Validity of balance and mobility screening tests for assessing fall risk in COPD

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Abstract

People with chronic obstructive pulmonary disease (COPD) have balance impairments and an increased risk of falls. The psychometric properties of short balance tests to inform fall risk assessment in COPD are unknown. Our objective was to determine the validity (concurrent, convergent, and known-groups) of short balance and mobility tests for fall risk screening. Participants with COPD aged $\geq$ 60 years attended a single assessment. Correlation coefficients described the relationships between the Brief Balance Evaluation Systems Test (Brief BESTest), Single-Leg Stance (SLS), Timed Up and Go (TUG), and Timed Up and Go Dual-Task (TUG-DT) tests, with the comprehensive Berg Balance Scale (BBS), chair-stand test, and measures of exercise tolerance, functional limitation, disability, and prognosis. Independent t-tests or Mann–Whitney U tests were used to examine differences between groups with respect to fall risk. Receiver operating characteristic curves examined the ability of the screening tests to identify individuals with previous falls. A total of 86 patients with COPD completed the study (72.9 $\pm$ 6.8 years; forced expiratory volume in 1 second: 47.3 $\pm$ 20.3% predicted). The Brief BESTest identified individuals who reported a previous fall (area under the curve (AUC) = 0.715, $p = 0.001$), and the SLS showed borderline acceptable accuracy in identifying individuals with a fall history (AUC = 0.684, $p = 0.004$). The strongest correlations were found for the Brief BESTest and SLS with the BBS ($r = 0.80$ and $r = 0.72$, respectively) and between the TUG and TUG-DT with the chair-stands test ($r = 0.73$ and $r = 0.70$, respectively). The Brief BESTest and SLS show the most promise as balance screening tools for fall risk assessment in older adults with COPD. These tests should be further evaluated prospectively.

Keywords

COPD, balance, accidental falls, BriefBESTest, mobility

Introduction

Emerging research has shown that older adults with chronic obstructive pulmonary disease (COPD) experience balance impairments[1,2] and falls,[3,4] in addition to secondary consequences on muscle function, mobility, exercise tolerance, and psychological well-being.[5,6] Although declines in balance are typical with aging,[7] balance deficits in older adults with COPD remain pronounced compared to age-matched healthy

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older adults using both clinical balance tests and posturography, suggesting a link between disease and balance impairments. Very few studies have evaluated the underlying contributions to these balance impairments; however, there is some evidence to support the importance of muscle strength to maintain balance control in older adults with COPD.[8,9] Older adults diagnosed with COPD fall at a greater rate, 1.17 falls per person per year, than persons of the same age without COPD,[4,10,11] and COPD itself has been identified as the single-most predictive chronic condition of falls in older adult Canadians.[12] Therefore, specific fall risk assessment strategies to identify people with COPD at the highest risk of falling are needed.

Balance and mobility screening is a fundamental part of evidence-based clinical practice guidelines for fall prevention in community-dwelling older adults.[13,14] It is recommended that older patients who may be at increased risk of falls receive a brief balance and mobility test to determine their level of fall risk and whether they require further intervention.[13,14] To date, there is no gold standard balance screening test for fall risk assessment in older adults or in people with COPD. Current guidelines for pulmonary rehabilitation from the American Thoracic Society/European Respiratory Society recommend balance testing as part of the outcome's assessment for this population; however, no specific tests are suggested.[15]

To develop effective fall prevention and risk reduction strategies, there is a need to identify the optimal balance screening test with strong psychometric properties and clinical feasibility for fall risk assessment in older adults with COPD. Although there have been many tests used to assess balance in people with COPD,[11] only a few are considered appropriate for fall risk screening. The Brief Balance Evaluation Systems Test (Brief BESTest), Single-Leg Stance (SLS), Timed Up and Go (TUG), and TUG-Dual Task (TUG-DT) are four tests of balance and mobility that show strong potential as optimal balance screening tests in COPD based on their acceptability to clinicians,[12,16] strength of psychometric properties demonstrated in COPD or similar older adult populations,[17–19] and short length of time to administer (<10 minutes).

