Systematic Reviews

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Determining Risk of Falls in Community Dwelling Older Adults: A Systematic Review and Meta-analysis Using Posttest Probability

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ABSTRACT

Background: Falls and their consequences are significant concerns for older adults, caregivers, and health care providers. Identification of fall risk is crucial for appropriate referral to preventive interventions. Falls are multifactorial; no single measure is an accurate diagnostic tool. There is limited information on which history question, self-report measure, or performance-based measure, or combination of measures, best predicts future falls.

Purpose: First, to evaluate the predictive ability of history questions, self-report measures, and performance-based measures for assessing fall risk of community-dwelling older adults by calculating and comparing posttest probability (PoTP) values for individual test/measures. Second, to evaluate usefulness of cumulative PoTP for measures in combination.

Data Sources: To be included, a study must have used fall status as an outcome or classification variable, have a sample size of at least 30 ambulatory community-living older adults (≥65 years), and track falls occurrence for a minimum of 6 months. Studies in acute or long-term care settings, as well as those including participants with significant cognitive or neuromuscular conditions related to increased fall risk, were excluded. Searches of Medline/PubMED and Cumulative Index of Nursing and Allied Health (CINAHL) from January 1990 through September 2013 identified 2294 abstracts concerned with fall risk assessment in community-dwelling older adults.

Study Selection: Because the number of prospective studies of fall risk assessment was limited, retrospective studies that classified participants (faller/nonfallers) were also included. Ninety-five full-text articles met inclusion criteria; 59 contained necessary data for calculation of PoTP. The Quality Assessment Tool for Diagnostic Accuracy Studies (QUADAS) was used to assess each study's methodological quality.

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Data Extraction: Study design and QUADAS score determined the level of evidence. Data for calculation of sensitivity (Sn), specificity (Sp), likelihood ratios (LR), and PoTP values were available for 21 of 46 measures used as search terms. An additional 73 history questions, self-report measures, and performance-based measures were used in included articles; PoTP values could be calculated for 35.
Data Synthesis: Evidence tables including PoTP values were constructed for 15 history questions, 15 self-report measures, and 26 performance-based measures. Recommendations for clinical practice were based on consensus.
Limitations: Variations in study quality, procedures, and statistical analyses challenged data extraction, interpretation, and synthesis. There was insufficient data for calculation of PoTP values for 63 of 119 tests.
Conclusions: No single test/measure demonstrated strong PoTP values. Five history questions, 2 self-report measures, and 5 performance-based measures may have clinical usefulness in assessing risk of falling on the basis of cumulative PoTP. Berg Balance Scale score (≤50 points), Timed Up and Go times (≥12 seconds), and 5 times sit-to-stand times (≥12) seconds are currently the most evidence-supported functional measures to determine individual risk of future falls. Shortfalls identified during review will direct researchers to address knowledge gaps.
Key Words: accidental falls, community-dwelling older adults, functional assessment

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INTRODUCTION

As many as one-third of older adults fall at least once over the course of a year.[1] Falls and fear of falling contribute to restricted activity as a strategy to reduce perceived risk of subsequent falls.[2] Resultant secondary deconditioning may actually increase risk of falling.[3] Fall-related injuries (eg, hip fractures and head injury) contribute to increasing care costs for older adults.[4] Fall risk-reduction programs have received significant funding in public health initiatives.[5] Nonetheless, accurately identifying those requiring intervention to reduce fall risk is challenging for health professionals caring for older adults.[6]

Susceptibility to falls results from an interaction of multiple factors: reduced efficacy of postural responses,[7] diminished sensory acuity,[8] impaired musculoskeletal,[9] neuromuscular,[9] and/or cardiopulmonary systems,[10] deconditioning associated with inactivity,[11] depression and low balance self-efficacy,[12] polypharmacy,[13] and a host of environmental factors.[14] The multifactorial nature of fall risk complicates identification of those most at risk.[15] Consequently, fall risk assessment tools are as plentiful as contributing factors (Table 1). Given the number of tests and measures available for fall risk assessment, how do clinicians select the best "diagnostic" tool(s) to examine their client's risk of falling? How does a given test or measure change degree of clinical certainty that a future fall is likely? Calculation of posttest probability (PoTP) allows a clinician to determine how much risk has shifted from a pretest probability of approximately 30% (the prevalence of fall among community-dwelling older adults).[1,16,17] The first step in determining a measure's PoTP begins with consideration of its diagnostic accuracy, as indicated by sensitivity (Sn) and specificity (Sp).

To determine diagnostic accuracy, a measure (index test) is compared with a gold standard or reference event (ie, a fall event).[16] This comparison is based on a "cut point" that defines positive and negative test results. A 2×2 table can be constructed to classify participants by fall status and clinical test results on the basis of the defined "cut point" (Figure 1). Sn is calculated by dividing the number of persons who fell *and* have a positive test results by the total number of fallers: the test's true positive rate. High Sn indicates the test correctly identifies most people with the diagnosis; therefore, a negative result in a test with high Sn helps to rule out the diagnosis. Sp is calculated by dividing the number of persons who did not fall *and* have a negative test result by the total number of nonfallers: the test's true negative rate. High Sp indicates that the test correctly identifies most people who did not fall; therefore, a positive result on a test with high Sp helps to identify those most likely to fall. Few tests or measures achieve both high Sn and Sp values.

Sn and Sp values are used to calculate a measure's positive and negative likelihood ratios (+LR, −LR).[16,17] The formula for calculation of LR is shown in Figure 1. An LR indicates what the expected test result would be in persons with the condition of interest compared with those without the condition. Both positive (+LR >1.0) and negative (−LR <1.0) likelihood ratios can be calculated for any test (see Figure 1). A +LR indicates the clinical usefulness of a positive test result: the larger the +LR value above 1.0, the more valuable the positive test result.[16,17] The −LR indicates the usefulness of a negative test result: the smaller the value below 1.0, the more valuable the negative test result.[16,17]

Likelihood ratios are then used to calculate pre- and posttest odds, which serve as indicators of strength of association between exposure (test result as indicator of fall risk) and outcome (fall event). Pretest odds (PrTO) are calculated by dividing prevalence (pretest probability) by its inverse: for falls this would be 30%/(1%-30%), a value of 0.43. Posttest odds (PoTO) are developed by multiplying PrTO by the measure's +LR (for positive tests results) and −LR (for negative test results).

Finally, the informative PoTP, which indicates the degree of change in surety of diagnosis given a test's likelihood ratios, can be calculated. The pretest probability (PrTP) of falling for community-living older adults is estimated as 30%,[1] with a PrTO of 0.43. Using these values and example LRs, we can calculate the PoTO and PoTP for an older adult on the basis of a positive and a negative test result (see Figure 1). If our fall-risk test has a moderate +LR of 5 and a moderate −LR of 0.5, a positive test result (high risk) would result in a PoTP of falling for this individual of 68%. A negative test result (low risk) would result in a PoTP of falling for this individual of 18%. Both values are substantially different from PrTP of 30%. For

Table 1. Measures Used as Search Terms and Additional Measures Identified During Review of Retrieved Articles[a]

Included[b]	Excluded[c]
Measures used as search terms	
Self-report measures Activity-Specific Balance Confidence (ABC) Barthel Index (BI) Center for Epidemiological Studies Depression Scale (CES-D) Fall Efficacy Scale International (FES-I) Geriatric Depression Scale (GDS) Medical Outcomes Study Short Form (SF-36) Mini-Mental State Evaluation (MMSE) Performance-based measures 30-s sit to stand Berg Balance Scale (BBS) Dynamic gait index (DGI) 5 times sit-to-stand time (5TSTS) 1 time Sit-to-stand time (OTSTS) Fullerton Advanced Balance Scale (FAB) Functional Reach Distance (FR) Modified Clinical Test of Sensory Interaction and Balance (mCTSIB) Performance-Oriented Mobility Assessment (POMA-Tinetti) Physical Performance Test (PPT) Romberg Test/Sharpened Romberg/Tandem Stance Self-selected walking speed/10-m walk (SSWS) Single-limb stance/one-leg stance/unipedal stance (SLS) Timed Up and Go (TUG)	Self-report measures Dizziness Handicap Inventory (DHI) Fear Avoidance Beliefs Questionnaire Functional Gait Assessment Home and Community Environment Questionnaire History of Falls Questionnaire Lower Extremity Functional Scale Patient Specific Functional Scale Rivermead Mobility Index WHO Quality of Life-BREF (WHOQOL-BREF) Performance-based measures 2-min walk distance 6-min walk distance 360° Turn Test Balance Evaluation Systems (BEST) Test, mini Best Test Brunell Balance Assessment Test Canadian Occupational Performance Measure Continuous Scale Physical Functional Performance Test Fast Walking Speed (FWS) Functional Independence Measure (FIM) Four-Square Step Test (FSST) High-Level Mobility Assessment Tool Multidirectional Reach Test Push and Release Test Sensory Organization Test (SOT) Timed Backward Walk Walking while talking Test
Additional measures derived from article review	
History questions Age > 80 y (yes/no) Alcohol use (yes/no) Ambulatory assistive device (AD) use (yes/no) Dependence in activities of daily living (yes/no) History of previous falls (yes/no) Nocturia/urgency/incontinence (yes/no) Polypharmacy (yes/no) Psychoactive medication use (yes/no) Self-reported depression (yes/no) Self-Reported difficulty walking Self-reported fear of falling (yes/no) Self-reported imbalance (yes/no) Self-reported physical activity/exercise Self-reported health status Self-reported pain Self-report measures Balance Self-Perception Test Falls Risk Assessment Questionnaire Longitudinal Study of Aging Physical Activity Questionnaire Older Adults Resources and Services (OARS) ADL scale Self-Rated Health Questionnaire Subjective Ratings of Specific Tasks Short Orientation Memory Concentration Test Sickness Impact Profile (SIP)	Self-report measures Balance Efficacy Scale Community Balance and Mobility Scale Demura Fall Risk Assessment Fall Assessment and Intervention Record Falls Behavioral Scale for Old People Fall Risk Assessment Tool for Older People Fall Risk Assessment Tool Falls Assessment Risk and Management Tool Fall risk by exposure Fall Risk Questionnaire Fear of Falling Avoidance Questionnaire Gait Efficacy Scale Goal Attainment Scale Hauser Ambulation Index Hendrich II Fall Risk Model Home Falls and Accidents Screening Tool 21-item Fall Risk Index Performance-based measures Alternate Step Test Body mass index Cadence Figure-8 Walking Test Grip strength Get up and go (untimed) Lateral Reach Test Lateral Reach Test

(*continues*)

Table 1. Measures Used as Search Terms and Additional Measures Identified During Review of Retrieved Articles[a] (*Continued*)

Included[b]	Excluded[c]
Performance-based measures	Lower extremity strength
Ability to sit to stand without upper extremity support (yes/no)	Melbourne Fall Risk Assessment Tool
Alternate Step Test	Morse Fall Scale
Half-turn test (# steps)	Motor Fitness Scale
Maximum step length	Obstacle course
Minimal chair height	Peninsula Health Fall Risk Assessment Tool
Modified Gait Abnormality Rating Scale (mGARS)	Queensland Fall Risk Assessment Tool
Physiological Profile Assessment (PPA)	Short Physical Performance Battery
Pick up 5 lb weight test	St. Thomas Risk Assessment Tool (Stratefy)
Spring Scale Test	STEADI
8-Stairs ascend/descend time	Stance and Swing (time and %)
Stride length	Gait cycle time
Tandem walk (able/unable)	Step Up Test
	Trail Walking Test

[a]In order for a measure to be included in analysis, data extracted from research articles about the measure had to include number of participants who did/did not fall, the value of a threshold or cut score for the measure, and/or reported sensitivity and specificity values, such that posttest probability (PoTP) could be calculated.
[b]Sufficient information for calculation of PoTP.
[c]Insufficient information for CALCULATION of PoTP.

the clinician, this information enhances determination of who would/would not benefit from a more in-depth examination and intervention to reduce risk of falling.[16,17]

In clinical medicine, when no single diagnostic test has PoTP large enough to cross threshold for intervention, the results of several tests are combined to calculate a cumulative PoTP value.[16] In effect, the PoTP of one test becomes the pretest probability for the next test. If both pretest probability (as in falls risk of 30%) and a test/measures' likelihood ratio values are moderate, as in most measures of balance and risk of falls, the cumulative PoTP can be thought of as increasing surety.[16,17] Two or more positive tests with a high cumulative PoTP value (above the baseline PrTP of 30%) suggest the individual is at high risk of experiencing falls, and supports the need for intervention. Two or more negative tests leading to substantially lower PoTP (below the baseline PrTP of 30%) would indicate lower risk of future falls. Mixed results (some positive, some negative) are more challenging to interpret.

Physical therapists, like other health professionals, collect information about an individual's health and functional status is several ways: by asking questions about medical history (eg, do you remember falling in the last 6 months?), by administering self-report measures (eg, fear of falling scales or depression scales), and by using performance-based tests (eg, Berg Balance Scale, walking speed, or Timed Up and Go test). Combining multiple sources of information assists the diagnostic process to identify issues that can be addressed by intervention.[18] It is not clear what history questions, self-report measures, or performance-based measures best identify those community-living older adults at risk of falling.

Although there have been systematic reviews of individual measures (eg, the Timed Up and Go[19] and the Berg Balance Scale[20]), no reviews that provided measure-to-measure comparison of predictive properties for tools used to assess risk of falling were identified in the literature. The Academy of Geriatric Physical Therapists charged a team of 10 researchers and clinicians to undertake such a systematic review. This was to provide support of the work of another group charged to develop a clinical practice guideline for management of falls in later life. This systematic review has 2 aims: (1) to evaluate the predictive ability of fall risk assessment tools for community-dwelling older adults by calculating and comparing PoTP values, and (2) to explore usefulness of cumulative PoTP using test results from multiple measures. The measure-to-measure comparison and consolidation of findings will assist clinicians in selection of measures as well as in clinical decision making about need for intervention to prevent falls. It will also inform researchers where evidence about ability of a measure's ability to predict falls is lacking and needs further investigation.

METHODS

The Institute of Medicine Guidelines for Systematic Review,[21] the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Guidelines,[22] and the Cochrane Handbook of Systematic Reviews of Diagnostic Test Accuracy[23] served as resources for this systematic review and meta-analysis.

A fall was defined as an event in which an older adult unintentionally came to rest on the ground or other lower supporting surface, unrelated to a medical incident or to an overwhelming external physical force.[6] Risk was defined using the World Health Organization's (WHO) definition: the probability that an unwanted health event (eg a future fall) will occur was used.[24] For older adults, fall risk is always present and cannot be reduced to zero, although many risk factors for falls are modifiable.

