mean, 1.8) (73) and endurance training (mean group difference, 127 s [95% CI, 78–176 s]; effect size, 1.46). The UULEX is related to isometric shoulder muscle strength ($r = 0.56$) (73) and isokinetic shoulder muscle endurance ($r = 0.50$), but not to isokinetic shoulder muscle strength (74).

GST

The GST replicates an everyday activity and includes unsupported arm activity (Appendix E1 and Appendix E2, panel L) (77). The purpose of the GST is to determine the extent to which the ability to use the arms is impaired when performing everyday activities is impaired. In the GST, patients are instructed to move 20 items from two shopping bags on the floor up to a 90-cm-high cart (placed 30 cm in front of the patient), and then up to a shelf (placed 15 cm above shoulder level).

The GST has been shown to have excellent test-retest reliability during a 6-week period (ICC, 0.97), with an absolute change between test-retest of −0.7 seconds (95% limits of agreement, −3.9 and 2.5 s; effect size, 0.5) (77). The GST is responsive to change after pulmonary rehabilitation (mean difference, 3.3 s [77]) and has demonstrated construct validity (72, 77). It is also moderately to strongly correlated ($r = 0.69$–0.85) with the UULEX, in terms of cardiorespiratory responses (77).

An advantage of the GST over the 6PBRT and the UULEX is that it involves not only shoulder flexion but also bending over, reaching overhead, and lifting and placing objects. It has been argued that the relatively high noise-to-signal ratio (mean change of 3.3 s during a 30–40-s duration) may compromise the responsiveness of the test (72). Further reliability and validation studies are warranted to ensure the reproducibility of intra- and interrater timing here.

Tests with Subcomponents

The Glittre Activities of Daily Living Test

Global tests that reproduce daily activities are preferred in the assessment of functional capacity and limitations over tests focused on isolated components of functional activity (78). In this regard, the Glittre Activity of Daily Living test (Glitter ADL; Appendix E1 and Appendix E2, panel M) is appealing because it incorporates 11 functional activities included in the ICF framework (Table 2 and Table 3) (79), such as standing up from a chair, walking 10 m, climbing a 3-stair staircase, and lifting the arms without support while moving 1-kg cartons one at a time from one shelf at shoulder level to another at waist level, and to the floor (and back up again, in reverse order). The whole circuit is completed five times, as fast as possible.

In COPD, the Glittre ADL test has excellent test-retest reliability ($r = 0.93$). The mean difference between tests ranges from 17 (80) to 22 seconds (95% CI, 12–32 s) (79), and is considered valid, as it is related moderately to FEV_1, St. George's

Respiratory Questionnaire activity subscore ($r = 0.43$), dyspnea during activities of daily living ($r = 0.35$), and hospitalization rate ($r = 0.35$) (79, 81).

The Glittre ADL test is responsive to change after pulmonary rehabilitation, with a mean difference of −53 seconds after 4 weeks of rehabilitation (95% CI, −29 to −78 s) (79). No MDC has been determined, but a decrease of approximately 1 minute in Glittre ADL test time has been suggested to be clinically meaningful (81).

The Glittre ADL test is able to discriminate between patients with COPD and healthy subjects, in terms of their functional capacity (82). It induces slightly higher oxygen uptake than the 6MWT, with similar cardiovascular and ventilatory demand in patients with moderate to very severe COPD (83). The Glittre ADL test is also correlated with functional activities such as time sitting ($r = 0.50$) and walking ($r = -0.46$), the number of steps climbed ($r = -0.53$), and walking energy expenditure ($r = -0.50$) (2), as well as average daily energy expenditure ($r = 0.91$) (3). Notably, the Global Initiative for COPD (GOLD) spirometric stage does not seem to influence Glittre ADL-test performance (84).

Cardiovascular, ventilatory, and metabolic variables are highly reproducible in Glittre ADL tests (80, 83), with the $\dot{V}O_2$, heart rate and pulmonary ventilation during exercise reaching 79–89% of the peak values obtained from a maximal incremental test on a treadmill (85). The feasibility of the Glittre ADL test in patients with multiple comorbidities or who are oxygen dependent remains to be confirmed. However, the requirement of wearing a weighted backpack throughout the test was implemented to imitate the use of oxygen breathing apparatus.

