Will My Patient Fall?

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Context Effective multifactorial interventions reduce the frequent falling rate of older patients by 30% to 40%. However, clinical consensus suggests reserving these interventions for high-risk patients. Limiting fall prevention programs to high-risk patients implies that clinicians must recognize features that predict future falls.

Objective To identify the prognostic value of risk factors for future falls among older patients.

Data Sources and Study Selection Search of MEDLINE (1966-September 2004), CINAHL (1982-September 2004), and authors' own files to identify prospective cohort studies of risk factors for falls that performed a multivariate analysis of such factors.

Data Extraction Two reviewers independently determined inclusion of articles and assessed study quality. Disagreements were resolved by consensus. Included studies were those identifying the prognostic value of risk factors for future falls among community-dwelling persons 65 years and older. Clinically identifiable risk factors were identified across 6 domains: orthostatic hypotension, visual impairment, impairment of gait or balance, medication use, limitations in basic or instrumental activities of daily living, and cognitive impairment.

Data Synthesis Eighteen studies met inclusion criteria and provided a multivariate analysis including at least 1 of the risk factor domains. The estimated pretest probability of falling at least once in any given year for individuals 65 years and older was 27% (95% confidence interval, 19%-36%). Patients who have fallen in the past year are more likely to fall again [likelihood ratio range, 2.3-2.8]. The most consistent predictors of future falls are clinically detected abnormalities of gait or balance (likelihood ratio range, 1.7-2.4). Visual impairment, medication variables, decreased activities of daily living, and impaired cognition did not consistently predict falls across studies. Orthostatic hypotension did not predict falls after controlling for other factors.

Conclusions Screening for risk of falling during the clinical examination begins with determining if the patient has fallen in the past year. For patients who have not previously fallen, screening consists of an assessment of gait and balance. Patients who have fallen or who have a gait or balance problem are at higher risk of future falls.

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PATIENT SCENARIO

A 76-year-old woman walks into your office unaided, without any noticeable gait abnormality, but reports that she has balance problems. Her daughter fills out an intake questionnaire at her mother's new-patient evaluation; the patient's medication list includes hydrochlorothiazide, glyburide, aspirin, and temazepam as needed for sleep. The daughter hands you a bone densitometry report indicating that the patient has osteoporosis of the femoral neck. Since most osteoporotic hip fractures occur after a fall, you would like to calculate your patient's risk of falling to decide whether she needs specific interventions to prevent falls.

Why Is This Question Important?

One third of community-dwelling individuals older than 65 years fall every year.[1,2] Falls were the most common mechanism of injury (62%) among an estimated 2.7 million nonfatal injuries among those 65 years and older treated in United States emergency departments in 2001,[3] indicating that falls are a serious medical and public health problem. Five percent to 10% of falls cause serious injuries such as major head trauma, major lacerations, or fracture.[2] Falls, and especially injurious falls, predict placement in a skilled nursing facility.[4]

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Evidence from a meta-analysis of randomized trials of falls prevention in those 60 years and older suggests that multifactorial interventions to prevent falls are effective, reducing the fall rate by approximately 12 falls per 100 person-months, or about 30% to 40% in relative terms.[5] Another systematic review found that multifactorial interventions reduce falls in unselected community-dwelling adults (relative risk reduction, 27%; 95% confidence interval [CI], 15%-37%) as well as in

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those with a history of falls or known risk factors for falls (relative risk reduction, 14%; 95% CI, 2%-24%).[6]

A typical intervention begins with a multifactorial assessment of fall risk, including medication review, assessment of basic and instrumental activities of daily living, measurement of orthostatic blood pressure, vision assessment, gait and balance evaluation, cognitive evaluation, and assessment of environmental hazards. The clinician performs this assessment as part of the history and physical examination (with the exception of the assessment of environmental hazards, which typically is performed as part of a home safety evaluation). The multifactorial risk assessment is relatively straightforward but may lead to resource-intensive interventions, including physical therapy assessment and treatment; outfitting the home with equipment (bedside commode, grab bars) to decrease risk of falls; or neuroimaging, neuropsychological testing, or both to evaluate causes of cognitive impairment.

Clinical practice guidelines suggest that multifactorial interventions should be reserved for high-risk patients, who also must desire the interventions. High-risk status is often identified by a history of recurrent falls; a fall requiring medical attention; or an abnormality of gait, balance, or both.[7,8] A refinement of this approach would be to quantify a patient's global risk of falling and to intervene if the risk exceeds a certain threshold. This study provides information on risk factors for falls in community-dwelling or population-based samples of older adults using this quantitative approach to risk stratification. We evaluated risk factors identifiable during the routine clinical examination. The risk factors we identified can be considered screening tests for future falls. Therefore, we use likelihood ratios (LRs) to describe the results for an individual finding, rather than relative risks, because LRs allow calculation of the probability of a fall for a particular patient.