In this review, fall status (prospectively or retrospectively) was the gold standard to which the various index measures where compared. Based on the literature, a 6-month

		"Gold Standard" Reference Test	
		Fall	No Fall
Index Test Outcome (based on Cut Score)	Positive Test	**A** # Fallers with Positive Test True Positives	**B** # Non Fallers with positive test False Positives
	Negative Test	**C** # Fallers with Negative Test False Negatives	**D** # Non Fallers with Negative test True Negatives

Sensitivity (Sn) = A / (A + C) (true positive rate)

Specificity (Sp) = D / (B + D) (true negative rate)

Positive Likelihood Ratio (+LR) = Sn / (1-Sp) (true positive rate / true negative rate)

Negative Likelihood Ratio (-LR) = (1- Sn) / Sp (false negative rate / true negative rate)

Pre-test Probability (PrTP) = Prevalence in the population; for falls 30%

Pre-test Odds (PrTO) = PrTP / (1-PrTP) For Falls: .30/(1-.30) = .43

Post-Test Odds (PoTO) = PrTO x (+LR) example for moderate effect +LR For falls: .43 x 5.0 = 2.15

= PrTO x (-LR) example for moderate effect –LR for falls: .43 x .50 = 0.22

Post-Test Probability (PoTP) = change in estimate of diagnosis given a test's likelihood ratios

= PoTO / (1 + PoTO)

PoTP if test is positive given moderate effect +LR of 5: 2.15 / (1+ 2.15) = 68%

PoTP if test is negative, given moderate effect –LR of .05: 0.22 / (1+ 0.22) = 18%

Figure 1. Usefulness of a 2×2 table for interpreting test results. In this systematic review and meta-analysis, data about each test from multiple studies were combined to calculate an overall sensitivity and specificity values, and positive (+LR) and negative (−LR) likelihood ratios. On the basis of consistent epidemiological evidence, pretest probability for future falls was set at 30%. Calculation of pretest odds from pretest probability, followed by calculation of posttest odds, allows estimation of posttest probability. Assuming a moderate effect +LR of 5 and −LR of 0.5, posttest probability after a positive test would increase from 30% to 68%. Assuming a moderate effect −LR of 0.5, posttest probability after a negative test would decrease from 30% to 18%. When test results are positive, the size of the increase in posttest probability beyond pretest predictive toward 100% determines how much "more sure" the clinician can be that an older adult would likely experience a future fall. When test results are negative, how much posttest probability decreases toward 0 from pretest value determines how much "more sure" that an older individual would not be likely to fall.

period was deemed sufficient time for fall occurrence. On the basis of anticipation that the number of prospective studies of fall risk assessment would be small, a decision was made to include retrospective studies tracking previous falls over at least a 6-month period as well. Although retrospective recall of falls may be somewhat inaccurate, given the high number of retrospective studies of falls in the literature, the combination of prospective and retrospective data provides "best available" evidence at the present time.

DATA SOURCES AND SEARCHES

MEDLINE and CINAHL databases were searched, as those most likely to index geriatric, gerontology, and rehabilitation research literature. Search strategies (key words) and results are summarized in the PRISMA flow diagram of Figure 2. The first search did not yield the number or type of articles needed for a comprehensive review. A medical librarian carried out a second search by combining key words in various groupings. Unfortunately, search strings were not recorded and could not be accurately reformulated. To enhance search rigor, a third search was undertaken using names of specific measures gathered from websites (Rehabilitation Measures Database,[25] PTNow,[26] and the American Physical Therapy Association's Guide to Physical Therapist Practice[18]) and the team's clinical experience as search terms. References from retrieved articles were also reviewed. This multisearch strategy ensured that

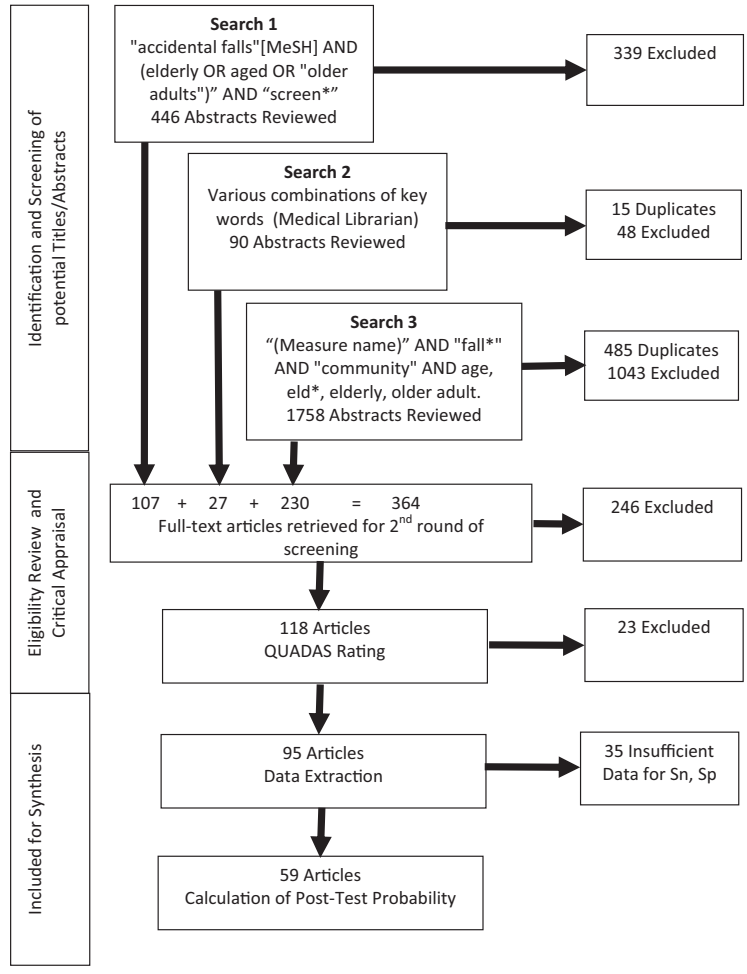

Figure 2. PRISMA diagram for the systematic review process. A total of 2294 abstracts were reviewed; these included 500 duplicates and 1430 that did not immediately meet inclusion criteria. A total of 364 full-text articles were retrieved, examined, and appraised: an additional 269 did not meet inclusion criteria. Data were extracted from the remaining 95 articles; 57 of these contained information necessary for calculation of posttest probability.

the combined final search results were as comprehensive as possible.

Study Selection

To be included in the review, each study had to (1) include a study sample of 30 or more independently ambulatory (with/without assistive device) community-dwelling adults 65 years or older; (2) collect falls data for at least a 6-month period, either following study enrollment (prospective studies) or recall falls before the study enrollment (retrospective); (3) focus on evaluating risk of future falls and/or differentiating characteristics of fallers versus nonfallers; (4) use fall status (none, one, and/or recurrent) as an outcome variable (prospective) or classification variable (retrospective); and (5) be published in English, in a peer-reviewed journal between January 1990 and September 2013. The start date for the search was the year 1990 as the point in time that commonly used measures began to be developed (eg, Functional Reach in 1990); the end date was September 2013, when data examination began.

Studies were excluded from the review if they included (1) persons younger than 65 years; (2) participants with cognitive dysfunction, or with orthopedic or neurological diagnoses associated with elevated fall risk; (3) data from acute care, postacute care, or extended care settings; (4) little evidence of how falls were defined or documented; or (5) equipment unavailable in most physical therapy settings, such as force plates, computerized motion analysis, or other technology-based assessment systems.

Abstracts of all 2294 articles identified in the searches were retrieved and reviewed. Interrater reliability was addressed in a multistep training process. First, each researcher in the team reviewed the same set of 10 abstracts, applying inclusion and exclusion criteria. Next, all participated in a series of conference calls, and discussed the review process until consensus was reached for the set of 10 abstracts. By the review of the 10th abstract, the team

reached a 95% agreement rate before discussion. Next, teams of 2 reviewers were assigned sets of 100 abstracts, and charged to reach agreement on inclusion/exclusion criteria in their sets. To reduce potential reviewer bias, reviewers were paired differently for each set of 100 abstracts, until all were reviewed. At the end of the abstract review process, 364 full-text articles were retrieved. Retrieved full-text articles were rescreened on the basis of inclusion/exclusion criteria before quality review and data extraction; an additional 246 failed to meet inclusion criteria, leaving 118 articles for quality assessment.

Quality Assessment

We used the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) Critical Appraisal Tool to evaluate methodological quality and risk of bias of retrieved studies.[27] QUADAS is composed of 14 questions designed to assess validity, potential for bias, and methodological soundness of diagnostic studies. Items are scored as yes, no, unsure, or not applicable. Total criterion score is calculated as: 100 × (#yes responses)/(14 − # not applicable responses). Criterion scores were reported for all included studies. Interrater reliability was addressed as in the abstract review process. First, each researcher independently rated the same 5 articles using the QUADAS tool. This was followed by conference calls to discuss the rating process, and until consensus on rating of these 5 articles. There was 92% agreement by evaluation of the fifth article. Two person teams then rated sets of 20 articles with the goal of reaching consensus. Agreement about the QUADAS score between team members ranged from 90% to 97%. During quality assessment, 23 more articles failed to meet inclusion criteria, leaving 95 for data extraction

Data Extraction

The American Physical Therapy Association Section on Research's Evaluation Database to Guide Effectiveness (EDGE) Task Force data extraction form[28] was used to record data extracted from each article. It was modified slightly to include level of evidence for studies of diagnostic accuracy as defined by Australia's National Health and Medical Research Council.[29] Level of evidence for this project was defined as follows: Level I included prospective studies with QUADAS 75 or more as Level I evidence; Level II included prospective studies with QUADAS less than 75. Retrospective studies were classified as Level III, regardless of the QUADAS score.

Each researcher independently extracted data from sets of retrieved articles. Interrater reliability was determined by a second independent data extraction of a subset of 25 of the 90 remaining articles. Agreement ranged from 93% to 97% on the comparison of data extraction records for these 25 articles. The study coordinator performed a third reviewed to correct data when there was disagreement. Extracted data were combined into a summary Excel spreadsheet so that measures could be sorted by name.

Data Synthesis and Analysis

After sorting of data by measure name, reviewer teams used extracted data to construct individual evidence tables for each test/measure. The study coordinator reviewed these tables for accuracy. When number of fallers/nonfallers and number above and below cut point values were available, or if Sn and Sp were provided, 2×2 tables were constructed so that Sn, Sp, LRs, odds ratios and PoTP could be calculated.[16,17] Fifty-nine of 95 articles (prospective evidence Level I n = 27; Level II n = 5; retrospective evidence Level III n = 27) contained information necessary for calculation of PoTP. Finally, 3 cumulative evidence tables were created on the basis of type of data collected: medical history questions (Table 2), self-report measures (Table 3), and performance-based measures (Table 4). These 3 tables summarized best evidence available from January 1990 to September 2013, and allowed direct comparison between measures.

When measures were supported by more than one study, data were combined to create larger samples more likely to be representative of the overall community-dwelling older adult population. The number of fallers and nonfallers, as well as the number of participants with positive and negative findings on the test of interest, was combined across studies, and composite prevalence, Sn, Sp, LR, and PoTP values were calculated.[16,17] The resulting overall values for Sn, Sp, LR, and PoTP would likely be more accurate estimates of community-dwelling older adult population's true values, as demonstrated by narrow 95% confidence intervals.[16,17]

RESULTS

Information necessary to calculate Sn and Sp was available for 56 of the 112 included measures (50%). There were 15 questions related to medical history questions (Table 2), 15 self-report measures (Table 3), and 26 performance-based measures (Table 4) with data either about number of fallers and nonfallers having scores above and below cut score, or Sn and Sp, such that calculation of PoTP was possible.

Posttest Probability: Medical History Questions

Information collected during the medical history interview is used to screen clients and identify areas requiring further examination.[18] As seen in Table 2, no medical history questions achieved both high Sn and Sp values for fall risk, typically being more specific than sensitive. LRs of several individual studies yielded PoTP of 50% or more. These included difficulty with activities of daily living (ADL),[33,34] assistive device use,[30,35,42] fear of falling,[35,51] and previous fall history,[33,37,43,48,49,52,54,55,57,59] The combined summary calculations, however, demonstrated small to moderate LRs and small change in PoTP. The medical history questions providing the largest increase in PoTP above PrTP of 30% included *previous falls* (PoTP= 44%), use of *psychoactive medications* (PoTP = 38%), requiring *assistance for any ADL* (PoTP = 38%), being *fearful of falling* (PoTP = 38%),

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a]

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With + Test	Non Fallers With − Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If + Test	If − Test
Activities of daily living (ADL) Not independent Self-report dichotomous	Kwan et al[30]	I	84.6	Pro (24)	Fall inj/ ≥2 falls	74.9 (6.4)	86	174	2 IADL depend	14	157	NR	16 (9-26)	90 (85-94)	1.7 (0.9-3.2)	0.9 (0.8-1.0)	42	28
	Muir et al[31]	I	84.6	Pro (12)	Any fall	79.7 (5.3)	59	58	Any ADL depend	12	52	NR	20 (11-33)	90 (79-96)	2.0 (0.8-4.9)	0.9 (0.8-1.0)	46	28
	Tinetti et al[32]	I	76.9	Pro (12)	Any fall	76.9 (5.3)	546	557	Any ADL depend	364	251	ANOVA $P < .05$	67 (62-71)	45 (41-49)	1.2 (1.1-1.3)	0.7 (0.6-0.9)	34	23
	Muir et al[33]	I	76.9	Pro (12)	Any fall	79.9 (4.7)	78	104	Any ADL depend	7	100	NR	9 (4-18)	96 (90-99)	2.3 (0.7-7.7)	1.0 (0.9-1.0)	50	30
	Coll-Planas et al[34]	I	76.9	Pro (12)	Any fall	82 (NR)	116	76	Bathing depend	74	44	OR = 2.4 $P = .003$	64 (54-73)	58 (46-69)	1.5 (1.1-2.0)	0.6 (0.5-0.9)	39	20
									Walking outside	51	51	OR = 1.6 $P = .12$	44 (35-53)	67 (55-77)	1.3 (0.9-2.0)	0.8 (0.7-1.1)	36	26
									Dressing depend	34	60	OR = 1.6 $P = .20$	29 (21-38)	79 (68-87)	1.4 (0.8-2.3)	0.9 (0.8-1.1)	38	28
									Transfer depend	13	75	OR = 9.5 $P = .01$	11 (6-18)	99 (93-100)	8.5 (1.1-64)	0.9 (0.8-1.0)	78	28
									Stairs depend	31	72	OR = 2.2 $P = .05$	27 (19-36)	95 (87-99)	5.1 (1.9-14)	0.8 (0.7-0.9)	69	26
	Hellstrom et al[35]	III	100	Retro (6)	Any fall	81.7 (4.8)	81	297	Any ADL depend	37	258	χ^2 $P < .001$	47 (36-58)	87 (83-90)	3.6 (2.5-5.2)	0.6 (0.5-0.8)	61	20
	Flemming[36]	III	69.2	Retro (4)	Any fall	78.7 (7.2)	40	267	Any ADL depend	37	75	χ^2 $P = .005$	93 (79-98)	29 (23-34)	1.3 (1.2-1.4)	0.3 (0.1-0.8)	36	11
	Summary: Posttest probability of falling if positive for requiring ADL assistance (excluding Coll-Planas 2007 walking, dressing, transfer, stairs; to avoid duplication of subjects)						1006	1533	Any ADL depend	545	937	NA	54 (51-57)	61 (59-64)	1.4 (1.3-1.5)	0.8 (0.7-0.8)	38	26
Age	Stalenhoef et al[37]	I	84.6	Retro (12)	Any fall	M: 77.2 (4.9) W: 78.5 (5.2)	207	104	≥80	84	63	NR	41 (34-48)	61 (51-70)	1.0 (0.8-1.4)	1.0 (0.9-1.2)	30	30
	Yamada and Iscihashi[38]	I	84.6	Retro (12)	Any fall	80.5 (5.6)	59	112	≥80	34	41	NR	58 (44-70)	37 (28-46)	0.9 (0.7-1.2)	1.2 (0.8-1.7)	28	34