The Short Physical Performance Battery Test

The short physical performance battery test (SPPB) was developed from three performance measures already in use (86): standing balance test in three positions, usual gait speed for a 4-m course (87), and the 5STS (Appendix E1 and Appendix E2, Panel N). Each of these subtests is scored from 0 (unable/ unsafe) to 4 (best performance) points, and a summative score (on a scale ranging from 0 to 12) is established at the very end of the test. The internal consistency of these three subtests' grouped scores is acceptable (Cronbach's alpha = 0.76 [86]).

Poor lower extremity function as measured with the SPPB test predicts an increased risk for COPD-related disability (odds ratio, 2.57; 95% CI, 1.65–4.01) (88, 89). The SPPB predicted disability with good accuracy in a 2-year follow-up study (odds ratio, 2.57; 95% CI, 1.65–4.01). A significant difference in SPPB scoring was also found between control subjects and patients with COPD (mean change, −1.0 [95% CI, −1.25 to −0.73; $P < 0.0001$) (90). In the absence of validation of the SPPB test for the COPD population, it is too early to recommend its widespread use to assess functional capacity in this population.

Clinical Perspective

Although several studies have focused on lower extremity function in patients with COPD, there is more to daily participation than changes in position and movement activities. As shown in this seminar, studies on upper limb functional tests are promising and highlight reduced arm exercise capacity in patients with COPD (90). From a clinical functional perspective, the most promising and comprehensive test presented is the Glittre ADL test, with 11 links to ICF categories that address upper and lower body capacity through various activities, all of which are important for mobility and daily participation.

By highlighting measurement properties and linking common functional tests to the ICF for patients with COPD, this review should assist health care professionals in substantiating their decisions regarding the use of specific functional tests for COPD assessment and management where functional capacities and participation in physical activities of daily life are concerned. Improving patient-centered outcomes that echo the requirements for daily participation is essential in promoting patient autonomy, as well as maximizing patient's exercise capacity and functional status. In this way, the quality of life and participation in activities of daily living can be increased (91).

The choice regarding the most appropriate functional test to use in a given situation should take into consideration the ease of administration, the measurement properties, and whether or not the test addresses activities relevant and limited for the patient (*see* part 1 of the seminar series). Apart from the field walking tests (6MWT, ESWT), for which the absolute and relative contraindications are consistent with those in maximal exercise testing (45, 92), there are no specific contraindications for the other functional tests addressed in this review. In the interim, it would seem prudent to apply the relative and absolute contraindications that are recommended for the field walking tests, considering that the functional tests often produce ventilatory and heart rate requirements that are similar to those for the field walking tests.

Adequate functional capacity assessment will give clinicians a proper insight into the implications of COPD for patients, in terms of their usual activities, as well as enabling clear rehabilitation objectives to be established. Such information is required to prescribe adequate individualized exercises or interventions that can maximize patients' daily participation and autonomy, as well as help reaching their significant goal of staying longer in their own homes.

Conclusions

This 2-part seminar emphasizes the growing interest in and importance of assessing functional capacity using patient-centered outcome measures that reflect the functional performance of patients with COPD, not only in a pulmonary rehabilitation context but also in disease management.

Further studies addressing the methodological aspects and measurement properties of these functional tests in patients with COPD are recommended. Furthermore, the effect of pharmacotherapies on the performance of the tests must also be examined, especially for the Glittre ADL test, which has been found to be the most comprehensive measure examined here because of the high number of ICF functional activities included in the assessment. ■