Markers and Causes of Falls

The definition of "risk factor" in many studies is unclear, creating difficulties when synthesizing data on risk factors for falls.[9] Use of an assistive device such as a cane or a walker may be statistically associated with a higher risk of falls, but this does not imply that the device causes falls. Instead, use of an assistive device may simply be a marker for other problems that are causally associated with falls. To further complicate matters, there is no convention in defining the causes of falls. For example, suppose that an individual experiences a stroke, which then leads to a new gait abnormality, which then leads to a fall. Also, suppose that the stroke is not causally associated with the fall except via the gait abnormality. In this scenario, either the stroke or the gait abnormality could be considered a cause for the fall. As a result, knowledge of either the prior stroke or the gait abnormality would be equally adequate clues that this individual might fall. Because researchers have multiple options for measuring and attributing risk, studies using different approaches may generate seemingly contradictory results.

Clinicians should collect information about risk of falling in a fashion that provides a natural basis for intervening to reduce the risk of future falls. A meta-analysis of randomized, controlled trials of interventions[5] provides a suitable starting point for identifying risk factors, because intervention on a common set of risk factors in these randomized trials led to a decrease in the rate of falling. Thus, at least some of these risk factors are in the causal pathway for falls. The common set of risk factors identifiable during a routine clinical evaluation includes orthostatic hypotension, visual impairment, impairment of gait or balance, medication use, limitations in basic or instrumental activities of daily living, and cognitive impairment. We conducted a systematic review of studies that analyzed these features for predicting future falls.

Multifactorial Evaluation of Patients at High Risk for Future Falls

In this section, we present an approach to performing a multifactorial evaluation for falls in patients who are at high risk for future falls. For these high-risk patients, all 6 risk factors should be assessed (as well as home safety for environmental hazards) to replicate the risk factors assessed in randomized trials. The risk factor assessment strategy we present here is not a screening strategy; it is an in-depth assessment to discover the potential causes of falls in a particular patient in enough detail to make decisions on which factors need intervention. The particular approach we describe is based on our own experience in clinical settings. Later, we will examine the best way to screen patients to decide who should receive this multifactorial evaluation.

Orthostatic Hypotension

When blood pressure is correctly measured,[10] orthostatic hypotension is defined as a decrease in systolic pressure of at least 20 mm Hg or in diastolic pressure of at least 10 mm Hg within 3 minutes of standing.[11] A systematic review found that patients should remain supine for at least 2 minutes before measuring supine vital signs and remain standing for at least 1 minute before measuring standing vital signs.[12]

Visual Acuity

Visual impairment is commonly defined as visual acuity of 20/40 or worse.[13] Patients who normally use eyeglasses or contact lenses should wear these during testing. Each eye should be tested independently, so the patient should always have the nontested eye covered. Distance vision may be tested using a Snellen wall chart with the patient standing at a distance of 6 m.[13] Near vision may be tested with the patient holding a handheld Rosenbaum card at 36 cm; however, inaccuracies in many of the printed cards (and the distance at which the patient holds the card) make this a relatively crude screening approach.[14]

Gait and Balance Examination (and Associated Mobility Concerns)

Detecting gait and balance problems begins with watching patients as they rise from a chair or as they walk into the examination room. Clinicians recognize that an asymmetrical gait is not normal. But symmetrical abnormalities are also important and include a wide-based stance, walking very slowly, stooped postures, shuffling gaits, and swerving from side to side. Using a cane, walker, or the arm of a friend implies the need of assistive devices for balance. Likewise, patients who enter the clinic using wheelchairs or electric scooters may be at increased risk of falling during transfers, if these patients are ambulatory.

When transitioning from history taking to the physical examination, the clinician can test the patient's quadriceps muscle strength by asking the patient to get up from a chair without using the chair arms. If the patient cannot get up from the chair, or has difficulty, this sign of lower-extremity muscle weakness, balance, or coordination problems is a source of fall risk for the patient.[2]

More formal approaches to the examination of gait and balance exist. The Tinetti Performance-Oriented Mobility Assessment requires the clinician to score the patient on multiple aspects of gait and balance while watching the patient walk and rise from a chair; the clinician also performs several additional tests.[13,15] Details on how to perform the assessment may be found online through the American Geriatrics Society after a free registration process.[13]

Assessing Medication Use

Psychotropic medications (ie, those with central nervous system effects) are commonly implicated in falls. Psychotropic medications that have the most data supporting an increased risk of falls include antidepressants, sedative-hypnotics (benzodiazepines, barbiturates, chloral hydrate, and hydroxyzine), and typical antipsychotic medications (phenothiazines and butyrophenones).[16] However, all medications with central nervous system effects may cause falls. Also, the more medications of any type a patient takes, the higher the risk of falls.[17]

Assessing Basic and Instrumental Activities of Daily Living

Patients with impairments in their basic or instrumental activities of daily living are at increased risk of falling. Basic activities of daily living typically include toileting, feeding, dressing, grooming, ambulation, and bathing.[13,18] Instrumental activities of daily living include using the telephone, shopping, preparing food, housekeeping, doing laundry, transportation, managing medications, and handling one's own finances.[13,18] Asking about these activities can be part of a previsit questionnaire for the patient (or patient's caregiver) to fill out.[19] The previsit questionnaire may simply ask whether the patient needs or does not need help with any of the 6 basic or 8 instrumental activities of daily living listed above.[19] Needing help on any basic or instrumental activity of daily living indicates an increased risk of falls.