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Non Fallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
	LeClerc et al[39]	II	76.9	Pro (6)	≥2 falls	F: 79.5 (6.6) NF: 79.0 (6.9)	99	769	≥75	72	185	$P > .05$	73 (63-81)	24 (21-27)	1.0 (0.8-1.1)	1.1 (0.8-1.6)	30	32
	Sohng et al[40]	III	92.3	Retro (12)	Any fall	73.3 (6.1)	148	203	≥75	50	118	NR	34 (26-42)	58 (51-65)	0.8 (0.6-1.1)	1.1 (1.0-1.3)	23	32
	Payne et al[41]	III	92.3	Retro (12)	Any fall	R: 75.5 (7.7) U: 76.0 (7.3)	34	81	≥80	11	10	NR	32 (17-51)	79 (69-87)	1.5 (0.8-2.9)	0.9 (0.7-1.1)	39	28
	Summary: Posttest probability of falling if >80 y of age						547	1269	>80	251	471	NA	46 (42-50)	37 (34-40)	0.7 (0.7-0.8)	1.5 (1.3-1.6)	23	39
Ambulatory assistive device use Self-report and observation	Sai et al[42]	I	92.3	Pro (12)	Any fall	76.7 (6.1)	95	42	Yes	30	40	χ^2 $P < .05$	32 (22-42)	95 (84-99)	6.6 (1.7-26.0)	0.7 (0.6-0.8)	74	23
	Brauer et al[43]	I	84.6	Pro (6)	Any fall	71 (5)	35	65	Yes	2	60	χ^2 $P > .05$	6 (1-19)	92 (83-97)	0.7 (0.2-3.6)	1.0 (0.9-1.1)	23	30
	Kwan et al[30]	I	84.6	Pro (24)	Any fall	74.9 (6.4)	86	174	Yes	15	165	NR	17 (10-27)	95 (90-98)	3.4 (1.5-7.4)	0.9 (0.8-1.0)	59	28
	Muir et al[31]	I	84.6	Pro (12)	Any fall	79.7 (5.3)	59	58	Yes	15	50	NR	28 (16-42)	86 (75-94)	2.0 (0.9-4.4)	0.8 (0.7-1.0)	46	28
	Tinetti et al[32]	I	84.6	Pro (12)	Any fall	76.9 (5.3)	546	557	Yes	80	512	ANOVA $P < .05$	15 (12-18)	92 (89-94)	1.9 (1.3-2.6)	0.9 (0.9-1.0)	45	28
	Yamada and Iscihashi[38]	I	84.6	Pro (12)	Any fall	80.5 (5.6)	59	112	Yes	5	99	χ^2 $P = .61$	9 (3-19)	88 (81-94)	0.7 (0.3-2.0)	1.0 (0.0-1.2)	23	30
	Muir et al[33]	I	76.9	Pro (12)	Any fall	79.9 (4.7)	78	104	Yes	12	93	NR	15 (8-25)	90 (83-95)	1.5 (0.7-3.2)	0.9 (0.8-1.1)	39	28
	Hellstrom et al[35]	III	100	Retro (6)	Any fall	81.7 (4.8)	81	297	Yes	45	223	χ^2 $P < .001$	56 (44-67)	75 (70-80)	2.2 (1.7-2.9)	0.6 (0.5-0.8)	49	20
	Shumway-Cook et al[44]	III	84.5	Retro (6)	Any fall	F: 86.2 (6.4) NF: 78.4 (5.8)	15	15	Yes	12	15	NR	80 (52-96)	100 (78-100)	NA	0.2 (0.1-0.6)	NA	8

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Non Fallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
	Desai et al[45]	III	76.9	Retro (12)	Any fall	F 81.5 (6.9) NF 79.4 (5.5)	47	25	Yes	35	7	χ^2 $P > .05$	74 (60-86)	28 (12-49)	1.0 (0.8-1.4)	0.9 (0.4-2.0)	30	28
	Huang[46]	III	76.9	Retro (12)	Any fall	76 (NR)	199	197	Yes	92	138	χ^2 $P < .001$	46 (39-53)	70 (63-76)	1.5 (1.2-2.0)	0.8 (0.7-0.9)	39	26
	Shumway-Cook et al[47]	III	76.9	Retro (6)	≥2 falls	78.7 (7.2)	22	22	Yes	5	22	χ^2 $P < .05$	23 (8-45)	100 (85-100)	NA	0.8 (0.6-1.0)	NA	26
	Flemming[36]	III	69.2	Pro (4)	Any fall	78.7 (7.2)	40	267	Yes	37	77	χ^2 $P = .004$	93 (80-98)	29 (24-35)	1.3 (1.2-1.5)	0.3 (0.1-0.8)	36	11
	Summary: Posttest probability of falling if ambulatory assistive device use						1362	1935	Yes	385	1501	NA	28 (26-31)	78 (76-79)	1.3 (1.1-1.4)	0.9 (0.9-1.0)	36	26
Alcohol consumption Self-report (yes/no)	Sai et al[42]	I	92.3	Pro (12)	Any fall	76.7 (6.1)	95	42	Yes	46	18	NR	48 (38-59)	43 (28-59)	0.9 (0.6-1.2)	1.2 (0.8-1.8)	28	34
	Bongue et al[48]	I	84.6	Pro (12)		70.7 (4.6)	563	1196	Yes	509	101	NR	90 (88-93)	8 (7-10)	1.0 (1.0-1.0)	1.1 (0.8-1.5)	30	32
	Swanenburg et al[49]	I	76.9	Pro (12)	≥2 falls	73.7 (7)	85	185	Daily	27	154	NR	32 (22-43)	83 (77-88)	1.9 (1.2-3.0)	0.8 (0.7-1.0)	45	26
	LeClerc et al[39]	II	76.9	Pro (6)	≥2 falls	F: 79.5 (6.6) NF: 79.0 (6.9)	769	99	Yes	155	78	χ^2 $P > .05$	20 (17-23)	79 (69-86)	1.0 (0.6-1.4)	1.0 (0.9-1.1)	30	30
	Sohng et al[40]	III	92.3	Retro (12)	Any fall	73.3 (6.1)	148	203	Yes	61	111	χ^2 $P = .44$	41 (33-50)	55 (48-62)	0.9 (0.7-1.2)	1.1 (0.9-1.3)	28	32
	Payne et al[41]	III	92.3	Retro (12)	Any fall	R: 75.5 (7.7) U: 76.0 (7.3)	34	81	Yes	11	49	NR	32 (17-51)	61 (49-71)	0.8 (0.5-1.4)	1.1 (0.8-1.5)	28	32
	Huang[46]	III	76.9	Retro (12)	Any fall	F: 81.3 (5.1) NF: 79.7 (4.3)	200	201	Yes	18	175	χ^2 $P > .05$	9 (5-14)	87 (82-91)	0.7 (0.4-1.2)	1.1 (1.0-1.1)	23	32
	Summary: Posttest probability of falling if history of alcohol consumption						1894	2007	Yes	827	686	NA	44 (41-46)	34 (32-36)	0.7 (0.6-0.7)	1.7 (1.6-1.8)	23	42

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Non Fallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
Depression Self-report (yes/no)	Muir et al[31]	I	84.6	Pro (12)	Any fall	79.7 (5.3)	59	58	Yes	16	48	NR	27 (16-40)	83 (71-91)	1.6 (0.8-3.2)	0.9 (0.7-1.1)	41	28
Difficulty walking or missteps Self-report	Srygley et al[50]	I	84.6	Pro	Any fall	76.4 (4.3)	68	198	≥2 missteps	9	177	NR	13 (6-24)	89 (84-93)	1.3 (0.6-2.6)	1.0 (0.9-1.1)	36	30
	Sohng et al[40]	III	92.3	Retro (12)	Any fall	73.3 (6.1)	148	203	Difficulty walking	71	128	χ^2 $P = .05$	48 (40-56)	63 (56-70)	1.3 (1.0-1.7)	0.8 (0.7-1.0)	36	23
	Summary: Posttest probability of falling if self-reported difficulty walking						216	401	Difficulty walking	80	305	NA	37 (931-44)	76 (72-80)	1.6 (1.2-2.0)	0.8 (0.7-0.9)	41	26
Fear of falling Self-report (yes/no)	Coll-Planas et al[34]	I	76.9	Pro (12)	Any fall	82 (NR)	116	76	Yes	33	63	OR = 1.9 $P = .07$	28 (20-38)	83 (73-91)	1.7 (0.9-3.0)	0.9 (0.7-1.0)	42	28
	Muir et al[31]	I	84.6	Pro (12)	Any fall	79.7 (5.3)	59	58	Yes	20	47	NR	34 (22-47)	81 (69-90)	1.8 (0.9-3.4)	0.8 (0.7-1.0)	44	26
	Muir et al[33]	I	76.9	Pro (12)	Any fall	79.9 (4.7)	78	104	Yes	11	97	NR	14 (7-24)	93 (87-97)	2.1 (0.9-5.2)	0.9 (0.8-1.0)	47	28
	Swanenburg et al[49]	I	76.9	Pro (12)	≥2 falls	73.7 (7)	85	185	Yes	24	149	NR	28 (19-39)	81 (74-86)	1.5 (0.9-2.3)	0.9 (0.8-1.0)	39	28
	Hellstrom et al[35]	III	100	Retro (6)	Any fall	81.7 (4.8)	81	297	Yes	48	219	χ^2 $P < .001$	60 (48-70)	70 (68-79)	2.3 (1.7-2.9)	0.6 (0.4-0.7)	50	20
	Keskin et al[51]	III	84.6	Retro	Any fall	F: 68 (3) NF: 70 (5)	12	19	Yes	5	18	χ^2 $P = 02$	42 (15-72)	95 (74-100)	7.9 (1.1-60)	0.6 (0.4-1.0)	77	20
	Flemming[36]	III	69.2	Retro (4)	Any fall	78.7 (7.2)	40	267	Yes	24	165	χ^2 $P = .009$	60 (43-75)	62 (56-68)	1.6 (1.2-2.1)	0.7 (0.4-1.0)	41	23
	Summary: Posttest probability of falling if self-report of fear of falling						471	1006	Yes	165	758	NA	35 (31-40)	75 (73-78)	1.4 (1.2-1.7)	0.9 (0.8-0.9)	38	28
Health status Self-reported (fair or poor)	Kwan et al[30]	I	84.6	Pro (24)	Any fall	74.9 (6.4)	86	174	≤ fair	69	49	IRR = 1.55 $P =$ NR	80 (70-88)	28 (22-35)	1.1 (1.0-1.3)	0.7 (0.4-1.1)	32	23
	Muir et al[31]	I	84.6	Pro (12)	Any fall	79.7 (5.3)	59	58	≤ fair	12	38	NR	20 (11-33)	66 (52-78)	0.6 (0.3-1.1)	1.2 (2.0-1.1)	20	34

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Non Fallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
	Iinattiniemi et al[52]	II	69.2	Pro (11)	Any fall	F: 88(3) NF: 88 (2)	273	282	≤ fair	49	242	χ^2 $P = .22$	18 (14-23)	86 (81-90)	1.3 (0.9-1.9)	1.0 (0.9-1.0)	36	30
	Summary: Posttest probability of falling if health is rated fair or poor						418	514	≤ fair	130	329	NA	31 (27-36)	64 (60-68)	0.9 (0.7-1.0)	1.1 (1.0-1.2)	28	32
History of falling Self-report	Aoyama et al[53]	I	92.3	Pro (6)	Any fall	80.5 (5.7)	25	33	Any fall	18	13	NR	72 (51-88)	39 (23-58)	1.2 (0.8-1.7)	0.7 (0.3-1.5)	34	23
	Herman et al[54]	I	92.3	Pro (24)	Any fall	76.3 (6.1)	131	131	Any fall	46	116	χ^2 $P < .001$	35 (27-44)	89 (82-93)	3.1 (1.8-5.2)	0.7 (0.6-0.8)	57	23
	Lindeman et al[55]	I	92.3	Pro (12)	Any fall	F: 68.8 (6.0) NF: 66.5 (5.8)	30	26	Any fall	19	20	χ^2 $P = .003$	63 (43-80)	77 (56-91)	2.7 (1.3-5.8)	0.5 (0.3-0.8)	54	18
	Sai et al[42]	I	92.3	Pro (12)	Any fall	76.7 (6.1)	95	42	Any fall	54	26	OR = 3.8 $P < .05$	57 (46-67)	62 (46-76)	1.5 (1.0-2.3)	0.7 (0.5-1.0)	39	23
	Bongue et al[48]	I	84.6	Pro (12)	Any fall	70.7 (4.6)	563	1196	Any fall	236	965	NR	42 (38-46)	81 (78-83)	2.2 (1.9-2.5)	0.7 (0.7-0.8)	49	23
	Brauer et al[43]	I	84.6	Pro (6)	Any fall	71 (5)	35	65	Any fall	19	49	χ^2 $P < .05$	54 (37-71)	75 (63-85)	2.2 (1.3-3.7)	0.6 (0.4-0.9)	49	20
	Kwan et al[30]	I	84.6	Pro (24)	Any fall	74.9 (6.4)	86	174	Any fall	33	135	NR	38 (28-50)	78 (71-84)	1.7 (1.2-2.5)	0.8 (0.7-1.0)	42	26
	Muir et al[31]	I	84.6	Pro (12)	Any fall	79.7 (5.3)	59	58	Any fall	34	58	NR	58 (44-70)	100 (93-100)	NA	0.4 (0.3-0.6)	NA	15
	Panzer et al[56]	I	84.6	Pro (12)	≥2 falls	F: 80.1 (6.2) NF: 75.1 (6.5)	39	23	≥2 falls	23	6	χ^2 $P = .24$	59 (42-74)	26 (10-48)	0.8 (0.6-1.1)	1.6 (0.7-3.4)	26	41
	Stalenhoef et al[37]	I	84.6	Pro (9)	≥2 falls	M: 77.2 (4.9) W: 78.5 (5.2)	46	192	Any fall	7	133	OR = 3.0	15 (6-29)	69 (62-75)	0.5 (0.3-1.0)	0.6 (0.5-0.7)	68	20

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Non Fallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
	Coll-Planas et al[34]	I	76.9	Pro (12)	Any fall	82 (NR)	116	76	Any fall	93	31	OR = 1.8 $P = .002$	80 (72-87)	41 (30-53)	1.4 (1.1-1.7)	0.5 (0.3-0.8)	38	18
	LeClerc et al[39]	I	76.9	Pro (6)	≥2 falls	F: 79.5 (6.6) NF: 79.0 (6.9)	99	769	≥2 falls	65	496	χ^2 $P < .001$	66 (55-75)	65 (61-68)	1.9 (1.6-2.2)	0.5 (0.4-0.7)	45	18
	Muir et al[33]	I	76.9	Pro (12)	Any fall	79.9 (4.7)	78	104	Any fall	31	89	NR	40 (29-51)	86 (77-92)	2.8 (1.6-4.7)	0.7 (0.6-0.9)	55	23
	Swanenburg et al[49]	I	76.9	Pro (12)	≥2 falls	73.7 (7)	85	185	≥2 falls	23	173	NR	27 (18-38)	93 (89-96)	4.2 (2.2-8.0)	0.8 (0.7-0.9)	64	26
	Buatois et al[57]	II	69.2	Pro (18)	≥2 falls	70.1 (4.4)	96	903	≥2 falls	53	743	χ^2 $P < .001$	55 (45-65)	82 (80-85)	3.1 (2.5-3.9)	0.5 (0.4-0.7)	57	18
	Flemming[36]	II	69.2	Pro (4)	Any fall	78.7 (7.2)	40	267	Any fall	27	152	χ^2 $P = .004$	68 (51-81)	57 (51-63)	1.6 (1.2-2.0)	0.6 (0.4-0.9)	41	20
	Gerdhem et al[58]	II	69.2	Pro (12)	Any fall	F: 75 (NR) NF: NR	232	746	Any fall	103	585	OR = 2.9 $P < .05$	44 (38-51)	78 (75-81)	2.1 (1.7-2.5)	0.7 (0.6-0.8)	47	23
	Iinattiniemi et al[52]	II	69.2	Pro (11)	Any fall	F: 88 (3) NF: 88 (2)	273	282	≥2 falls	88	243	χ^2 $P < .01$	32 (27-38)	86 (82-90)	2.3 (1.7-3.3)	0.8 (0.7-0.9)	50	26
	Myers et al[59]	III	86.5	Retro (12)	Any fall	74.5 (8.3)	17	20	Any fall	14	15	χ^2 $P < .01$	82 (57-96)	75 (51-91)	3.3 (1.5-7.3)	0.2 (0.1-0.7)	59	8
	Summary: Posttest probability of falling if history of previous fall/s						2109	5292	Any fall	906	4047	NA	43 (41-45)	77 (75-78)	1.8 (1.7-2.0)	0.8 (0.7-0.8)	44	26
History of imbalance Self-report	Shumway-Cook et al[44]	III	76.9	Retro (6)	≥2 falls	78.7 (7.2)	22	22	Yes	21	9	χ^2 $P = .0002$	95 (77-100)	59 (36-79)	2.3 (1.4-3.9)	0.1 (0.0-0.5)	50	4
Limited physical activity or exercise Self-report	Kwan et al[30]	I	84.6	Pro (24)	Fall inj/ ≥2 falls	74.9 (6.4)	86	174	Avoid stairs	54	97	NR	63 (52-73)	56 (48-63)	1.4 (1.1-1.8)	0.7 (0.5-0.9)	38	23