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References

1 World Health Organization. Towards a common language for functioning, disability and health ICF. *International Classification.* 2002;1149:1–22.
2 Marques A, Jácome C, Gabriel R, Figueiredo D. Comprehensive ICF core set for obstructive pulmonary diseases: validation of the activities and participation component through the patient's perspective. *Disabil Rehabil* 2013;35:1686–1691.
3 Stucki A, Stoll T, Cieza A, Weigl M, Giardini A, Wever D, Kostanjsek N, Stucki G. ICF Core Sets for obstructive pulmonary diseases. *J Rehabil Med* 2004;36(44, Suppl):114–120.
4 Jácome C, Marques A, Gabriel R, Figueiredo D. Chronic obstructive pulmonary disease and functioning: implications for rehabilitation based on the ICF framework. *Disabil Rehabil* 2013; 35:1534–1545.
5 Beauchamp MK, Sibley KM, Lakhani B, Romano J, Mathur S, Goldstein RS, Brooks D. Impairments in systems underlying control of balance in COPD. *Chest* 2012;141:1496–1503.
6 Smith MD, Chang AT, Seale HE, Walsh JR, Hodges PW. Balance is impaired in people with chronic obstructive pulmonary disease. *Gait Posture* 2010;31:456–460.
7 Lajoie Y, Gallagher SP. Predicting falls within the elderly community: comparison of postural sway, reaction time, the Berg balance scale and the Activities-specific Balance Confidence (ABC) scale for comparing fallers and non-fallers. *Arch Gerontol Geriatr* 2004;38:11–26.
8 Bogle Thorbahn LD, Newton RA. Use of the Berg Balance Test to predict falls in elderly persons. *Phys Ther* 1996;76:576–583.
9 Berg K, Wood-Dauphnée S, Williams JI, Gayton D. Measuring balance in the elderly: preliminary development of an instrument. *Physiother Can* 1999;41:304–311.
10 Steffen TM, Hacker TA, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: six-minute walk test, Berg Balance Scale, timed up & go test, and gait speeds. *Phys Ther* 2002;82:128–137.
11 Berg K, Wood-Dauphnée S, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. *Can J Public Health* 1992;83 (Suppl 2):S7–S11.
12 Crișan AF, Oancea C, Timar B, Fira-Mladinescu O, Tudorache V. Balance impairment in patients with COPD. *PLoS One* 2015;10:e0120573.
13 Ozalevli S, Ilgin D, Narin S, Akkoclu A. Association between disease-related factors and balance and falls among the elderly with COPD: a cross-sectional study. *Aging Clin Exp Res* 2011;23:372–377.
14 Donoghue D, Physiotherapy Research and Older People (PROP) group; Stokes EK. How much change is true change? The minimum detectable change of the Berg Balance Scale in elderly people. *J Rehabil Med* 2009;41:343–346.
15 Beauchamp MK, Hill K, Goldstein RS, Janaudis-Ferreira T, Brooks D. Impairments in balance discriminate fallers from non-fallers in COPD. *Respir Med* 2009;103:1885–1891.
16 Beauchamp MK, O'Hoski S, Goldstein RS, Brooks D. Effect of pulmonary rehabilitation on balance in persons with chronic obstructive pulmonary disease. *Arch Phys Med Rehabil* 2010;91:1460–1465.
17 Beauchamp MK, Janaudis-Ferreira T, Parreira V, Romano JM, Woon L, Goldstein RS, Brooks D. A randomized controlled trial of balance training during pulmonary rehabilitation for individuals with COPD. *Chest* 2013;144:1803–1810.
18 Lesinski M, Hortobágyi T, Muehlbauer T, Gollhofer A, Granacher U. Effects of balance training on balance performance in healthy older adults: a systematic review and meta-analysis. *Sports Med* 2015;45: 1721–1738.
19 Dall PM, Kerr A. Frequency of the sit to stand task: an observational study of free-living adults. *Appl Ergon* 2010;41:58–61.
20 Mesquita R, Janssen DJ, Wouters EF, Schols JM, Pitta F, Spruit MA. Within-day test-retest reliability of the Timed Up & Go test in patients with advanced chronic organ failure. *Arch Phys Med Rehabil* 2013; 94:2131–2138.
21 Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991;39:142–148.