Therefore, the objective of this study was to determine the validity of the Brief BESTest, SLS, TUG, and TUG-DT for fall risk assessment in people with COPD. Specifically, we aimed to determine 1) the construct validity of the clinical screening tests for fall risk assessment in people with COPD and 2) the concurrent validity of the tests for identifying COPD

individuals with a history of falls. We hypothesized that the screening tests would demonstrate moderate to strong correlations with other measures of balance and measures of muscle strength and moderate correlations with measures of exercise tolerance, functional limitation, disability, and prognosis. We also hypothesized that lower balance screening test scores would categorize individuals with higher fall risk. Lastly, we hypothesized that the screening tests would have acceptable accuracy for identifying fallers with COPD.

Methods

This cross-sectional analysis was part of an ongoing prospective cohort study (ClinicalTrials.gov identifier: NTC03229473) and was approved by Hamilton Integrated Research Ethics Board (HiREB #3331 and #4335) and the Joint West Park Healthcare Centre-Toronto Grace Health Centre Research Ethics Board (JREB #17-018-WP).

Participants

Participants with COPD were recruited, between January 2018 and November 2019, from clinics at the Firestone Institute for Respiratory Health in Hamilton and at West Park Healthcare in Toronto and from programs at Compass Community Health in Hamilton. Inclusion criteria were aged ≥60 years; physician-diagnosis of COPD, emphysema, or chronic bronchitis (forced expiratory volume in 1 second (FEV_1)/forced vital capacity ratio of less than 0.70[20]); and ability to provide written informed consent. Participants were excluded if they were unable to communicate due to language impairments (e.g. aphasia) or use of a non-English language, if they experienced other health conditions that significantly limited their balance or mobility (e.g. stroke, Parkinson's Disease), if they were participating in a specific fall prevention intervention, or if they were unable to follow instructions due to dementia/severe cognitive impairment.

Sample size was targeted at 85 based on a moderate correlation ($r = 0.3$) between measures ($\alpha = 0.05$, power 80%) and assuming a dropout rate of 15%. For known-groups validity, a sample size of 22 per group was determined considering a mean difference of 3.1 seconds on the TUG between persons with and without a history of falls in COPD[17] ($\alpha = 0.05$, power 80%).

Primary measures

Balance and mobility measures were selected based on the following criteria: (1) administration time < 10 minutes and (2) commonly used by clinicians in respiratory rehabilitation or evidence for psychometric properties in older adults.

The Brief BESTest[21] contains six tasks for each of the six subsystems of balance control and evaluates both static balance and dynamic balance. The test is scored of 24 points with lower scores representing more impaired balance. The Brief BESTest has shown excellent inter- and intra-rater reliability in community-dwelling older adults, and there is evidence that it can identify individuals with a falls history in COPD.[17]

The SLS is a simple test where the participant is asked to stand on one leg for as long as possible (max 60 seconds) with hands on their hips. The longer a participant is able to hold in SLS, the better their balance. The SLS has shown excellent reliability in COPD[7] as well as in community-dwelling older adults.[19]

The TUG test measures the time taken for a participant to get up from a chair, walk 3 meters, turn around, and walk back to the sit. The TUG has excellent reliability across varying COPD severities[18,19] and has been shown to discriminate individuals with COPD with and without a falls history.[4,22,23]

The TUG-DT involves the same tasks as the TUG, but the participant is asked to count backward by threes while completing the test. The TUG-DT has convergent validity and excellent reliability[24] as well as ability to discriminate older adults with and without a history of falls.[25]

Secondary measures

Measures of balance included the Berg Balance Scale (BBS) and the Activities-specific Balance Confidence scale (ABC scale). The BBS[26] is a 14-item balance test recognized as the gold standard tool for assessing balance (higher scores indicate better balance).[23] The ABC scale is a measure of balance that rates the participants' confidence in performing 16 different activities without losing their balance on a scale from 0% to 100%, where 100% is completely confident.