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Non Fallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
	Swanenburg et al[49]	I	76.9	Pro (12)	2+ falls	73.7 (7)	85	185	Seden-tary	8	171	NR	9 (4-18)	92 (88-96)	1.2 (.5-2.8)	1.0 (0.9-1.1)	30	30
	Tinetti et al[32]	I	84.6	Pro (12)	Any fall	76.9 (5.3)	546	557	Walk <3 blocks/d	329	288	ANOVA $P < .05$	60 (56-64)	52 (48-56)	1.3 (1.1-1.4)	0.8 (0.7-0.9)	36	26
	Hellstrom et al[35]	III	100	Retro (6)	Any fall	81.7 (4.8)	81	297	<3 h	58	164	χ^2 $P < .001$	72	55	1.6	0.5	41	18
	Sohng et al[40]	III	92.3	Retro (12)	Any fall	73.3 (6.1)	148	203	Stayed home	42	138	NR	28 (21-36)	68 (61-74)	0.9 (0.6-1.2)	1.1 (0.9-1.2)	26	32
	Karlsson et al[60]	III	77.9	Retro (12)	≥2 falls	75 (NR)	2049	8928	No exercise	1443	3108	Regres-sion $P < .01$	70 (68-72)	35 (34-36)	1.1 (1.1-1.1)	0.8 (0.8-0.9)	32	26
									No HHW	738	6071	Regres-sion $P < .01$	36 (34-38)	70 (69-71)	1.2 (1.1-1.3)	0.9 (0.9-0.9)	34	28
	Iinattiniemi et al[52]	III	69.2	Retro (11)	Any fall	88 (2)	273	282	Seden-tary	81	219	χ^2 $P = .06$	30 (24-35)	78 (72-82)	1.3 (1.0-1.8)	0.9 (0.8-1.0)	36	28
	Rosengren et al[61]	III	64.2	Retro (12)	Any fall	F: 74.8 (NR) NF: 73.7 (NR)	1918	8912	No exercise	1283	2683	χ^2 $P = .2$	67 (65-69)	30 (29-31)	1.0 (0.9-1.0)	1.1 (1.0-1.2)	30	32
									No HHW	683	6042	χ^2 $P = .004$	37 (33-38)	68 (67-69)	1.1 (1.0-1.2)	0.9 (0.9-1.0)	32	28
	Summary: Posttest probability of falling if self-report of limited habitual physical activity (excluding Karslon and Rosengren HHW to avoid duplication of subjects)						5186	19 538	Limited physi-cal activity	3298	6867	NA	64 (2-65)	35 (34-36)	1.0 (1.0-1.0)	1.0 (1.0-1.1)	30	30
Nocturia, incontinence, urinary urgency, or difficulty Self-report	Stewart et al[62]	III	84.6	Retro (12)	Any fall	W: 79.9 (4.6) M: 80.0 (4.2)	254	1254	≥2 nocturia	141	688	OR = 1.8 $P = .03$	56 (49-62)	55 (52-58)	1.2 (1.1-1.4)	0.8 (0.7-0.9)	34	26
	Coll-Planas et al[34]	I	76.9	Pro (12)	Any fall	82 (NR)	116	76	≥2 nocturia	46	48	OR = 1.1 $P = .64$	40 (31-49)	63 (51-74)	1.1 (0.7-1.6)	1.0 (0.8-1.2)	32	30

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Non Fallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
	Bongue et al[48]	I	84.6	PRO (12)	Any fall	70.7 (4.6)	563	1196	Yes	108	1066	OR = 1.9 *P* = NR	19 (16-23)	89 (87-91)	1.8 (1.4-2.2)	0.9 (0.9-1.0)	44	28
	Hellstrom et al[35]	III	100	Retro (6)	Any fall	81.7 (4.8)	81	297	Yes	19	254	χ^2 *P* = .05	23 (15-34)	86 (81-89)	1.6 (1.0-2.6)	0.9 (0.8-1.0)	41	28
	Huang[46]	III	76.9	Retro (12)	Any fall	F: 81.3 (5.1) NF: 79.7 (4.3)	195	202	Yes	66	160	χ^2 *P* < .001	34 (27-41)	79 (73-85)	1.6 (1.2-2.3)	0.8 (0.7-0.9)	41	26
	de Rekeneire et al[63]	III	69.2	Retro (12)	Any fall	Range: 70-79	652	2398	Yes	314	1537	χ^2 *P* < .01	48 (44-52)	64 (62-66)	1.3 (1.2-1.5)	0.8 (0.8-0.9)	36	26
	Flemming[36]	III	69.2	Retro (4)	Any fall	78.7 (7.2)	40	267	Yes	16	195	χ^2 *P* = .09	40 (25-57)	73 (67-78)	1.5 (1.0-1.3)	0.8 (0.6-1.1)	39	26
	Coll-Planas et al[34]	I	76.9	Pro (12)	Any fall	82 (NR)	116	76	Yes	57	46	OR = 1.5 *P* = NR	49 (40-59)	61 (49-72)	1.2 (0.9-1.7)	0.8 (0.7-1.1)	60	26
	Iinattiniemi et al[52]	III	69.2	Retro (11)	Any fall	88 (2)	273	282	Yes	30	267	χ^2 *P* = .01	11 (8-15)	95 (91-97)	2.1 (1.1-3.8)	0.9 (0.9-1.0)	47	28
	Summary: Posttest probability if any urinary difficulty						2290	6048	Any urinary difficulty	797	14261	NA	35 (33-37)	70 (69-72)	1.2 (1.1-1.3)	0.9 (0.9-1.0)	34	26
Pain Self-report	Kwan et al[30]	I	84.6	Pro (24)	Fall inj/≥2 falls	74.9 (6.4)	86	174	Signifi-cant	45	134	NR	47 (36-58)	74 (67-80)	1.8 (1.3-2.5)	0.7 (0.6-0.9)	44	23
Polyphar-macy ≥4 medications, self-report	Peeters et al[64]	I	93.3	Pro (37)	≥2 falls	F: 76.9 (6.9) NF: 74.9 (7.3)	325	1004	≥4 meds	96	777	χ^2 *P* = .01	30 (25-35)	77 (75-80)	1.3 (1.1-1.6)	0.9 (0.8-1.0)	36	28
	Kwan et al[30]	I	84.6	Pro (24)	≥2 falls	74.9 (6.4)	86	174	≥4 meds	33	135	NR	38 (28-49)	78 (71-84)	1.7 (1.2-2.5)	0.8 (0.7-1.0)	42	26
					Fall inj/≥2 falls	74.9 (6.4)	86	174	≥4 meds	14	150	NR	16 (9-26)	86 (80-91)	1.2 (0.6-1.2)	1.0 (0.9-1.1)	34	30

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Non Fallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
	Brauer et al[43]	I	84.6	Pro (6)	Any fall	71 (5)	35	65	≥3 meds	7	45	χ^2 $P > .05$	20 (8-37)	69 (57-80)	0.7 (0.2-1.4)	1.2 (0.9-1.5)	23	34
	Muir et al[31]	I	84.6	Pro (12)	Any fall	79.7 (5.3)	59	58	≥4 meds	48	13	NR	81 (69-90)	22 (13-35)	1.1 (0.9-1.3)	0.8 (0.4-1.7)	32	26
	Coll-Planas et al[34]	I	76.9	Pro (12)	Any fall	82 (NR)	116	76	≥5 meds	74	32	OR = 1.2 $P = .06$	64 (54-73)	42 (31-54)	1.1 (0.9-1.4)	0.9 (0.6-1.3)	32	28
	Swanenburg et al[49]	I	76.9	Pro (12)	≥2 falls	73.7 (7)	85	185	≥4 meds	54	110	NR	64 (52-74)	59 (52-67)	1.6 (1.2-2.0)	0.6 (0.5-0.8)	41	20
	Muir et al[33]	I	76.9	Pro (12)	Any fall	79.9 (4.7)	78	104	≥4 meds	64	35	NR	82 (72-90)	34 (25-44)	1.2 (1.0-1.5)	0.5 (0.3-0.9)	34	18
	LeClerc et al[39]	I	76.9	Pro (6)	≥2 falls	F: 79.6 (6.6) NF: 79.0 (6.9)	99	769	≥4 meds	91	99	χ^2 $P > .05$	92 (85-96)	13 (11-15)	1.1 (1.0-1.1)	0.6 (0.3-1.3)	32	20
	Buatois et al[57]	II	69.2	Pro (18)	≥2 falls	70.1 (4.4)	96	903	≥4 meds	52	569	χ^2 $P = .001$	54 (44-64)	63 (60-67)	1.5 (1.2-1.8)	0.7 (0.6-0.9)	39	23
	Payne et al[41]	III	92.3	Retro (12)	Any fall	R: 75.5 (7.7) U: 76.0 (7.3)	34	81	≥6 meds	10	47	NR	29 (15-48)	58 (47-69)	0.7 (0.4-1.3)	1.2 (0.9-1.6)	23	34
	Sai et al[42]	III	92.3	Retro (12)	Any fall	76.7 (6.1)	95	42	≥4 meds	35	35	NR	37 (27-47)	83 (69-93)	2.2 (1.2-4.6)	0.8 (0.6-0.9)	49	26
	Perracini et al[65]	III	84.6	Retro (12)	Any fall	F-LA 87/ MA 79 NF-La 78/ MA 76	68	54	≥5 meds	41	30	χ^2 $P = .03$	60 (48-72)	56 (41-69)	1.4 (1.0-1.9)	0.7 (0.5-1.0)	38	23
	Shumway-Cook et al[47]	III	84.5	Retro (6)	Any fall	F: 86.2 (6.4) NF: 78.4 (5.8)	15	15	≥4 meds	2	15	NR	13 (2-40)	100 (78-100)	NA	0.9 (0.7-1.1)	NA	28

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Non Fallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
	Huang[46]	III	76.9	Retro (12)	Any fall	F: 81.3 (5.1) NF: 79.7 (4.3)	190	190	≥4 meds	78	129	χ^2 $P < .05$	41 (34-48)	70 (63-76)	1.4 (1.0-1.8)	0.9 (0.7-1.0)	38	28
	Flemming[36]	III	69.2	Retro (4)	Any fall	78.7 (7.2)	40	267	≥4 meds	34	71	χ^2 $P = .12$	85 (70-94)	27 (21-32)	1.2 (1.0-1.3)	0.6 (0.3-1.2)	34	20
	Summary: Posttest probability of falling if taking ≥4 medications of any kind						1507	4161	≥4 meds	733	2292	NA	48 (46-51)	55 (54-57)	1.1 (1.0-1.2)	0.9 (0.9-1.0)	32	28
Psychoactive medications Self-report (yes/no)	Beauchet et al[66]	I	92.3	Pro (12)	Any fall	84.8 (5.2)	54	133	Any	30	67	χ^2 $P = .46$	56 (41-69)	50 (42-59)	1.1 (0.8-1.5)	0.9 (0.6-1.3)	32	28
	Peeters et al[64]	I	93.3	Pro (37)	≥2 falls	F: 76.9 (6.9) NF: 74.9 (7.3)	325	1004	Any	67	877	χ^2 $P < .001$	21 (16-26)	89 (86-90)	1.8 (1.4-2.4)	0.9 (0.8-1.0)	44	28
	Bongue et al[48]	I	84.6	Pro (12)	Any fall	70.7 (4.6)	563	1196	Any	135	1030	NR	24 (21-27)	86 (84-88)	1.7 (1.4-2.1)	0.9 (0.8-0.9)	42	28
	Kwan et al[30]	I	84.6	Pro (24)	Fall inj/≥2 falls	74.9 (6.4)	86	174	Any	7	165	NR	8 (3-16)	95 (90-98)	1.6 (0.6-4.1)	1.0 (0.9-1.0)	41	30
	Peeters et al[67]	I	84.6	Pro (36)	Any Fall	1F: 74.9 (6.4) ≥2F: 77.0 (6.9) NF: 74.8 (6.2)	740	597	Any	81	535	χ^2 $P < .001$	11 (9-13)	90 (87-92)	1.1 (0.8-1.4)	1.0 (1.0-1.0)	32	30
	Tinetti et al[32]	I	84.6	Pro (12)	Any fall	76.9 (5.3)	546	557	Any	89	512	ANOVA $P < .05$	16 (13-20)	92 (89-94)	2.0 (1.4-2.8)	0.9 (0.9-1.0)	46	28
	LeClerc et al[39]	II	76.9	Pro (6)	≥2 falls	F: 79.5 (6.6) NF: 79.0 (6.9)	99	769	Any	50	406	χ^2 $P > .05$	51 (40-61)	53 (49-56)	1.1 (0.9-1.3)	0.9 (0.8-1.2)	32	28

(*continues*)

Table 2. Summary of Findings for Determining Risk of Falls During Patient Medical History Component of the Physical Therapy Examination[a] (*Continued*)

History Questions	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age, Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With + Test	Non Fallers With − Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If + Test	If − Test
	Buatois et al[57]	II	69.2	Pro (18+)	≥2 falls	70.1 (4.4)	96	903	Any	19	812	χ^2 $P = .06$	20 (12-29)	95 (88-92)	2.0 (1.3-3.1)	0.9 (0.8-1.0)	46	28
	Hellstrom et al[35]	III	100	Retro (6)	Any fall	81.7 (4.8)	81	297	Any	62	218	χ^2 $P < .02$	77 (66-85)	73 (68-78)	2.9 (2.3-3.6)	0.3 (0.2-0.5)	55	11
	Huang[46]	III	76.9	Retro (12)	Any fall	F: 81.3 (5.1) NF: 79.7 (4.3)	194	198	Any	44	176	χ^2 $P < .05$	23 (17-29)	87 (81-91)	1.7 (1.1-2.7)	0.9 (0.8-1.0)	42	28
	de Rekeneire et al[63]	III	69.2	Retro (12)	Any fall	Range: 70-79	652	2398	Any	48	2288	χ^2 $P = .01$	7 (5-10)	95 (95-96)	1.6 (1.2-2.2)	1.0 (0.9-1.0)	41	30
	Iinattiniemi et al[52]	III	69.2	Retro (11)	Any fall	88 (2)	273	282	Any	118	187	χ^2 $P = .02$	43 (37-49)	66 (60-72)	1.3 (1.0-1.6)	0.9 (0.8-1.0)	36	28
	Summary: Posttest probability of falling if using any psychoactive medication						3709	8508	Any	750	7269	NA	22 (19-22)	85 (85-86)	1.4 (1.3-1.5)	0.9 (0.9-1.0)	38	26
	Summary: Posttest probability of falling if using any psychoactive medication						3709	8508	Any	750	7269	NA	22 (19-22)	85 (85-86)	1.4 (1.3-1.5)	0.9 (0.9-1.0)	38	26

Abbreviations: AD, use of any assistive device; ADL, activities of daily living; ANOVA, analysis of variance; AUC, area under the curve; CI_{95}, 95% confidence interval; Depend, dependence; F, faller/persons who fell; Fall inj, fall with injury; HHW, heavy house work; IADL, instrumental activities of daily living; LA, less active; IRR, Incident Rate Ratio; M, men in the sample; MA, more active; −, negative; +, positive; NA, not applicable; NF, nonfaller/persons who did not fall; NR, not reported; OR, odds ratio; Pro, prospective; QUADAS, Quality Assessment Tool for Diagnostic Accuracy Studies; R, rural; Retro, retrospective; ROC, receiver operating characteristic curve; SD, standard deviation; Sn, sensitivity; Sp, specificity; U, urban; W, women in the sample.