22 Flansbjer UB, Holmbäck AM, Downham D, Patten C, Lexell J. Reliability of gait performance tests in men and women with hemiparesis after stroke. *J Rehabil Med* 2005;37:75–82.
23 Resnik L, Borgia M. Reliability of outcome measures for people with lower-limb amputations: distinguishing true change from statistical error. *Phys Ther* 2011;91:555–565.
24 Brusse KJ, Zimdars S, Zalewski KR, Steffen TM. Testing functional performance in people with Parkinson disease. *Phys Ther* 2005;85: 134–141.
25 Dal Bello-Haas V, Klassen L, Sheppard MS, Metcalfe A. Psychometric properties of activity, self-efficacy, and quality-of-life measures in individuals with Parkinson disease. *Physiother Can* 2011;63:47–57.
26 Mathias S, Nayak USL, Isaacs B. Balance in elderly patients: the "get-up and go" test. *Arch Phys Med Rehabil* 1986;67:387–389.
27 Huxham FE, Goldie PA, Patla AE. Theoretical considerations in balance assessment. *Aust J Physiother* 2001;47:89–100.
28 Gunter KB, White KN, Hayes WC, Snow CM. Functional mobility discriminates nonfallers from one-time and frequent fallers. *J Gerontol A Biol Sci Med Sci* 2000;55:M672–M676.
29 Butcher SJ, Pikaluk BJ, Chura RL, Walkner MJ, Farthing JP, Marciniuk DD. Associations between isokinetic muscle strength, high-level functional performance, and physiological parameters in patients with chronic obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis* 2012;7:537–542.
30 Shumway-Cook A, Baldwin M, Polissar NL, Gruber W. Predicting the probability for falls in community-dwelling older adults. *Phys Ther* 1997;77:812–819.
31 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: 279–287.
32 Bohannon RW. Test-retest reliability of the five-repetition sit-to-stand test: a systematic review of the literature involving adults. *J Strength Cond Res* 2011;25:3205–3207.
33 Seeman TE, Charpentier PA, Berkman LF, Tinetti ME, Guralnik JM, Albert M, Blazer D, Rowe JW. Predicting changes in physical performance in a high-functioning elderly cohort: MacArthur studies of successful aging. *J Gerontol* 1994;49:M97–M108.
34 Schaubert KL, Bohannon RW. Measures obtained from community-dwelling. *J Strength Cond Res* 2005;19:717–720.
35 Bohannon RW. Reference values for the five-repetition sit-to-stand test: a descriptive meta-analysis of data from elders. *Percept Mot Skills* 2006;103:215–222.
36 Jones SE, Kon SSC, Canavan JL, Patel MS, Clark AL, Nolan CM, Polkey MI, Man WD. The five-repetition sit-to-stand test as a functional outcome measure in COPD. *Thorax* 2013;68: 1015–1020.
37 Roig M, Eng JJ, MacIntyre DL, Road JD, Reid WD. Deficits in muscle strength, mass, quality, and mobility in people with chronic obstructive pulmonary disease. *J Cardiopulm Rehabil Prev* 2011;31: 120–124.
38 Csuka M, McCarty DJ. Simple method for measurement of lower extremity muscle strength. *Am J Med* 1985;78:77–81.
39 Puhan MA, Siebeling L, Zoller M, Muggensturm P, ter Riet G. Simple functional performance tests and mortality in COPD. *Eur Respir J* 2013;42:956–963.
40 Ozalevli S, Ozden A, Itil O, Akkoclu A. Comparison of the sit-to-stand test with 6 min walk test in patients with chronic obstructive pulmonary disease. *Respir Med* 2007;101:286–293.
41 Vaidya T, de Bisschop C, Beaumont M, Ouksel H, Jean V, Dessables F, Chambellan A. Is the 1-minute sit-to-stand test a good tool for the evaluation of the impact of pulmonary rehabilitation? Determination of the minimal important difference in COPD. *Int J Chron Obstruct Pulmon Dis* 2016;11:2609–2616.
42 Jones CJ, Rikli RE, Beam WCA. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Res Q Exerc Sport* 1999;70:113–119.
43 Morita AA, Biasca GW, Paes T, Furlanetto K, Sant'Anna T, Schneider L, Donária L, Nellessen A, Travassos A, Hernandes NA, *et al*. Which is the best protocol of the sit-to-stand test in patients with COPD? *Eur Respir J* 2016;46:PA2078.
44 Singh SJ, Puhan MA, Andrianopoulos V, Hernandes NA, Mitchell KE, Hill CJ, Lee AL, Camillo CA, Troosters T, Spruit MA, *et al*. An official