For lower body strength and physical function,[27] the 30-second Repeated Chair Stand (chair-stand) test, which involves counting the number of sit-to-stands the participant can complete in 30 seconds, was used. A higher number of chair stands indicate greater lower body strength. This test score has been validated as a surrogate measure of strength in older adults with COPD.[28]

Exercise tolerance was assessed using the six-minute walk test (6MWT) that measures the distance a participant can walk in six consecutive minutes. The score has well-established psychometric properties in COPD.[29]

Functional limitation was assessed using the physical-function scale (PF-10), which is a sub-score of the 36-Item Short-Form Health Survey.[30] Functional limitation attributable to dyspnea was measured using the modified Medical Research Council dyspnea scale (mMRC dyspnea scale), where the participant is asked to rate their breathlessness on a scale from 0 to 4 (a higher number indicates greater disability).[31]

Prognosis was measured using the validated body mass index (BMI), airflow Obstruction, Dyspnea and Exercise capacity (BODE) index,[32] where a total score of 10 points is assigned based on spirometry, dyspnea, 6MWT distance, and BMI. Scores between 0 and 4 classified the participant as "better prognosis" and between 5 and 10 as "worse prognosis."

Falls were ascertained by asking whether the participant had experienced a fall in the past year upon providing the definition: "A fall would be when you find yourself suddenly on the ground or a lower surface, without intending to get there, after you were either in a lying, sitting or standing position."[33] Self-reported balance problems and worry about falls were determined by asking the participant whether they had experienced balance problems in the past year and whether they currently experienced worry about falls. The Elderly Falls Screening Test (EFST) was used to assess fall risk and takes into consideration falls history, injurious falls, and gait speed.[33] A score of <2 classifies the participant as "low-risk" for falls and a score of ≥2 as "high-risk."

Data collection

Patients with COPD were screened by telephone for eligibility and invited to attend a 2-hour session. Clinical and demographic information was retrieved from the patient's medical record. A physiotherapist with 5 years of experience conducted the tests. The primary balance tests were randomized and administered first, followed by measures of balance, body strength, and exercise tolerance, and lastly by the questionnaires.

Table 1. Social, demographic, and clinical characteristics of participants in the study ($N = 86$).

Variables	Total sample, $N = 86$	Males, $N = 45$	Females, $N = 41$
Social and demographics, mean (SD)			
Age (years)	72.9 (6.8)	71.6 (6.5)	74.3 (6.8)
Body mass index (kg/m^2)	28.4 (7.0)	29.3 (6.7)	27.4 (7.1)
Smoking history (pack years)	46.0 (27.0)	54.3 (27.6)	36.7 (23.1)
Supplemental oxygen, n (%)	25 (29.1)	11 (24.4)	14 (34.1)
Gait aid, n (%)	43 (50.0)	20 (44.4)	23 (56.1)
Balance and falls history, n (%)			
Fall in previous year	34 (39.1)	16 (35.6)	18 (43.9)
One fall in previous year	20 (23.3)	8 (17.8)	12 (29.3)
Two or more falls in previous year	14 (16.4)	8 (17.8)	6 (14.6)
Worried about falling	40 (46.5)	17 (37.8)	23 (56.1)
Self-reported balance problems	48 (55.8)	26 (57.8)	22 (53.7)
Clinical, mean (SD)			
Chronic conditions (including COPD)	5.0 (2.5)	4.7 (2.6)	5.1 (2.5)
FEV_1 (L)	1.2 (0.6)	1.5 (0.7)	1.0 (0.3)
FEV_1 (% predicted)	47.3 (20.3)	48.6 (22.3)	45.6 (18.0)
FVC (L)	2.6 (1.0)	3.2 (1.0)	1.9 (0.5)
FVC (% predicted)	72.5 (17.9)	73.5 (20.7)	71.5 (14.4)
FEV_1/FVC	0.5 (0.2)	0.50 (0.2)	0.5 (0.1)

SD: standard deviation; COPD: chronic obstructive pulmonary disease; FEV_1: forced expiratory volume in 1 second; FVC: forced vital capacity.