[a]Posttest probabilities are based on an assumption of a 30% pretest probability for future falls.

Table 3. Summary of Findings for Determining Risk of Falls Using Self-Report Measures, Grouped by Construct Being Measured[a]

Self-Report Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Nongallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
Measures of balance confidence and fear of falling																		
Activity-Specific Balance Confidence Scale 0%-100% Low: less confidence	Payne et al[41]	III	92.3	Retro (12)	Any fall	R: 75.5 (7.7) U: 76.0 (7.3)	34	81	<60	12	71	NR	35 (20-53)	88 (78-94)	2.9 (1.4-6.0)	0.7 (0.6-1.0)	55	23
Balance Self-Perception Test Ordinal 0-60 points Low: less confidence	Shumway-Cook et al[44]	III	76.9	Retro (6)	≥2 falls	F: 77.6 (7.8) NF: 74.6 (5.4)	22	22	≤50	16	18	*t* test *P* = .01	73 (50-89)	82 (60-95)	4.0 (1.6-10)	0.3 (0.2-0.7)	63	11
Falls Efficacy Scale International Ordinal 16-64 points High: more concern about falling	Delbaere et al[68]	I	92.3	Pro (12)	≥2 falls	77.9 (4.6)	166	334	>21	103	181	OR = 1.3 *P* = .01	62 (54-69)	54 (49-60)	1.4 (1.2-1.6)	0.7 (0.6-0.9)	38	23
	Kwan et al[30]	I	84.6	Pro (24)	Fall inj/ ≥2 falls	74.9 (6.4)	86	174	≥24	64	127	NR	74 (64-83)	73 (66-79)	2.8 (2.1-3.6)	0.4 (0.2-0.5)	54	14
	Summary: posttest probability of falling on the basis of high FES-I score						252	508	≥24	167	308	NA	66 (60-72)	60 (56-65)	1.7 (1.0-2.4)	0.6 (0.1-0.2)	42	20
Falls Efficacy Scale-Modified Ordinal 0-10 rating on 14 items, averaged High: more concern	Payne et al[41]	III	92.3	Retro (12)	Any fall	R: 75.5 (7.7) U: 76.0 (7.3)	34	81	<6	6	76	NR	21 (8-41)	94 (86-98)	3.5 (1.1-10)	0.8 (0.7-1.0)	60	26
Falls Risk Assessment Questionnaire Ordinal 0-16 points High: greater risk	Flemming[36]	III	69.2	Pro (3)	Any fall	F: 78.7 (7.2) NF: 78.6 (7.7)	40	267	>8	216	51	*t* test *P* < .001	75 (59-87)	81 (76-85)	3.9 (2.9-5.3)	0.3 (0.2-0.5)	63	11
Measures of activities of daily living																		
Barthel index Ordinal 0-20 points Low: more disability	Stalenhoef et al[37]	I	84.6	Pro (9)	Any fall	M: 7.2 (4.9) F: 78.5 (5.2)	2F 46	192	<19	22	180	OR = 3.3 *P* < .05	48 (38-59)	94 (89-97)	7.8 (4.3-14)	0.6 (0.5-0.7)	77	20

(*continues*)

Table 3. Summary of Findings for Determining Risk of Falls Using Self-Report Measures, Grouped by Construct Being Measured[a] (*Continued*)

Self-Report Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Nongallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
Oars ADL Scale Ordinal 0-28 points Low: more disability	Perracini et al[65]	III	84.6	Retro (12)	Any fall	LA-F: 86.6 MA-F: 78.5 LA-NF: 77.6 MA-NF: 75.6	66	52	>4	41	37	*t*-test LA, $P = .004$ MA, $P = .18$	62 (49-74)	71 (57-83)	2.2 (1.4-3.4)	0.5 (0.4-0.7)	49	18
Measures of cognition																		
MMSE Ordinal 0-30 points Low: more impairment	Beauchet et al[66]	I	92.3	Pro (12)	Any fall	F: 85.7 (5.2) NF: 84.4 (5.3)	54	133	<25	34	64	*t*-test $P > .05$	63 (49-76)	52 (43-61)	1.3 (1.0-1.7)	0.7 (0.5-1.1)	36	23
	Shumway-Cook et al[44]	III	76.9	Retro (6)	Any fall	F: 77.6 (7.8) NF: 74.6 (5.4)	22	33	NR	10	27	χ^2 $P = .02$	45 (24-68)	82 (65-93)	2.5 (1.1-6.0)	0.7 (0.4-1.0)	52	23
	Summary: Posttest probability of falling on the basis of low MMSE score						76	166	<25	44	91	NA	58 (46-69)	55 (47-63)	1.3 (1.0-1.7)	0.8 (0.6-1.0)	36	26
Short-Orientation Memory Concentration Test Ordinal 0-28 points High: more impairment	Coll-Planas et al[34]	I	76.9	Pro (12)	Any fall	82 (NR)	116	76	≥9	38	52	OR = 1.1 $P = .72$	33 (24-42)	68 (57-79)	1.0 (0.7-1.6)	1.0 (0.8-1.2)	30	30
Measures of depression																		
Center for Epidemiologic Studies Depression Scale Ordinal 0-60 points High: more depression	Tinetti et al[32]	I	84.6	Pro (12)	Any Fall	76.9 (5.3)	546	557	≥16	116	457	ANOVA $P < .05$	21 (18-25)	82 (79-85)	1.2 (0.9-1.5)	1.0 (0.9-1.0)	34	30
	de Rekeneire et al[63]	III	69.2	Retro (12)	Any fall	Range: 70-79	652	2398	≥16	41	2292	χ^2 $P < .05$	6 (5-8)	96 (95-96)	1.4 (1.0-2.0)	1.0 (1.0-1.0)	38	30
	Summary: Posttest probability if CES-D indicates depression						1198	2955	≥16	157	2749	NA	13 (11-15)	93 (92-94)	1.9 (1.5-2.3)	0.9 (0.9-1.0)	45	28
Geriatric Depression Scale-15 item Ordinal 0-15 points	Beauchet et al[66]	I	92.3	Pro (12)	Any fall	F: 85.7 (5.2) NF: 84.4 (5.3)	54	133	>4	11	118	χ^2 $P = .003$	20 (11-34)	89 (82-94)	1.8 (0.9-3.7)	0.9 (0.8-1.0)	44	28
GDS-4-item Ordinal 0-4 points	Kwan et al[30]	I	84.6	Pro (24)	Any fall	74.9 (6.4)	86	174	≥6	28	146	IRR = 1.82 $P < .05$	33 (23-44)	84 (78-89)	2.0 (1.3-3.2)	0.8 (0.7-0.9)	46	26

(*continues*)

Table 3. Summary of Findings for Determining Risk of Falls Using Self-Report Measures, Grouped by Construct Being Measured[a] (*Continued*)

Self-Report Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Nongallers With −Test	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability, %	
																	If +Test	If −Test
	Iinattiniemi et al[52]	II	69.2	Pro (11)	Any fall	F: 88 (3) NF: 88 (2)	273	282	>7	71	241	χ^2 $P < .01$	26 (21-32)	85 (81-89)	1.8 (1.3-2.5)	0.9 (0.8-0.9)	44	28
	Summary: Posttest probability of falling based on GDS-15 Score						413	589	≥7	110	505	NA	27 (22-31)	86 (83-88)	1.9 (1.5-2.4)	0.9 (0.8-0.9)	45	28
	Bongue et al[48]	I	84.6	Pro (12)	Any fall	70.7 (4.6)	563	1196	≥1	198	872	OR = 1.5 NR	35 (31-39)	73 (71-75)	1.3 (1.1-1.5)	0.9 (0.8-1.0)	36	28
	Coll-Planas et al[34]	I	76.9	Pro (12)	Any fall	82 (NR)	116	76	≥1	55	46	OR = 1.5 $P = .23$	48 (38-57)	61 (49-72)	1.2 (0.9-1.7)	0.9 (0.7-1.1)	34	28
	Summary: Posttest probability of falling based on GSD-4 Score						679	1272	≥1	253	918	NA	37 (34-41)	72 (70-75)	1.3 (1.2-1.5)	0.9 (0.8-0.9)	36	28
Measures of physical activity																		
Longitudinal study of Aging Physical Activity Questionnaire LASA-PAQ Ordinal 0-30 points	Peeters et al[64]	I	92.3	Pro (36)	≥2 falls	F: 76.8 (6.8) NF: 74.8 (6.3)	325	1004	No HHW	173	611	χ^2 $P < .05$	63 (48-59)	61 (58-64)	1.4 (1.2-1.6)	0.8 (0.7-0.9)	38	26
	Peeters et al[69]	1	84.6	Pro (12)	≥2 falls	77.9 (7.1)	76	332	>8	48	208	ROC AUC = .65	63 (51-74)	63 (57-68)	1.7 (1.4-2.1)	0.6 (0.4-0.8)	42	20
SF-36 Physical Activity Subscale Ordinal 0-100 points	Bohannon et al[70]	III	90	Retro (24)	Any fall	F: 80.8 (7.2) NF: 78 (7.75)	29	29	<72.5	27	19	*t* test $P < .001$	93 (77-99)	66 (46-82)	2.7 (1.6-4.5)	0.1 (0.0-0.4)	54	4
Measures of caregiver concern about fall risk																		
Subjective risk rating for specific tasks Ordinal 0-7 points	Hashidate et al[71]	III	77.9	Retro (12)	Any fall	65 and older	17	13	≥2	14	7	χ^2 $P < .05$	82 (57-96)	54 (25-81)	1.8 (1.0-3.3)	0.3 (0.1-1.0)	44	11
Measures of overall health status																		
Sickness Impact Profile (SIP-68) Ordinal High = poor health	Stalenhoef et al[37]	I	84.6	Pro (9)	≥2 falls	M: 77.2 (4.9) W: 78.5 (5.2)	46	192	≥8	6	148	OR = 2.5 P = NR	13 (5-26)	77 (70-83)	0.6 (0.3-1.3)	1.1 (1.0-1.3)	20	3.2

(*continues*)

Table 3. Summary of Findings for Determining Risk of Falls Using Self-Report Measures, Grouped by Construct Being Measured[a] (*Continued*)

Self-Report Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test	Nongallers With −Test	Difference *P*	Sn (CI95), %	Sp (CI95), %	+LR (CI95)	−LR (CI95)	Posttest Probability, % If +Test	Posttest Probability, % If −Test
Self-rated health Ordinal 0-10 points	Payne et al[41]	III	92.3	Retro (12)	Any fall	R: 75.5 (7.7) U: 76.0 (7.3)	34	81	<5	8	64	NR	24 (11-41)	79 (69-87)	1.1 (0.5-2.4)	1.0 (0.8-1.2)	32	30
									<8	21	31	NR	62 (44-78)	38 (28-50)	1.0 (0.7-1.4)	1.0 (0.6-1.7)	30	30

Abbreviations: ADL, activities of daily living; ANOVA, analysis of variance; AUC; CES-D, Center for Epidemiological Studies Depression; CI_{95}, 95% confidence interval; F, fallers; fall inj, fall with injury;FES-I, Falls Efficacy Scale International; GDS, Geriatric Depression Scale; HHW, heavy house work; IRR; LA, less active; LASA-PAQ, Longitudinal Study of Aging Physical Activity Questionnaire; LR, likelihood ratio; MA, more active; MMSE, Mini-Mental State Questionnaire; NA, not applicable; NF, nonfallers; NR, not reported; −, negative; OARS, Older Adults Resources and Services; OR, odds ratio; +, positive; Pro, prospective; QUADAS, Quality Assessment Tool for Diagnostic Accuracy Studies; Retro, retrospective; R, rural; ROC; SD, standard deviation; SF-36, 36-item Short Form Health Survey; Sn, sensitivity; Sp, specificity; U, urban.

[a]Posttest probabilities are based on an assumption of a 30% pretest probability for future falls.

and use of an *ambulatory assistive device* (PoTP = 36%). Five of these six questions (excluding fear of falling), when answered negatively, reduced PoTP to 26%. One study[34] (Level I, prospective, n = 192) suggested that any reported difficulty with transfers (PoTP = 78%) or stairs (PoTP = 69%) should trigger further evaluation. Although less powerful, self-reported difficulty with walking might indicate possibility of future falls (PoTP = 41%).[40,50] Although the literature suggests that advancing age (>80 years),[37-41] poor self-reported health,[30,31,52] and frequent alcohol consumption[39,40,41,43,46,48,49] are risk factors for falls, these conclusions were not supported by summary PoTP values for either positive or negative test results. Evidence about polypharmacy was inconsistent across studies.

Posttest Probability: Self-Report Measures

Self-report measures, in the form of questionnaires, are often used to collect data before physical therapy examination.[18] Some of these measures demonstrate clinical utility as fall risk tools (Table 3).

Positive test results for 4 ordinal measures of balance confidence/fear of falling substantially increased PoTP. Although data about the Falls Risk Assessment Questionnaire[36] (>8 of 16 points; PoTP = 63%), the Balance Self-Perception Test[44] (<50 of 60 points; PoTP = 63%), and the Activities Specific Balance Confidence Test[41] (<90 of 100%; PoTP = 59%) look promising, results were based on a single study with small sample sizes. The *Falls Efficacy Scale International* (≥24; PoTP = 42%) is supported by 2 Level I prospective studies with moderate sample sizes,[30,68] and may be more trustworthy.

Both positive and negative test results on ordinal measures of ADL appear to be informative. Scoring 19 points or less on the Barthel index resulted in a PoTP of 77%, whereas scoring 20 points or more resulted in a PoTP of 20% for multiple falls.[37] This was derived from a single study with moderate sample size (n = 242). The Older Adults Resources and Services (OARS) ADL scale[65] produced similar results. It should be noted that the OARS scale requires specialized training and more time to administer than the Barthel index.

Cognitive dysfunction, as measured by the Mini-Mental State Evaluation (MMSE) score less than 25, appears to shift PoTP slightly (38% if positive, 23% if negative) on the basis of 1 Level I[66] and 1 Level III[44] study, both with small sample sizes. Because cognitive dysfunction was one of the exclusion criteria for the review, the value of the MMSE as a fall risk tool may have been underestimated.