systematic review of the European Respiratory Society/American Thoracic Society: measurement properties of field walking tests in chronic respiratory disease. *Eur Respir J* 2014;44:1447–1478.

45 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;44:1428–1446.

46 Pepin V, Brodeur J, Lacasse Y, Milot J, Leblanc P, Whittom F, Maltais F. Six-minute walking versus shuttle walking: responsiveness to bronchodilation in chronic obstructive pulmonary disease. *Thorax* 2007;62:291–298.

47 McCarthy B, Casey D, Devane D, Murphy K, Murphy E, Lacasse Y. Pulmonary rehabilitation for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2015;(2):CD003793.

48 Puente-Maestu L, Palange P, Casaburi R, Laveneziana P, Maltais F, Neder JA, O'Donnell DE, Onorati P, Porszasz J, Rabinovich R, *et al*. Use of exercise testing in the evaluation of interventional efficacy: an official ERS statement. *Eur Respir J* 2016;47:429–460.

49 Casanova C, Celli BR, Barria P, Casas A, Cote C, de Torres JP, Jardim J, Lopez MV, Marin JM, Montes de Oca M, *et al*.; Six Minute Walk Distance Project (ALAT). The 6-min walk distance in healthy subjects: reference standards from seven countries. *Eur Respir J* 2011;37: 150–156.

50 Revill SM, Morgan MD, Singh SJ, Williams J, Hardman AE. The endurance shuttle walk: a new field test for the assessment of endurance capacity in chronic obstructive pulmonary disease. *Thorax* 1999;54:213–222.

51 Kon SSC, Canavan JL, Nolan CM, Clark AL, Jones SE, Cullinan P, Polkey MI, Man WD. The 4-metre gait speed in COPD: responsiveness and minimal clinically important difference. *Eur Respir J* 2014;43:1298–1305.

52 Kon SSC, Patel MS, Canavan JL, Clark AL, Jones SE, Nolan CM, Cullinan P, Polkey MI, Man WD. Reliability and validity of 4-metre gait speed in COPD. *Eur Respir J* 2013;42:333–340.

53 DePew ZS, Karpman C, Novotny PJ, Benzo RP. Correlations between gait speed, 6-minute walk distance, physical activity, and self-efficacy in patients with severe chronic lung disease. *Respir Care* 2013;58:2113–2119.

54 Karpman C, Benzo R. Gait speed as a measure of functional status in COPD patients. *Int J Chron Obstruct Pulmon Dis* 2014;9:1315–1320.

55 Karpman C, Lebrasseur NK, Depew ZS, Novotny PJ, Benzo RP. Measuring gait speed in the out-patient clinic: methodology and feasibility. *Respir Care* 2014;59:531–537.

56 Shephard RJ, Bailey DA, Mirwald RL. Development of the Canadian Home Fitness Test. *Can Med Assoc J* 1976;114:675–679.

57 Marrara KT, Marino DM, Jamami M, Oliveira Junior AD, Di Lorenzo VA. Responsiveness of the six-minute step test to a physical training program in patients with COPD. *J Bras Pneumol* 2012;38: 579–587.

58 da Costa JNF, Arcuri JF, Gonçalves IL, Davi SF, Pessoa BV, Jamami M, Di Lorenzo VA. Reproducibility of cadence-free 6-minute step test in subjects with COPD. *Respir Care* 2014;59:538–542.

59 Pessoa BV, Arcuri JF, Labadessa IG. Validity of the six-minute step test of free cadence in patients with chronic obstructive pulmonary disease. *Braz J Phys Ther* 2014;18:228–236.

60 Perrault H, Baril J, Henophy S, Rycroft A, Bourbeau J, Maltais F. Paced-walk and step tests to assess exertional dyspnea in COPD. *COPD* 2009;6:330–339.