Statistical analysis

Descriptive statistics were computed using measures of central tendency and dispersion. Spearman correlation coefficients for non-normally distributed data were used to describe the relationships between the screening tests and the BBS, ABC scale, chair-stands test, 6MWT, mMRC, BODE index, and PF-10. Cohen's interpretation was used to categorize correlations as weak (0.1), moderate (0.3), or strong (0.5).[34]

Differences between groups with respect to falls, fall risk, gait aid use, worry about falling, supplemental oxygen use, and prognosis were examined using Mann–Whitney U tests. Receiver operating characteristic (ROC) curves were plotted for each of the tests to examine their ability to identify individuals with a fall history, using the AUC as a measure of the test's accuracy. An AUC of 0.7 or greater was considered acceptable accuracy for screening.[35] The optimal cutoff value was determined using the point closest to the upper left-hand corner of the ROC curve—point that optimizes sensitivity and specificity.

Ceiling and floor effects were examined for the Brief BESTest and SLS and considered significant if ≥15% of participants were at the upper or lower limits of the test score.[36] Where ceiling and floor effects could not be calculated, refusal rates were examined. All tests were conducted using SPSS version 25 with a 95% confidence level.

Results

A total of 86 participants with COPD, 45 males (52.3%), mean age of 72.9 (6.8) years, and FEV_1 predicted of 47.3% (20.3%) completed the study. On average, participants had a smoking history of 46 (27.0) pack years and 5.0 (2.5) chronic conditions. Twenty-five participants (29.1%) were on supplemental oxygen, and half of the sample ($n = 43$) used a gait aid. Thirty-four participants (39.1%) reported at least one fall in the previous year, with 48 (55.8%) having self-reported balance problems and 40 (46.5%) reporting they were worried about falling (Table 1).

Concurrent validity

The Brief BESTest was the only screening test to demonstrate acceptable accuracy for identifying individuals with history of falls (AUC = 0.715, 95% CI = 0.607 to 0.808, $p = 0.001$). The SLS showed borderline acceptable accuracy in identifying individuals with a falls history (AUC = 0.684, 95% CI = 0.574 to 0.780, $p = 0.004$). The cutoff value for the Brief BESTest was ≤66.7% (82.4% sensitivity and 54.9%
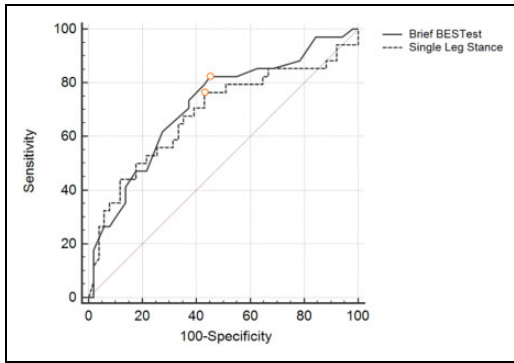
Figure 1. Receiver operating characteristic curve of the Brief BESTest and SLS for discriminating between people with COPD with and without a fall history. The optimal cutoff scores (maximum sensitivity and specificity) are identified by the round symbol. Brief BESTest: Brief Balance Evaluation Systems Test; SLS: Single-Leg Stance; COPD: chronic obstructive pulmonary disease.

specificity) and for the SLS was ≤ 6.8 seconds (76.5% sensitivity and 56.9% specificity) (Figure 1).

Convergent validity

All balance screening tests were moderately to strongly correlated with the BBS, ABC scale, chair-stands, 6MWT, PF-10, Bode Index, and mMRC scale ($r = 0.30$ to $r = 0.80$), except between the SLS and chair-stands, PF-10, BODE index, and mMRC scale that showed weak correlations ($r = -0.10$ to $r = 0.28$) (Table 2). The strongest correlations were demonstrated by the Brief BESTest and SLS with the BBS, $r = 0.80$ and $r = 0.72$, respectively, and between the TUG and the TUG-DT with the chair-stands test, $r = -0.73$ and $r = 0.70$, respectively. All the correlations were significant except between the SLS and the BODE index ($r = -0.10$, $p > 0.05$).