Two of 3 ordinal measures of depression appear to have potential to indicate risk of falling. Both the *Geriatric Depression Scale-15* (GDS-15) score less than 6 (supported by 2 Level I[30,66] and 1 Level II[52] prospective studies) and the Center for Epidemiological Studies Depression (CES-D) score 16 or more[32,63] yielded a PoTP of 45% if positive, and a PoTP of 28% if negative. The GDS-15 has fewer

Table 4. Summary of Findings for Determining Risk of Falls Using Performance-Based Functional Measures[a]

Functional Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test Mean (SD)	Nonfallers With −Test Mean (SD)	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability	
																	If +Test	If −Test
Alternate Step Test Continuous, s	Tiedemann et al[72]	I	92.3	Pro (12)	≥2 falls	80.4 (4.5)	74	265	≥10	51 12.2 (4.6)	95 10.8 (23.8)	*t* test *P* = .007	69 (57-79)	64 (58-70)	1.9 (1.5-2.4)	0.5 (0.3-0.7)	45	18
BBS Ordinal 0-56 points Low score: high risk	LeClerc et al[39]	I	76.9	Pro (6)	≥2 falls	F: 79.5 (6.6) NF: 79.0 (6.9)	99	769	≤30	19 39.4 (8.5)	703] 43.9 (8.5)	*t* test *P* > .05	19 (12-28)	91 (89-93)	2.2 (1.4-3.6)	0.9 (0.8-1.0)	49	28
	Muir et al[31]	I	76.9	Pro (12)	Any fall	79.9 (4.7)	78	104	≤50	43 48.9 (9.1)	62 52.0 (6.1)	NR	55 (43-66)	60 (50-69)	1.4 (1.0-1.9)	0.8 (0.6-1.0)	38	26
	O'Brien et al[73]	III	76.9	Retro (12)	Any fall	F: 76.0 (6.7) NF: 73.8 (4.1)	13	23	≤45	7 45.0 (NR)	23 55.0 (NR)	MW-U *P* < .001	54 (25-81)	100 (85-100)	NA	0.5 (0.3-0.8)	NA	18
	Shumway-Cook et al[44]	III	76.9	Retro (6)	≥2 falls	F: 77.6 (7.8) NF: 74.6 (5.4)	22	22	≤49	17 36.6 (11.1)	19 52.6 (3.4)	*t* test *P* < .001	77 (55-92)	86 (65-97)	5.7 (1.9-16.6)	0.3 (0.1-0.6)	71	11
	Summary: Posttest probability of falling on the basis of BBS score ≤50						212	918	≤50	86	807	NA	41 (34-47)	88 (85-90)	3.4 (2.6-4.3)	0.7 (0.6-0.80)	59	23
BBS and history of imbalance	Shumway-Cook et al[44]	III	76.9	Retro (6)	≥2 falls	F: 77.6 (7.8) NF: 74.6 (5.4)	22	22	≤42/ no or <51/yes	20	18	NR	91 (71-99)	82 (60-95)	5.0 (2.0-12)	0.1 (0.0-0.4)	68	4
Clinical Test of Sensory Organization and Balance Foam and dome continuous, sec Less time: higher risk	Ricci et al[74]	III	69.2	Retro (12)	≥2 falls	≥2F: 74.8 (7.3) NF: 74.5 (6.4) Single fallers not reported due to no difference between NF and single fallers in 5 of 6 conditions)	32	32	EO-Firm <30 s	1 29.7 (1.7)	32 30.0 (0.0)	ANOVA *P* = .50	3 (1-16)	100 (89-100)	NA	1.0 (0.9-1.0)	NA	30
									EC-Firm A <30 s	5 27.9 (5.4)	30 29.7 (1.1)	ANOVA *P* = .08	16 (5-33)	94 (79-99)	2.5 (0.5-12)	0.9 (0.8-1.1)	52	28
									Dome-FOAM <30 s	7 26.8 (5.0)	30 29.2 (4.4)	ANOVA *P* = .18	22 (9-40)	94 (78-99)	3.5 (0.8-16)	0.8 (0.7-1.0)	60	26
									EO-FOAM <30 s	6 26.9 (5.0)	32 30.0 (0.0)	ANOVA *P* = .04	19 (7-36)	100 (89-100)	NA	0.8 (0.7-1.0)	NA	26
									EC-FOAM <30 s	16 21.4 (11.4)	26 26.2 (8.4)	ANOVA *P* = .02	50 (32-68)	81 (64-93)	2.7 (1.2-6.0)	0.6 (0.4-0.9)	54	20
									Dome-FOAM <30 s	13 21.1 (11.8)	26 26.9 (7.7)	ANOVA *P* = .01	41 (24-49)	81 (64-93)	2.2 (0.9-5.0)	0.7 (0.5-1.0)	49	23

(*continues*)

Table 4. Summary of Findings for Determining Risk of Falls Using Performance-Based Functional Measures[a] (*Continued*)

Functional Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test Mean (SD)	Nonfallers With –Test Mean (SD)	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	–LR (CI_{95})	Posttest Probability	
																	If +Test	If –Test
Dynamic gait index Ordinal (0-24) Low scores: higher risk	Weiss et al[75]	I	76.9	Pro (6)	≥2 falls	F: 77.9 (5.1) NF: 78.8 (4.4)	12	59	NR	4	58	NR	64 (41-83)	98 (91-100)	3.7 (5.2-26.9)	0.7 (0.2-0.6)	94	23
		III	76.9	Retro (6)	≥2 falls	F: 77.9 (5.1) NF: 78.8 (4.4)	32	39	NR	12 20.7 (3.3)	35 22.2 (1.8)	*t*-test $P = .15$	38 (21-56)	90 (76-97)	3.7 (1.3-10.3)	0.7 (0.5-0.9)	61	23
	Shumway-Cook et al[44]	III	76.9	Retro (6)	≥2 falls	F: 77.6 (7.8) NF: 74.6 (5.4)	22	22	19	13 15.6 (5.7)	11 20.6 (2.9)	*t* test $P = .001$	59 (36-79)	64 (41-83)	1.6 (0.9-3.1)	0.6 (0.4-1.2)	41	20
	Herman et al[54]	III	69.2	Retro (12)	Any fall	76.3 (NR)	74	204	≤19	66 22.5 (1.8)	6 23.0 (1.4)	*t* test $P = .03$	90 (81-96)	3 (1-6)	0.9 (0.9-1.0)	3.3 (1.1-9.4)	28	59
	Summary: Posttest probability of recurrent falls on the basis of DGI score ≤19						140	324	≤19	95	111	NA	68 (60-76)	34 (29-40)	1.0 (0.9-1.2)	0.9 (0.7-.3))	30	28
	Summary: Posttest probability of recurrent falls on the basis of DGI score ≤19 (excluding Herman 2009)						66	120	≤19	29	107	NA	44 (32-57)	89 (82-94)	4.0 (2.3-7.3)	0.6 (0.5-0.8)	63	20
Fullerton Advanced Balance Scale Ordinal 0-40	Hernandez and Rose[76]	III	84.6	Retro (12)	≥2 falls	77.0 (6.5)	59	133	25	43 20 (7.3)	69 25 (6.7)	*t* test $P = .19$	73 (60-84)	52 (43-61)	1.5 (1.2-1.9)	0.5 (0.3-0.8)	39	18
5TSTS Continuous, s	Tiedemann et al[72]	I	92.3	Pro (12)	≥2 falls	80.4 (4.5)	80	282	≥12 s	53 14.8 (6.2)	127 12.5 (4.8)	*t* test $P < .001$	66 (55-76)	45 (39-51)	1.2 (1.0-1.5)	0.8 (0.5-1.1)	34	25
	Buatois et al[57]	II	69.2	Pro (≥18)	≥2 falls	70.1 (4.4)	96	903	≥15 s	58	582	χ^2 $P < .001$	60 (50-70)	64 (61-68)	1.7 (1.4-2.0)	0.6 (0.5-0.8)	42	20
	Buatois et al[77]	II	46.2	Pro (18)	≥2 falls	70 (4)	183	1775	≥15 s	101	1146	NR	55 (48-63)	65 (62-67)	1.6 (1.4-1.8)	0.7 (0.6-0.8)	41	23
	Summary: Posttest probability of falling on the basis of 5TSTS time ≥12 s						359	2960	≥12	212	1858	NA	59 (54-64)	63 (61-65)	1.6 (1.4-1.8)	0.7 (0.6-0.7)	41	20
One time sit to stand Continuous, s	Tiedemann et al[72]	I	92.3	Pro (12)	≥2 falls	80.4 (4.5)	45	170	≥1 s	22 1.0 (0.6)	89 1.1 (0.6)	*t* test $P = .25$	49 (34-64)	52 (45-60)	1.0 (07-1.4)	1.0 (0.7-1.3)	30	30

(*continues*)

Table 4. Summary of Findings for Determining Risk of Falls Using Performance-Based Functional Measures[a] (*Continued*)

Functional Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test Mean (SD)	Nonfallers With –Test Mean (SD)	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	–LR (CI_{95})	Posttest Probability	
																	If +Test	If –Test
30-s Sit-to-Stand Test Continuous, s	Cho et al[78]	III	69.2	Retro (12)	Any fall	F: 72.1 (5.9) NF: 71.7 (5.1)	31	55	15 times	20	46	*t* test $P = .001$	65 (45-81)	84 (71-92)	3.9 (2.0-7.6)	0.4 (0.3-0.7)	63	15
Ability to sit to stand without UE use Dichotomous (able/unable)	de Rekeneire et al[63]	III	69.2	Retro (12)	Any fall	Range: 70-79	652	2398	Unable	35	2333	χ^2 $P = .01$	5 (4-7)	97 (96-98)	2.0 (1.3-3.0)	1.0 (0.9-1.0)	46	30
Stride length Continuous, cm	Van Swearingen et al[79]	III	92.3	Retro (12)	≥2 falls	75.5 (7.3)	53	31	<87	34 76.1 (24.2)	24 99.8 (23.5)	*t* test $P < .001$	64 (50-77)	77 (59-90)	2.8 (1.4-5.6)	0.5 (0.3-0.7)	55	18
Functional (anterior) reach Continuous, cm or inch	Stalenhoef et al[37]	I	84.6	Pro (9)	≥2 falls	M: 77.2 (4.9) W: 78.5 (5.2)	46	192	≤15 cm ≤5.9 in	19	180	OR = 2.0	41 (27-57)	94 (89-97)	6.6 (3.5-12.6)	0.6 (0.5-0.8)	74	20
	O'Brien et al[73]	III	76.9	Retro (12)	Any fall	F: 76.0 (6.7) NF: 73.8 (4.1)	13	23	<22 cm <8.7 in	8 22.2 (5.9)	20 27.7 (4.9)	MW-U $P < .01$	62 (32-86)	87 (66-97)	4.7 (1.5-14.7)	0.4 (0.2-0.9)	67	15
	Summary: Posttest probability of falling on the basis of functional reach distance <22 cm						59	215	<22 cm	27	200	NA	55 (40-69)	93 (89-96)	7.9 (4.6-13)	0.5 (0.4-0.7)	77	17
Maximal step length (longest trial) (% height) continuous	Lindeman et al[55]	I	92.3	Pro (12)	Any fall	F: 68.8 (6.0) NF: 66.5 (5.8)	30	26	<0.66	21 0.6 (01)	18 0.7 (0.1)	KS $P = .03$	70 (51-85)	69 (48-86)	2.3 (1.2-4.2)	0.4 (0.2-0.8)	50	15
Maximal step length (mean 5 trials) (% height) continuous									<0.64	23 0.6 (0.1)	16 0.7 (0.1)	KS $P = .02$	77 (58-90)	62 (41-80)	2.0 (1.2-3.4)	0.4 (0.2-0.8)	46	15
Minimal chair height Continuous with physiological profile assessment	Kwan et al[80]	III	84.6	Retro (12)	Any fall	74.9 (6.4)	81	199	NR	52	131	Wilks lambda $P < .001$	64 (53-75)	66 (59-72)	1.9 (1.5-2.4)	0.5 (0.4-0.7)	45	18

(*continues*)

Table 4. Summary of Findings for Determining Risk of Falls Using Performance-Based Functional Measures[a] (*Continued*)

Functional Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test Mean (SD)	Nonfallers With −Test Mean (SD)	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability	
																	If +Test	If −Test
Modified Gait Abnormality Rating Scale Ordinal 0-21	Van Swearingen et al[79]	III	92.3	Retro (12)	≥2 falls	75.5 (7.3)	53	31	>9	33 9.3 (4.9)	27 3.6 (3.5)	*t* test $P < .001$	62 (48-75)	87 (70-96)	4.8 (1.9-12.3)	0.4 (0.3-0.6)	67	15
mGARS >9 with PPT <15 Combined									mGARS >9 and PPT <15	48	27	NR	91 (79-97)	87 (70-96)	7.0 (2.8-17.6)	0.1 (0.1-0.3)	75	4
Performance-Oriented Mobility Assessment (POMA/Tinetti) Ordinal 0-28 points	Topper et al[81]	I	92.3	Pro (12)	Any fall	83 (6)	58	37	NR	54	33	KW $P = .03$ ROC −0.62	93 (83-98)	89 (75-97)	8.6 (3.4-21.8)	0.1 (0.0-0.2)	79	4
	Panzer et al[56]	I	84.6	Pro (12)	≥2 falls	F: 80 (6) NF: 75 (7)	27	47	<26/28	14	47	NR	52 (32-71)	100 (92-100)	NA	0.5 (0.3-0.7)	NA	18
	Tinetti et al[32]	I	84.6	Pro (12)	Any fall	79.6 (5.2)	546	557	<12/22 <15/ 28	252	384	ANOVA $P < .05$	46 (42-50)	69 (65-73)	1.5 (1.3-1.7)	0.8 (0.7-0.9)	39	26
	Raiche et al[82]	I	76.9	Pro (12)	Any fall	80.0 (4.4)	53	172	<36/40 <25/ 28	37	83	NR	70 (56-82)	48 (41-56)	1.4 (1.1-1.7)	0.6 (0.4-1.0)	38	20
	Avdic and Pecar[83]	III	61.5	Retro (6)	≥2 falls	71.7 (5.6)	21	56	<17/26 <18/28	20 15.8 (7.3)	49 23.1 (5.9)	*t*-test $P < .01$	95 (76-100)	88 (76-95)	7.6 (3.8-15.3)	0.5 (0.1-0.4)	77	18
	Summary: Posttest probability of falling on the basis of POMA score <25						705	869	<25	377	596	NA	53 (50-57)	69 (65-72)	1.7 (1.5-1.9)	0.7 (0.6-0.7)	42	23
Pick up 5-lb weight test Dichotomous (able/unable)	Tiedemann et al[72]	I	92.3	Pro (12)	≥2 falls	80.4 (4.5)	80	282	Unable	9	262	χ^2 $P = .22$	11 (5-20)	93 (89-96)	1.6 (0.8-2.4)	1.0 (0.9-1.0)	41	30
7-item PPT Ordinal 0-28	Van Swearingen et al[79]	III	92.3	Retro (12)	≥2 falls	75.5 (7.3)	53	31	<15	42 11.8 (4.6)	22 17.6 (4.0)	*t* test $P < .001$	79 (66-89)	71 (52-(86)	2.7 (1.6-4.8)	0.3 (0.2-0.5)	54	11
PPT <15 and mGARS >9									mGARS >9 PPT <15	48	27	NR	91 (79-97)	87 (70-96)	7.0 (2.8-17.6)	0.1 (0.1-0.3)	75	4

(*continues*)

Table 4. Summary of Findings for Determining Risk of Falls Using Performance-Based Functional Measures[a] (*Continued*)