61 Borel B, Wilkinson-Maitland CA, Hamilton A, Bourbeau J, Perrault H, Jensen D, Maltais F. Three-minute constant rate step test for detecting exertional dyspnea relief after bronchodilation in COPD. *Int J Chron Obstruct Pulmon Dis* 2016;11:2991-3000.

62 Bean JF, Kiely DK, LaRose S, Alian J, Frontera WR. Is stair climb power a clinically relevant measure of leg power impairments in at-risk older adults? *Arch Phys Med Rehabil* 2007;88:604–609.

63 Roig M, Eng JJ, MacIntyre DL, Road JD, Reid WD. Associations of the stair climb power test with muscle strength and functional performance in people with chronic obstructive pulmonary disease: a cross-sectional study. *Phys Ther* 2010;90:1774–1782.

64 Beauchamp MK, Jette AM, Ward RE, Kurlinski LA, Kiely D, Latham NK, Bean JF. Predictive validity and responsiveness of patient-reported and performance-based measures of function in the Boston RISE study. *J Gerontol A Biol Sci Med Sci* 2015;70:616–622.

65 Bean JF, Leveille SG, Kiely DK, Bandinelli S, Guralnik JM, Ferrucci L. A comparison of leg power and leg strength within the InCHIANTI study: which influences mobility more? *J Gerontol A Biol Sci Med Sci* 2003;58:728–733.

66 Vaes AW, Wouters EFM, Franssen FME, Uszko-Lencer NHMK, Stakenborg KHP, Westra M, Meijer K, Schols AM, Janssen PP, Spruit MA. Task-related oxygen uptake during domestic activities of daily life in patients with COPD and healthy elderly subjects. *Chest* 2011;140:970–979.

67 Annegarn J, Meijer K, Passos VL, Stute K, Wiechert J, Savelberg HHCM, Schols AM, Wouters EF, Spruit MA; Ciro+ Rehabilitation Network. Problematic activities of daily life are weakly associated with clinical characteristics in COPD. *J Am Med Dir Assoc* 2012;13: 284–290.

68 Rodriguez Gonzalez-Moro JM, de Lucas Ramos P, Izquierdo Alonso JL, López-Muñiz Ballesteros B, Antón Díaz E, Ribera X, Martín A. Impact of COPD severity on physical disability and daily living activities: EDIP-EPOC I and EDIP-EPOC II studies. *Int J Clin Pract* 2009;63:742–750.

69 Guccione AA, Felson DT, Anderson JJ, Anthony JM, Zhang Y, Wilson PWF, Kelly-Hayes M, Wolf PA, Kreger BE, Kannel WB. The effects of specific medical conditions on the functional limitations of elders in the Framingham Study. *Am J Public Health* 1994;84:351–358.

70 Lima VP, Iamonti VC, Velloso M, Janaudis-Ferreira T. Physiological responses to arm activity in individuals with chronic obstructive pulmonary disease compared with healthy controls: a systematic review. *J Cardiopulm Rehabil Prev* 2016;36:402–412.

71 Zhan S, Cerny FJ, Gibbons WJ, Mador MJ, Wu YW. Development of an unsupported arm exercise test in patients with chronic obstructive pulmonary disease. *J Cardiopulm Rehabil* 2006;26:180–187.

72 Janaudis-Ferreira T, Beauchamp MK, Goldstein RS, Brooks D. How should we measure arm exercise capacity in patients with COPD? A systematic review. *Chest* 2012;141:111–120.

73 Janaudis-Ferreira T, Hill K, Goldstein RS, Wadell K, Brooks D. Relationship and responsiveness of three upper-limb tests in patients with chronic obstructive pulmonary disease. *Physiother Can* 2013;65:40–43.

74 Nyberg A, Törnberg A, Wadell K. Correlation between limb muscle endurance, strength, and functional capacity in people with chronic obstructive pulmonary disease. *Physiother Can* 2016;68:46–53.