The Brief BESTest had negligible floor effects (1.2%) and no ceiling effect, and the SLS had negligible floor and ceiling effects, 3.5% and 2.3%, respectively. None of the participants refused or were unable to complete the TUG, and 5.5% of the participants refused or were unable to complete the TUG-DT.

Known-groups validity

All balance screening test scores were significantly different between individuals classified as high risk and low risk for falls by the EFST as well as between gait aid users and nonusers (Table 3). The Brief BESTest and the SLS were significantly different between individuals with and without history of falls,

and the Brief BESTest was the only test that significantly differed between individuals worried and not worried about falls (Table 3).

Differences in balance scores were demonstrated between supplemental oxygen users and nonusers only for the TUG and TUG-DT (Table 4). Similarly, the TUG and TUG-DT as well as the Brief BESTest were the only tests that were different between individuals with worse prognosis and better prognosis based on the BODE index score.

Discussion

This study concurrently examined the validity of four short balance and mobility screening tests for fall risk assessment in older adults with COPD. Our results identified the Brief BESTest and SLS as promising clinical screening tools for fall risk assessment in COPD. These findings have implications for clinical practice given the increased focus on fall risk assessment and prevention in this population.

To our knowledge, this was the first investigation to compare multiple balance and mobility screening tests for identifying people with and without a falls history in COPD. Our results show that the Brief BESTest was the only screening test to identify individuals with a falls history with acceptable accuracy (AUC = 0.72). A possible explanation for this may be that it involves six different tasks, each designed to measure a different aspect of balance control inclusive of static and dynamic balance. The Brief BESTest also includes a reactive balance task which assesses response to perturbation, an aspect of balance vital for fall avoidance.[7] Our cutoff score for the Brief BESTest was 66.7%, slightly less than 70% reported[17] in COPD individuals with a fall history. Our study included subjects with more severe COPD than the other study (mean FEV_1: 47.3% vs. FEV_1: 69.4%) as well as subjects with lower balance scores on the Brief BESTest. Therefore, it makes sense that the cutoff value would be slightly more conservative in our study. Prospective studies are needed to establish an optimal cutoff value for fall risk screening in COPD with a higher degree of certainty.

The SLS showed borderline acceptable accuracy (AUC = 0.68) and consistently demonstrated the second strongest associations with longer measures of balance and known-groups validity. This may indicate that either test can be selected for fall risk screening in COPD depending on the setting and context. The Brief BESTest may be most suitable to screen

Table 2. Convergent validity of the mobility and balance screening tests ($N = 86$).

Balances tests	BBS	ABC scale	Chair stands	6-MWT	PF-10	BODE index	mMRC dyspnea scale
Brief BESTest	0.80[a]	0.60[a]	0.48[a]	0.61[a]	0.35[a]	−0.28	−0.38[a]
SLS	0.72[a]	0.50[a]	0.28[b]	0.40[a]	0.23[b]	−0.10	−0.27[b]
TUG	−0.61[a]	−0.51[a]	−0.73[a]	−0.68[a]	−0.41[a]	0.50[a]	0.37[a]
TUG-DT	−0.49[a]	−0.48[a]	−0.70[a]	−0.63[a]	−0.41[a]	0.50[a]	0.34[a]

BBS: Berg Balance Scale; ABC scale: Activities-Specific Balance Confidence Scale; Chair stands: 30-second Repeated Chair Stands; 6MWT: Six-Minute Walk Test; PF-10: Physical-Functioning scale; BODE index: Body mass index, airflow obstruction, dyspnea and exercise capacity index; mMRC dyspnea scale: modified Medical Research Council dyspnea scale; Brief BESTest: Brief Balance Evaluation Systems Test; SLS: Single-Leg Stance; TUG: Timed Up and Go; TUG-DT: Timed Up and Go Dual-Task.
[a]Significant at $p < 0.01$.
[b]Significant at $p < 0.05$.