Functional Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test Mean (SD)	Nonfallers With –Test Mean (SD)	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	–LR (CI_{95})	Posttest Probability	
																	If +Test	If –Test
PPA Continuous (z-score) −2 to +3 points Age-referenced	Delbaere et al[84]	I	92.3	Pro (12)	Any fall	77.9 (4.6)	166	334	>0.6	116	148	OR = 1.2 *P* = .04	70 (62-77)	44 (39-50)	1.3 (1.1-1.4)	0.7 (0.5-0.9)	36	23
	Kwan et al[80]	III	84.6	Retro (12)	Any fall	F: 68 (3) NF: 70 (5)	81	199	NR	46 2.0 (1.2)	113 1.7 (1.3)	*t* test *P* < .05	57 (45-68)	57 (50-64)	1.3 (1.0-1.7)	0.8 (0.6-1.0)	36	26
	Summary: Posttest probability of falling on the basis of PPA score >0.6						247	533	>0.6	162	261	NA	66 (59-71)	49 (45-53)	1.3 (1.1-1.5)	0.7 (0.6-0.9)	36	23
SSWS Continuous, m/s	Tiedemann et al[72]	I	92.3	Pro (12)	≥2 falls	80.4 (4.5)	80	282	<1.0	40 0.94 (0.26)	192 1.03 (0.28)	*t* test *P* = .003	50 (39-61)	68 (62-73)	1.6 (1.2-1.2)	0.7 (0.6-0.9)	41	23
	Vicarro et al[85]	I	76.9	Pro (12)	Any fall	74 (5.7)	161	264	< 1.0	126	72	NR	78 (71-84)	27 (22-33)	1.1 (1.0-1.2)	0.8 (0.6-1.1)	32	26
									< 0.6	36	244	NR	22 (16-30)	92 (89-95)	2.9 (1.8-4.9)	0.8 (0.8-0.9)	55	26
	De-Pasquale and Toscano[86]	III	92.3	Retro (12)	Any fall	F: 83 (5.5) NF: 78 (7.8)	29	29	<1.2	19 1 (0.2)	22 1.3 (0.2)	*t* test *P* = .001	67 (46-82)	76 (56-90)	2.7 (1.4-5.5)	0.5 (0.3-0.8)	54	18
	Van Swearingen et al[79]	III	92.3	Retro (24)	≥2 falls	75.5 (7.3)	53	31	<0.6	38 0.50 (0.24)	23 0.74 (0.25)	*t* test *P* < .001	72 (58-83)	74 (55-88)	2.8 (1.5-5.2)	0.4 (0.2-0.6)	55	15
	Summary: Posttest probability of falling on the basis of SSWS <1.0 (excluding Vicarro <0.6 to avoid duplication of participants)						323	607	<1.0	223	317	NA	69 (64-74)	52 (48-56)	1.5 (1.3-1.6)	0.6 (0.5-0.7)	39	20
	Summary: Posttest probability of falling on the basis of SSWS <0.6 (based on Vicarro <0.06 and Van Swearingen)						214	295	<0.06	74	267	NA	35 (28-42)	91 (87-94)	3.6 (2.5-5.4)	0.7 (0.7-0.8)	61	23
Single-limb stance Dominant limb SLS/OLS Continuous, s	Bongue et al[48]	I	84.6	Pro (12)	Any fall	70.7 (4.6)	563	1196	<12.7	343	587	OR = 1.5 *P* < .05	61 (57-65)	49 (46-52)	1.2 (1.1-1.3)	0.8 (0.7-0.9)	34	26

(*continues*)

Table 4. Summary of Findings for Determining Risk of Falls Using Performance-Based Functional Measures[a] (*Continued*)

Functional Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test Mean (SD)	Nonfallers With −Test Mean (SD)	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	−LR (CI_{95})	Posttest Probability	
																	If +Test	If −Test
	Muir et al[33]	I	76.9	Pro (12)	Any fall	79.9 (4.7)	78	104	<10	58	48	RR: 1.58 *P* = .04	74 (63-84)	46 (36-56)	1.4 (1.1-1.7)	0.6 (0.4-0.9)	38	20
	Buatois et al[57]	II	69.2	Pro (18)	≥2 falls	70 (4)	96	903	<5	16	815	χ^2 *P* < .001	17 (9.8-26)	90 (88-92)	1.7 (1.1-2.8)	0.9 (0.8-1.0)	42	28
	Buatois et al[73]	II	46.2	Pro (18)	≥2 falls	70 (4)	183	1775	<5	29	1594	NR	35 (25-46)	90 (88-91)	3.4 (2.5-4.7)	0.7 (0.6-0.9)	59	23
	De-Pasquale and Toscano[86]	III	92.3	Retro (24)	Any fall	F: 83.6 (5.6) NF: 78 (7.8)	29	29	<6.5	14 3.2 (3.3)	26 10.3 (9.6)	*t* test *P* < .001	48 (29-64)	90 (73-98)	4.7 (1.5-14.5)	0.6 (0.4-0.8)	67	20
	Summary: Posttest probability of falling on the basis of SLS time <12.7 (Bonge, Muir)						641	1300	<12.7	401	635	NA	63 (59-66)	49 (47-52)	1.2 (1.1-0.3)	0.8 (0.7-0.9)	34	26
	Summary: Posttest probability of falling on the basis of SLS time <6.5 (Buatois, DePasquale)						308	2707	<6.5	59	2435	NA	19 (15-24)	90 (89-91)	1.9 (1.5-2.5)	0.9 (0.9-1.0)	45	28
Single-limb stance Alternatives Continuous, s	Bongue et al[48]	I	84.6	Pro (12)	Any fall	70.7 (4.6)	563	1196	<7.6	Non Dom 259	Non Dom 781	OR = 1.4 NR	46 (42-50)	65 (63-68)	1.3 (1.2-1.5)	0.8 (0.8-0.9)	36	26
									UE mvt yes	UE mvt first 5 s 285	UE mvt first 5 s 714	OR = 1.5 NR	51 (46-55)	60 (57-63)	1.3 (1.1-1.4)	0.8 (0.8-0.9)	36	26
Spring Scale Test Continuous % body weight	De-Pasquale and Toscano[86]	III	92.3	Retro (24)	Any fall	F: 83.5 (5.5) NF: 78.0 (7.8)	29	29	<10%	27 7.5 (1.4)	28 12.3 (1.7)	*t* test *P* = .001	93 (77-99)	97 (82-100)	27 (3.9-185)	0.1 (0.0-0.3)	92	4
8-Stair ascent time Continuous, s	Tiedemann et al[72]	I	92.3	Pro (12)	≥2 falls	80.4 (4.5)	80	282	≥5	43 5.9 (2.7)	163 5.5 (2.6)	*t* test *P* = .05	54 (42-65)	58 (52-64)	1.3 (1.0-1.6)	0.8 (0.6-1.0)	36	26
8-Stair descent time Continuous, s										50 6.6 (3.5)	155 5.7 (3.3)	*t* test *P* = .01	63 (51-73)	55 (49-61)	1.4 (1.1-1.7)	0.7 (0.5-0.8)	38	23
# Steps in a half turn Continuous # steps	Tiedemann et al[72]	I	92.3	Pro (12)	≥2 falls	80.4 (4.5)	80	282	≥4 steps	62	79	*t* test *P* = .08	78 (67-86)	28 (23-34)	1.1 (0.9-1.2)	0.08 (0.5-1.3)	32	26

(*continues*)

Table 4. Summary of Findings for Determining Risk of Falls Using Performance-Based Functional Measures[a] (*Continued*)

Functional Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test Mean (SD)	Nonfallers With –Test Mean (SD)	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	–LR (CI_{95})	Posttest Probability	
																	If +Test	If –Test
Tandem stance Continuous, s	Muir et al[31]	I	76.9	Pro (12)	Any fall	79.9 (4.7)	78	104	<30	39	64	NR	50 (38-62)	62 (52-71)	1.3 (0.9-1.8)	0.8 (0.6-1.1)	36	26
	De-Pasquale and Toscano[86]	III	92.3	Retro (24)	Any fall	F: 83.5 (5.5) NF: 78 (7.8)	29	29	<22	21 12.7 (10.8)	22 23.9 (9.9)	*t* test $P = .001$	72 (53-87)	76 (56-90)	3.0 (1.5-5.9)	0.4 (0.2-0.7)	56	15
	Summary: Posttest probability of falling on the basis of tandem stance time						107	133	<30	60	86	NA	56 (46-66)	65 (56-73)	1.6 (1.2-2.1)	0.7 (0.5-0.9)	41	23
Tandem walk (able/unable)	Sai et al[42]	I	92.3	Pro (12)	Any fall	76.7 (6.1)	94	42	Unable	91	11	NR	96 (90-99)	26 (14-42)	1.3 (1.1-1.6)	0.2 (0.1-0.5)	36	8
TUG Continuous, s Longer times: higher risk	Beauchet et al[66]	I	92.3	Pro (12)	Any Fall	84.8 (5.2)	54	133	≥20	44 27 (8.7)	49 23 (7.9)	χ^2 $P = .02$	82 (69-91)	37 (29-46)	1.3 (1.1-1.6)	0.5 (0.3-0.9)	36	18
	Bongue et al[48]	I	84.6	Pro (12)	Any fall	70.7 (4.6)	563	1196	≥11	193	894	OR = 1.5 $P < .05$	34 (30-38)	75 (72-77)	1.4 (1.2-1.6)	0.9 (0.8-0.9)	38	28
	Buatois et al[57]	II	69.2	Pro (≥18)	≥2 falls	70.1 (4.4)	96	903	≥12	12	836	χ^2 $P < .001$	13 (7-21)	93 (91-94)	1.7 (1.0-3.0)	0.9 (0.9-1.0)	42	28
	Buatois et al[77]	II	46.2	Pro (18)	≥2 falls	70 (4)	183	1775	≥12	25	1650	χ^2 $P < .05$	15 (10-21)	93 (92-94)	2.1 (1.4-3.1)	0.9 (0.9-10)	47	28
	LeClerc et al[39]	II	76.9	Pro (6)	≥2 falls	79.5 (6.9)	99	769	≥30	22 27.6 (17.2)	631 23.5 (16.9)	*t* test $P < .05$	25 (17-35)	82 (80-85)	1.4 (1.0-2.0)	0.9 (0.8-1.1)	38	28
	De-Pasquale and Toscan[86]	III	92.3	Retro (24)	Any fall	F: 83.5 (5.5) NF: 78.0 (7.8)	29	29	≥7.4	23 9.2 (1.3)	27 7.0 (0.9)	*t* test $P = .001$	79 (60-92)	93 (77-99)	11.5 (2.0-44.4)	0.2 (0.1-0.5)	83	8
	Payne et al[41]	III	92.3	Retro (12)	Any fall	R: 75.5 (7.7) U: 76.0 (7.3)	34	81	>15	12	69	NR	35 (20-54)	85 (76-92)	2.4 (1.2-4.8)	0.8 (0.6-1.0	51	26
	Greany and DiFAbio[87]	III	84.6	Retro (12)	Any fall	82.6 (5.5)	12	21	≥13.5	10 14.9 (3.1)	16 12.5 (2.4)	ANOVA $P < .05$	83 (52-98)	76 (53-92)	3.5 (1.6-7.8)	0.2 (0.1-0.8)	60	8
	Huo[88]	III	84.6	Retro (12)	Any fall	66.3 (5.2)	24	77	≥8	20 10.5 (2.9)	47 8.3 (2.5)	*t* test $P < .01$	83 (63-95)	61 (49-72)	2.1 (1.5-3.0)	0.3 (0.1-0.7)	47	11

(*continues*)

Table 4. Summary of Findings for Determining Risk of Falls Using Performance-Based Functional Measures[a] (*Continued*)

Functional Measure	Author	Level	QUADAS Score	Study Type, mo	Fall Defined	Age Mean (SD)	Fallers, N	Nonfallers, N	Cut Point	Fallers With +Test Mean (SD)	Nonfallers With –Test Mean (SD)	Difference *P*	Sn (CI_{95}), %	Sp (CI_{95}), %	+LR (CI_{95})	–LR (CI_{95})	Posttest Probability	
																	If +Test	If –Test
	Shumway-Cook et al[47]	III	84.6	Retro (6)	≥2 falls	F: 86.2 (6.4) NF: 78.4 (5.8)	15	15	>13.5	13 22.2 (9.3)	13 8.4 (1.7)	MANOVA $P < .001$	87 (60-98)	87 (60-98)	6.5 (1.8-24.0)	0.2 (1.8-24.0)	74	8
	O'Brien et al[73]	III	76.9	Retro (12)	Any fall	F: 76.0 (6.7) NF: 73.8 (4.1)	13	23	≥20	8 21.5 (11.3)	23 11.3 (2.4)	MW-U $P < .001$	63 (32-86)	100 (85-100)	NA	0.4 (0.2-0.8)	NA	15
	Vicarro et al[85]	III	76.9	Retro (12)	Any fall	74 (5.6)	161	264	≥15	42	242	NR	26 (19-34)	92 (88-95)	3.1 (1.9-5.0)	0.8 (0.7-0.9)	57	26
	Summary: Posttest probability of falling if TUG time >0.74 s (based on DePasquale, Huo)						53	106	>7.4	43	32	NA	56 (46-66)	65 (56-73)	1.6 (1.2-1.2)	0.7 (0.5-0.9)	41	23
	Summary: Posttest probability of falling if TUG time ≥12 s (excluding DePasquale, Huo)						1230	5180	>12	381	4465	NA	31 (28-34)	85 (84-86)	2.1 (1.9-2.4)	0.8 (0.8-0.8)	47	25
TUG Dual task	Shumway-Cook et al[47]	III	84.6	Retro (6)	≥2 falls	F: 86.2 (6.4) NF: 78.4 (5.8)	15	15	DT-C >13.5	12 27.7 (11.6)	14 9.7 (2.3)	MANOVA $P < .001$	80 (52-96)	93 (68-100)	12.0 (1.8-87.1)	0.2 (0.1-0.6)	84	8
									DT-M >13.5	12 27.2 (11)	14 9.7 (1.6)	MANOVA $P < .001$	80 (52-96)	93 (68-100)	12.0 (1.8-81.1)	0.2 (0.1-0.6)	84	8

Abbreviations: ANOVA, analysis of variance; BBS, Berg Balance Scale; CI_{95}, 95% confidence interval; DGI, dynamic gait index; EC, eyes closed; EO, eyes open; F, fallers; Firm, tested while standing on firm supporting surface; FOAM, tested while standing on foam surface; KS, Kolmogorov-Smirnov test; KW, Kruskal-Wallis test; LR, likelihood ratio; MANOVA, multivariate analysis of variance; M, men; mGARS, Modified Gait Abnormality Rating Scale; Mvt, movement; MW-U, Mann-Whitney *U* test; NA, not applicable; NF, nonfallers; Non Dom, nondominant; NR, not reported; +, positive; –, negative; OR, odds ratio; Pro, prospective; PPA, Physiological Profile Assessment; PPT, Physical Performance Test; QUADAS, Quality Assessment Tool for Diagnostic Accuracy Studies; Retro, retrospective; Sn, sensitivity; Sp, specificity; SD, standard deviation; SSWS, self-selected walking speed; 5TSTS, 5 times sit to stand; TUG, Timed Up and Go; UE, upper extremity; W, women.

[a]Posttest probabilities are based on an assumption of a 30% pre-test probability for future falls.

items and requires less time to complete. Although shorter, the GDS-4[34,48] was not as useful (PoTP = 36%) as the 15-item version.

Self-report measures of physical activity may also have clinical utility for fall risk assessment. A Level I study[64] with moderate sample size suggests that the Longitudinal Study of Aging Physical Activity Questionnaire (LASA-PAQ) score of more than 8 may be useful for identifying those at risk for multiple falls (PoTP = 46% if positive, PoTP = 20% if negative). A single Level III study[70] with small sample (n = 29) suggests that the Medical Outcome Short Form Health Survey (SF-36) Physical Activity Subscale score of less than 72.5 may be useful (PoTP = 54% if positive, PoTP = 20% if negative). Measures of caregiver concern[71] and of overall health status[41] were cited in single studies with small to moderate sample sizes. Neither demonstrated ability to identify fall risk.

Posttest Probability: Performance-Based Measures

Of the 28 performance-based measures included in the review, 17 were supported by a single study, 4 by 2 studies, and 7 by 3 or more studies (see Table 4). For most, Sp values were much higher than Sn values, indicating greater usefulness for ruling in risk of future falls than ruling them out. Although some PoTP values for the 20 measures evaluated by 1 or 2 studies looked promising, sample sizes tended to be small and confidence intervals for Sn, Sp, and LR values large. These measures require further investigation before recommendations on their use for predicting falls can be made with confidence. This discussion focuses on 7 measures supported by at least 3 studies. These allowed combining sample sizes, and resulted in smaller confidence intervals.[16,17]

The *Berg Balance Scale* (BBS) increased PoTP more than any other performance measure.[31,39,44,73] A cut score of 50 points provides a PoTP of 59% for those who score 50 or less (a positive test) and from a PoTP of 23% for those who score 51 or more points (a negative test). These BBS results are based on 2 Level I prospective studies[31,39] and 3 Level III retrospective studies[44,73] with a combined sample size of 1130 older adults.