75 Takeda K, Kawasaki Y, Yoshida K, Nishida Y, Harada T, Yamaguchi K, Ito S, Hashimoto K, Matsumoto S, Yamasaki A, *et al*. The 6-minute pegboard and ring test is correlated with upper extremity activity of daily living in chronic obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis* 2013;8:347–351.

76 Takahashi T, Jenkins SC, Strauss GR, Watson CP, Lake FR. A new unsupported upper limb exercise test for patients with chronic obstructive pulmonary disease. *J Cardiopulm Rehabil* 2003;23: 430–437.

77 Hill CJ, Denehy L, Holland AE, McDonald CF. Measurement of functional activity in chronic obstructive pulmonary disease: the grocery shelving task. *J Cardiopulm Rehabil Prev* 2008;28:402–409.

78 Pitta F, Troosters T, Spruit MA, Probst VS, Decramer M, Gosselink R. Characteristics of physical activities in daily life in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2005;171:972–977.

79 Skumlien S, Hagelund T, Bjørtuft O, Ryg MS. A field test of functional status as performance of activities of daily living in COPD patients. *Respir Med* 2006;100:316–323.

80 Tufanin A, Souza GF, Tisi GR, Tufik S, de Mello MT, Nascimento OA, Jardim JR. Cardiac, ventilatory, and metabolic adjustments in chronic obstructive pulmonary disease patients during the performance of Glittre activities of daily living test. *Chron Respir Dis* 2014;11:247–255.

81 Dechman G, Scherer SA. Outcome measures in cardiopulmonary physical therapy: focus on the Glittre ADL-test for people with chronic obstructive pulmonary disease. *Cardiopulm Phys Ther J* 2008;19:115–118.

82 Corrêa KS, Karloh M, Martins LQ, dos Santos K, Mayer AF. Can the Glittre ADL test differentiate the functional capacity of COPD patients from that of healthysubjects? *Rev Bras Fisioter* 2011;15:467–473.
83 Karloh M, Karsten M, Pissaia FV, de Araujo CLP, Mayer AF. Physiological responses to the Glittre-ADL test in patients with chronic obstructive pulmonary disease. *J Rehabil Med* 2014;46: 88–94.
84 Karloh M, Araujo CL, Gulart AA, Reis CM, Steidle LJ, Mayer AF. The Glittre-ADL test reflects functional performance measured by physical activities of daily living in patients with chronic obstructive pulmonary disease. *Braz J Phys Ther* 2016;20:223–230.
85 Berry MJ, Adair NE, Rejeski WJ. Use of peak oxygen consumption in predicting physical function and quality of life in COPD patients. *Chest* 2006;129:1516–1522.
86 Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol* 1994;49:M85–M94.
87 Puthoff ML. Outcome measures in cardiopulmonary physical therapy: short physical performance battery. *Cardiopulm Phys Ther J* 2008;19:17–22.
88 Eisner MD, Iribarren C, Blanc PD, Yelin EH, Ackerson L, Byl N, Omachi TA, Sidney S, Katz PP. Development of disability in chronic obstructive pulmonary disease: beyond lung function. *Thorax* 2011; 66:108–114.
89 Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N Engl J Med* 1995;332:556–561.
90 Eisner MD, Blanc PD, Yelin EH, Sidney S, Katz PP, Ackerson L, Lathon P, Tolstykh I, Omachi T, Byl N, *et al*. COPD as a systemic disease: impact on physical functional limitations. *Am J Med* 2008;121: 789–796.
91 Spruit MA, Singh SJ, Garvey C, ZuWallack R, Nici L, Rochester C, Hill K, Holland AE, Lareau SC, Man WD, *et al*.; ATS/ERS Task Force on Pulmonary Rehabilitation. An official American Thoracic Society/ European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. *Am J Respir Crit Care Med* 2013;188:e13–e64.
92 Weisman IM, Marciniuk D, Martinez FJ, Sciurba F, Sue D, Myers J, *et al*.; American Thoracic Society; American College of Chest Physicians. ATS/ACCP Statement on cardiopulmonary exercise testing. *Am J Respir Crit Care Med* 2003;167:211–277.