Table 3. Known-groups validity of balance and mobility screening tests.

Balance screening tests	Groups			
	Fall history ($n = 34$) versus no fall history ($n = 51$)	High risk ($n = 27$) versus low risk ($n = 59$)	Worried ($n = 40$) versus not worried ($n = 46$)	Gait aid ($n = 43$) versus no gait aid ($n = 43$)
Brief BESTest				
Mean (SD)	50.6 (21.3)–66.8 (20.3)	44.1 (22.9)–67.1 (18.7)	53.6 (20.4)–65.9 (22.8)	47.0 (20.9)–72.8 (15.9)
Median	54.2–66.7	43.8–66.7	54.2–68.8	50.0–72.9
	$p = 0.001$[a]	**$p < 0.001$[a]**	**$p = 0.008$[a]**	**$p < 0.001$[a]**
SLS				
Mean (SD)	8.7 (15.1)–11.7 (11.4)	7.3 (12.6)–12.0 (12.9)	7.9 (9.8)–12.8 (14.8)	6.3 (6.8)–14.8 (15.9)
Median	3.2–8.0	3.0–7.5	4.0–7.2	4.1–9.5
	$p = 0.004$[a]	**$p = 0.002$[a]**	$p = 0.063$	**$p < 0.001$[a]**
TUG				
Mean (SD)	13.2 (5.2)–11.8 (4.0)	14.8 (5.8)–11.3 (3.1)	13.3 (5.1)–11.6 (3.7)	14.8 (4.5)–10.0 (3.0)
Median	12.1–10.7	13.2–10.8	11.8–11.0	13.2–9.3
	$p = 0.181$	**$p = 0.003$[a]**	$p = 0.197$	**$p <0.001$[a]**
TUG-DT				
Mean (SD)	16.6 (8.2)–14.4 (5.4)	18.8 (8.9)–13.6 (4.4)	16.6 (8.0)–14.2 (5.0)	18.0 (7.3)–12.5 (4.5)
Median	14.7–13.3	15.5–12.4	13.8–13.6	15.6–11.3
	$p = 0.176$	**$p = 0.003$[a]**	$p = 0.245$	**$p < 0.001$[a]**

Brief BESTest: Brief Balance Evaluation Systems Test; SD: standard deviation; SLS: Single-Leg Stance; TUG: Timed Up and Go; TUG-DT: Timed Up and Go Dual-Task.
[a]Significant at $p < 0.05$.
The numbers in bold are the p values found

more comprehensively for balance impairment and to guide or monitor exercise training in COPD, such as in a rehabilitation setting. However, in a clinic setting where efficiency is the utmost priority, the SLS may be the better selection while still offering valuable information about fall risk status in COPD.

The Brief BESTest and SLS showed the strongest convergent validity with the BBS ($r = 0.80$ and $r = 0.72$, respectively), a robust measure of balance, and the ABC scale ($r = 0.60$ and $r = 0.50$, respectively), a patient-reported measure of balance confidence. It is notable that the SLS performed similarly to the Brief BESTest despite being the shortest and simplest screening test. While previous studies in COPD have demonstrated the convergent validity of the Brief BESTest with the BBS and ABC scale,[17] to our knowledge, this is the first study to demonstrate convergent validity of the SLS with both the BBS and the ABC scale in a COPD population. Similarly, the Brief BESTest and the SLS were the only tests differed between groups based on fall risk status, and the Brief BESTest was the only test that differed between those worried and not worried

Table 4. Known-groups validity of balance screening tests for disease-specific measures.