The single-task *Timed Up and Go* (TUG) test 12 seconds or more had a PoTP of 47% (positive test) and a PoTP of 25% if TUG time less than 12 seconds. TUG findings are based on 2 Level I[48,66] and 3 Level II[39,57,77] prospective studies, and 7 Level III[41,47,73,85-88] retrospective studies with a combined sample of 6410 older adults.

Single-limb stance (SLS) also altered PoTP substantially: being unable to maintain the SLS potions for at least 6.5 seconds (positive test) yielded a PoTP of 45%. Exceeding this time (negative test) yields a PoTP of 28%. SLS findings are supported by 2 Level I[27,44] and 2 Level II[53,73] prospective studies, as well as 1 level III[82] retrospective studies with a combined sample size of 3015 older adults.

For those requiring 12 seconds or more to complete the *5 times sit-to-stand test* (5TSTS) (positive test), the PoTP = 41%. For those able to complete this task in less than 12 seconds (negative test), the PoTP = 20%. These findings are derived from data in 1 Level I[72] and 2 Level II[57,77] prospective studies with a combined sample of 3319 participants.

The Performance-Oriented Mobility Assessment (POMA, Tinetti) includes both balance and gait subscales. Because scoring methodology differed across retrieved articles, we cautiously extrapolated values on the basis of a range of possible from 0 to 28 points to be able to do study-to-study comparison. Scoring less than 25 points (positive test) increased PoTP to 42%. Scoring more than 25 points (negative test) decreased PoTP to 23%. POMA findings are derived from 4 Level I[32,56,81,82] prospective studies and 1 Level III[83] retrospective study with a combined sample size of 1374 participants.

Self-selected walking speed (SSWS) less than 1.0 m/s (positive test) resulted in a PoTP of 39%. An SSWS 1.0 m/s or more (negative test) resulted in a PoTP of 20%. This is based on 2 Level I[72,85] prospective studies, and 2 Level III[79,86] retrospective studies with a combined sample size of 1354 participants used to calculate these values. Two of these[79,85] (combined sample size 509 participants) also considered an SSWS cut score of 0.6 m/s, reporting a PoTP of 61% for those walking 0.6 m/s or less (positive test), and a PoTP of 23% for those walking more than 0.6 m/s (negative test).

Results for the dynamic gait index were difficult to interpret because 1 of the 3 retrospective studies[54] had a very poor Sp, reporting 198 of 204 participants with no history of falling scoring less than 19 points as cut point, but reporting a mean (standard deviation) of 22.5 (1.8). When this study was excluded from synthesis, the ability of the dynamic gait index to predicting recurrent (≥2) falls was a PoTP of 63% for those scoring 19 or less (positive test) and a PoTP of 20% for those scoring more than 19 (negative test). This finding should be interpreted with caution, however, because the combined sample size is only 186 older adults, and the confidence intervals for Sn, Sp, and LRs are wide.

Combining Measures for Cumulative Posttest Probability

Table 5 summarizes the measures with the largest PoTP for positive test results and the smallest PoTP for negative test results, as discussed in the previous sections. The following paragraphs explain how clinicians might calculate cumulative PoTP values when more than one measure has a positive test result.

Although no single medical history question emerged as a powerful diagnostic tool for identifying older adults at risk of future falls, queries about fall history, ADL difficulty, use of an ambulatory device, concern about falling, and use of psychoactive medication, in combination, are likely useful for initial screening. Yes responses to any of these questions can be used to identify those who would most benefit from a more comprehensive risk assessment for falls.[6] If these questions are conceptually independent

Table 5. Summary of Clinically Useful Indicators of Risk of 1 or More Future Falls Based on a PrTP of 30%[a]

Category	Measure	Cut Point	+LR	−LR	PoTP, % If +Test	PoTP, % If −Test
Medical history questions	Any previous falls	Yes/no	1.8	0.8	44	26
	Psychoactive medication	Yes/no	1.4	0.8	38	26
	Requiring any ADL assistance	Yes/no	1.4	0.8	38	26
	Self-report fear of falling	Yes/no	1.4	0.9	38	28
	Ambulatory assistive device use	Yes/no	1.3	0.9	36	26
Self-report measures	Geriatric Depression Scale-15	<6 points	1.9	0.9	45	28
	Falls Efficacy Scale International	>24 points	1.7	0.6	42	20
Performance-based functional measures	Berg Balance Scale	<50 points	3.4	0.7	59	23
	Timed Up and Go Test	>11 s	2.1	0.8	47	25
	Single-limb stance eyes open	<6.5 s	1.9	0.9	45	28
	Five Times Sit-to-Stand Test	>12 s	1.6	0.7	41	20
	Self-selected walking speed	<1.0 m/s	1.5	0.6	39	20

Abbreviations: +LR, positive likelihood ratio; −LR, negative likelihood ratio; PoTP, posttest probability; PrTP, pretest probability; +, test positive test result; −, test negative test result.
[a]To the extent that tests are independent (unrelated) the PoTP of 1 positive test can be used as a new PrTP for the next positive test, etc., to develop a cumulative individualized risk estimate. Because the degree of relationship among tests is not clearly understood at this time, this strategy may inflate the cumulative risk estimate. Online resources such as www.easycalculation.com/statistics/post-test-probability.php can assist clinicians in quickly determining cumulative PoTP risk values.

of each other, it may be appropriate to use one question's PoTP as the next test's PrTP to develop a cumulative estimate of PoTP.[16,17] Clinicians can quickly calculate cumulative PoTP with online resources such as www.medcalc.org/calc/diagnostic_test.php (Sn, Sp, and LR) and https://www.easycalculation.com/statistics/post-test-probability.php (PoTP values).

As an example, during interview an older woman reports a previous fall, sleeping pill use, needing assistance with bathing, being fearful of falling, and use of a cane for ambulation. Assuming a PrTP of 30%, her cumulative PoTP would be calculated by using the largest PoTP as the next measure's PrTP, and multiplying by the test's +LR etc. It would increase to an individual PoTP of 44% on the basis of fall history, then to a cumulative PoTP of 52% on the basis of sleeping pill use, then to a cumulative PoTP of 60% because of self-reported fear of falling, and finally to a cumulative PoTP of 68% because she uses a cane to walk. This demonstrates a 2.4-fold increased risk from the original PrTP 30% value, and would support the need for more in-depth evaluation of balance and risk of falling. Conversely, the PoTP for an individual with no previous falls (individual PoTP = 26%), without psychoactive medication (cumulative PoTP = 22%), no ADL difficulty (cumulative PoTP = 18%), no fear of falling (cumulative PoTP = 17%), and no need of assistive device (cumulative PoTP = 16%) has been reduced by half from the PrTP of 30%. Education about home safety and value of activity may be sufficient to address this person's fall risk. Because these concepts are at least somewhat related, the cumulative PoTP may overestimate risk to some degree. The "cost" of referral for in-depth evaluation, even if the PoTP is somewhat inflated, is low when considered against the potential negative consequences of a future fall event.

No single self-report measure emerged as a strong predictor of future falls; however, adding the Fall Efficacy Scale-I (FES-I) and the GDS-15 as part of intake information for community-dwelling older adults may be useful. GDS-15 scores more than 6 (+LR = 1.9, PoTP = 45%) or less than 6 points (−LR = 0.9, PoTP = 28%) and FES-I scores 24 points or more (+LR = 1.7, PoTP = 42%) or below 24 points (−LR = 0.6, PoTP = 20%) may indicate whether further assessment is warranted. The use of cumulative PoTP may be most informative: a GDS score of more than 6 (individual PoTP 45%), and an FES-I score of less than 24 points (cumulative PoTP 58%), when combined with self-reported ADL difficulty (cumulative PoTP = 66%) and need for an assistive device (cumulative PoTP = 72%) certainly increases suspicion that a future fall will occur.

Performance-based measures demonstrated a stronger ability to predict future falls than either medical history questions or self-report measures. For screening purposes (where minimal time and equipment are desirable), adding SLS and SSWS to history questions may better determine who requires further examination: persons who cannot maintain SLS for at least 6.5 seconds (individual PoTP = 45%), who walk less than 1.0 m/s (cumulative PoTP = 55%), with previous falls (cumulative PoTP = 69%), self-reported fear of falling (cumulative PoTP = 76%), and who routinely use an assistive device (cumulative PoTP = 80%) would likely benefit from more comprehensive risk assessment.

For a more detailed risk assessment, the BBS and POMA contain similar test items, but the BBS has a larger range of possible scores and a more substantial impact on PoTP;

therefore, the BBS appears to be more useful than POMA in determining risk of future falls. Although the BBS, TUG, and 5TSTS all contain at least one sit-to-stand task (and therefore are not fully independent), they are not identical. Combining test results would more clearly identify those individuals most in need of intervention, despite the risk of inflated cumulative PoTP. A BBS score of 50 points or less (individual PoTP = 59%) combined with a TUG time of 12 seconds or more (cumulative PoTP = 75%) and a 5TSTS time of 12 seconds or more (cumulative PoTP = 83%) would justify initiation of a program to reduce risk. A further benefit of performance-based measures is the ability to observe potentially modifiable underlying factors during testing (eg, lower extremity muscle performance, flexibility and range of motion, and eyes open/closed balance performance) that can be addressed to reduce overall risk of falling.

DISCUSSION

Given the large numbers of tests and measures available to assess risk falling (Table 1) and that falls in later life are multifactorial, identifying those older individuals living in the community who are most likely to fall is problematic. This systematic review identified the medical history questions, self-report measures, and performance-based measures for which evidence of predictive ability is strongest. Calculation of PoTP, assuming PrTP of 30% (on the basis of epidemiologic evidence), has permitted comparison of predictive ability for 56 measures. Of these, 5 medical history questions, 2 self-report measures, and 5 functional measures are supported by 3 or more high-quality prospective and retrospective studies.

Clinicians who incorporate questions about previous falls, psychoactive medication use, need for ADL assistance, a yes response to the question "are you concerned that you might fall?" and routine use of a cane or walker as part of their screening effort and intake strategy will have greater confidence in their ability to identify those individuals in need of in-depth assessment on the basis of calculation of cumulative PoTP values. For screening purposes, measuring single-limb stance with eyes open (<6.5 seconds) and/or self-selected walking speed (<1.0 m/s) will assist clinicians identifying those community-living older adults in need of in-depth evaluation. On the basis of current best-available evidence, in-depth assessment of fall risk should include several performance-based measures: BBS Score (<50 points), Time Up and Go (> 11 seconds), and 5 times sit to stand (>12 seconds) on the basis of their individual as well as cumulative PoTP values for positive and negative tests results. The addition of the self-report measures GDS-15 and FES-I can also enhance confidence in level of risk.

Strengths/Weaknesses

To our knowledge, this is the first systematic review and meta-analysis to use PoTP values to compare measures used to evaluate risk of falling. The search strategy was designed to be as inclusive as possible; however, it is limited to articles published through mid-2013. This cut-off date was a practical one: a point at which data extraction and synthesis could commence and be completed in a timely manner. Both of these activities required much more time and energy than anticipated. There is likely additional evidence published since September 2013; updating this work would be a worthwhile project for future researchers. The lack of information about the ordering search terms in the second search is unfortunate, as it threatens replication. The inclusion of retrospective (known groups) studies may have elevated the ability of some measures to "predict" falls; retrospective studies were included because of the limited number of prospective studies (more difficult and costly to carry out) available in the literature. Variation in study quality, methods, and analysis presented a significant challenge to the synthesis process. Of note is that one of the exclusion criteria was a sample including persons with significant cognitive dysfunction; as a result, information about MMSE's value as indicator of risk may be underestimated. Although inclusion criteria required studies with samples of age 65 years or more, there may be differences in pretest probability by decade of age that we were unable to account for.

Because falls are multifactorial, it is not surprising that no single test/measure was diagnostic on its own. A more in-depth understanding of relationships between history questions (fall history, assistive device use, self-reported concern about falling, ADL difficulty, and psychoactive medications), fear of falling as measured by the FES-I, depression as measured by the GDS-15, and the 5 performance measures (BBS, TUG, SLS, 5TSTS, and SSWS) would refine the ability to use the additive strategy we discussed earlier.

Meaning of Study

Assuming a literature-based PrTP of 30%, and on the basis of our systematic review, we have identified 5 dichotomous medical history questions, 2 informative self-report measures, and 5 performance-based measures with clinical usefulness in assessing risk of falling on the basis of calculation of cumulative PoTP values (Table 5). Incorporating these measures into screening and examination of older adults, and interpreting results on the basis of cumulative PoTP values, would likely enhance identification of those who do, or do not, require specific intervention to reduce risk of falling. The findings suggest that an effective screening strategy would combine the answers to the medical history questions with the ability to maintain SLS at least 6.5 seconds and to walk at a speed of at least 1.0 m/s. Client-specific cumulative PoTP values can be calculated, and need for further risk assessment determined. Although diagnostic studies in clinical medicine seek cumulative diagnostic PoTP approaching 100%, it is unlikely that combining these clinical measures will yield such certainty.

However, given the negative consequences of falling in later life, a PoTP beyond the literature-based PrTP of 30% would be welcome. Physical therapists and others using these tests will need to determine the PoTP threshold needed to trigger intervention on the basis of their clinical judgment; a PoTP of 60% to 66%, for example, would suggest an individual as having a 2 in 3 chance of a future fall.

The use of the GDS-15 and a FES-I score as part of the physical therapy examination has the potential to contribute to fall risk assessment efforts. For those requiring in-depth risk assessment, the results of this meta-analysis suggest that the BBS score 50 points or less, TUG times 12 seconds or more, and 5TSTS times 12 seconds or more are currently the most evidence-supported performance-based measures to determine individual risk of future falls.

This cumulative, evidence-based, quantitative approach to multifactorial fall risk assessment would be valuable in required documentation to explain and support recommendations for further evaluation and intervention. This approach also provides a tool for patient/family education and for communication among interdisciplinary health care teams to explain level of risk and need for intervention. Finally, as level of risk decreases after intervention, this approach may be used for evaluation of outcome of intervention.

Unanswered Questions/Future Research

Researchers concerned with risk of falling, especially those who use receiver operating characteristics and area under the curve values, should be encouraged to always report cut-points, Sn, and Sp values, if not the number of participants who are "true positives" and "true negatives" (figure 1) in their manuscripts. In this way clinicians can more easily consider PoTP as they interpret an older individual's performance. Further study of the influence of advancing age and of level of physical activity on the risk of falling is certainly warranted. Consistency in how measures are implemented and scored across studies would enhance interpretation of collective results. Many of the measures included in the evidence tables looked promising as predictors of future falls, but were based on single studies with small sample sizes. It is important to investigate the usefulness of these measures, if only to narrow the range of possible indicators of fall risk to a smaller group. There are far too many measures being used to assess risk of falling in research and clinical practice: increasing the number of prospective studies would assist in narrowing the range of possible measures.

CONCLUSIONS

This systematic review and meta-analysis using individual-measure PoTP as well as cumulative, multitest PoTP identifies measures that, at this time, appear to be most informative about interpreting test results to quantify risk of falling. Combining 5 simple medical history questions (see Table 5) with 2 quickly implemented performance-based measures (single-limb stance <6.5 seconds, and self-selected walking speed <1.0 second) may be a useful way to identify persons most in need of a more in-depth examination of balance. Combining 3 performance measures (BBS score <50 points, TUG time >11 seconds, and 5 times sit-to-stand test >12 seconds) provides not only the opportunity to identify possible modifiable risk factors to inform intervention but also the means to quantify change in risk (PoTP) after intervention. The addition of 2 self-report measures (Geriatric Depression Scale <6 points and Falls Efficacy Scale International >24 points) provides additional insight into contributors to risk of falling as part of an in-depth examination and evaluation.

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