Balance screening tests	SO$_2$ ($n = 25$) versus NSO$_2$ ($n = 61$)	Worse prognosis ($n = 33$) versus better prognosis ($n = 42$)
Brief BESTest		
Mean (SD)	57.3 (16.0)–60.0 (23.7)	55.2 (19.2)–64.6 (22.2)
Median	54.2–62.5	58.3–66.7
	$p = 0.234$	$p = 0.041^a$
SLS		
Mean (SD)	8.9 (7.9)–11.3 (14.6)	8.7 (8.1)–13.4 (16.3)
Median	5.0–5.5	5.6–5.5
	$p = 0.772$	$p = 0.662$
TUG		
Mean (SD)	15.5 (4.4)–11.0 (3.8)	14.1 (4.5)–11.1 (3.9)
Median	15.0–10.3	13.1–9.7
	$p < 0.001^a$	$p = 0.001^a$
TUG-DT		
Mean (SD)	18.9 (5.8)–13.7 (6.4)	17.5 (6.0)–13.8 (6.9)
Median	18.7–12.5	16.8–12.1
	$p < 0.001^a$	$p = 0.001^a$

Brief BESTest: Brief Balance Evaluation Systems Test; SD: standard deviation; SLS: Single-Leg Stance; TUG: Timed Up and Go; TUG-DT: Timed Up and Go Dual-Task; SO$_2$: supplemental oxygen; NSO$_2$: no supplemental oxygen.
[a]Significant at $p < 0.05$
The numbers in bold are the p values found

about falls. Fear of falling is an important and prevalent mental health problem in COPD[37] (50% prevalence in our sample) and has been strongly associated with an increased risk of falls and activity reduction in both older adult and COPD populations.

An interesting finding is that TUG scores were similar between individuals with and without a falls history in COPD. This is in contrast to previous work,[4] which showed that lower TUG scores characterized previous fallers in COPD. While the subject characteristics in the previous report appear similar to our study, their sample size was much smaller ($n = 39$), and therefore, their estimates may have been less precise. The TUG also failed to differentiate between persons worried and not worried about falling which is consistent with the results for fall status. Although the TUG is currently the most commonly recommended fall risk screening tool by clinical practice guidelines in older adults,[14,38] our result suggests that it may not be the optimal fall risk screening test for older adults with COPD. Moreover, despite the preliminary evidence supporting its psychometric properties in older adults,[24,25] the TUG-DT did not perform better than the TUG in our study. This is consistent with previous studies comparing TUG-DT to TUG for fall risk

assessment for older adults.[39,40] However, given the established impact of dual-task performance on balance and fall risk in older adults,[40,41] there is a need for future research to confirm our findings on the value of the TUG-DT for fall risk assessment in COPD.

Given the known association between balance and falls,[42,43] it is perhaps not surprising that the Brief BESTest and SLS were the two tests with the strongest measurement properties for fall risk assessment. Where both of these are more "purer" evaluations of balance, the TUG and TUG-DT are broader evaluations of balance, mobility, and function. This may explain the observed differences in psychometric properties of these balance tests in a fall risk assessment context. Although the TUG and TUG-DT may not be preferred for fall risk screening in COPD according to our results, they may still offer valuable assessments of physical function in COPD, which is supported by our findings for known-groups validity with respect to more disease-specific outcomes such as use of supplemental oxygen and prognosis.

The design of our study limits the report on the cross-sectional validity of the balance screening tests for fall risk assessment. In addition, retrospective falls reporting may have been impacted by recall bias. The

generalizability of our study findings is also limited to older adults with moderate to severe COPD who are receiving care for their COPD. Finally, this study only evaluated four screening tests and it is possible that other tests would have shown better results. Nevertheless, we selected the tests with the best potential for use in clinical settings and those that had preliminary evidence supporting their measurement properties.

In summary, the Brief BESTest and SLS show are promising screening tools for fall risk assessment in older adults with COPD. Although the Brief BESTest demonstrated stronger psychometric properties and offers a more comprehensive measure of balance for guiding exercise prescription, the SLS may be better suited for clinical practice settings with time constraints. Further research is needed to confirm these results using a prospective study design.

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