Assessing Cognition

The standard approach to cognitive assessment has been the Folstein Mini-Mental State Examination,[20] though a shorter alternative is the Short Portable Mental Status Questionnaire.[21] The latter instrument is a 10-item clinician-administered questionnaire that asks the patient to provide the date, day of the week, "name of this place," patient's telephone number, patient's age, when the patient was born, the name of the current and most recent former US president, and the patient's mother's maiden name, as well as to serially subtract 3 from 20. Patients who have 5 or more errors are at increased risk of falls.[22]

METHODS

We searched MEDLINE (1966 to September 2004), CINAHL (1982 to September 2004), and our own files for articles pertaining to the clinical examination for "accidental falls" in adults. Given the vast literature on falls, we designed a search that favored specificity over sensitivity and we focused on cohort studies since they are most likely to provide valid information on the relationship between baseline findings and future falls.[23] We chose to focus on cohort studies, rather than randomized controlled trials, because cohort studies are more likely to enroll patients who are representative of patients seen in outpatient practices. After removal of duplicate articles, the combined search generated 383 articles for review, and an additional 37 articles were found from the reference list of retrieved articles and the authors' files. Two investigators (D.A.G., Y.B.) reviewed the titles and abstracts (requesting full text where appropriate), restricting articles to those that met the following inclusion criteria: (1) used prospective data collection, (2) included fall incidence during follow-up as an outcome, (3) reported data specific to a community-dwelling or population-based sample, (4) enrolled participants of mean age 65 years and older, (5) reported in English, and (6) reported fall outcome data between 6 and 12 months of follow-up. The last criterion was designed to ensure that data on falls were collected over a clinically relevant period.

We excluded articles in which data came exclusively from sources other than the patient (such as studies conducted in a gait/balance laboratory) or from studies that selected only a high-risk (or low-risk) group of patients based on physical examination. We allowed studies that excluded individuals who were nonambulatory or who had severe cognitive impairment that interfered with the ability to gather data. However, we excluded studies that screened patients in other ways involving history and physical examination (such as requiring that individuals be able to walk a certain distance, not use an assistive device, or be free of cognitive impairment). We resolved differences regarding inclusion and exclusion of articles by consensus.

After applying inclusion and exclusion criteria, there were 37 articles. Each of 2 authors (D.A.G., Y.B.) assessed quality, adapted from previous criteria established by Stalenhoef et al[23] (TABLE 1). The domains for multivariate analyses (TABLE 2) were derived from a list of common elements of multifactorial assessment of fall risk and interventions that reduce the risk of falls.[5] Disagreements were resolved by consensus.

We restricted our attention to the 18 studies that performed multivariate analysis on at least 1 of the 6 potential multivariate risk factors and that provided relevant data (Tables 1 and 2).[22,24-43] Although we found 2 clinical prediction rules for falls,[29,31] neither rule was retested on a separate sample, so we chose to focus on individual risk factors. For each of the 9 studies with extractable data in the appropriate patient population,[22,25,26,30,32,34-37] we identified risk factors that were statistically significant at the .05 level in that study's multivariate analysis. We then calculated an LR for each of these statistically significant risk factors using univariate data. This approach uses the multivariate analysis to screen for risk factors that have independent predictive value, an approach taken by previous work to reduce large amounts of overlapping clinical information to a more manageable level.[44] We calculated 95% CIs for LRs using the method of Simel et al.[45] Because the studies were heterogeneous in terms of how risk factors were defined and which variables were included in multivariate analyses, it was not possible to combine results across studies. However, we do provide an estimate of the pretest probability of falls in the subsequent year for studies with extractable data, excluding 1 study with a follow-up of only 11 months,[36] 1 study exclusively in 85-year-olds,[37] and 1 of 2 studies conducted among largely the same cohort.[34]

RESULTS

Precision of the Clinical Examination

Of all the included studies, 1 specifically examined interrater and intrarater reliability of 4 commonly used balance tests.[46] A 5% stratified random sample of study participants (60/1200) were retested on the Timed Up and Go, 1-leg stand, Functional Reach, and Tinetti balance examinations within 2 weeks of their original testing. Half the sample was retested for interrater reliability, and the other half was tested for intrarater reliability. Intraclass correlation for interrater and intrarater reliability fell within the 0.93-0.99 range for all measures (results were not broken out by balance test or by interrater/intrarater reliability).

Accuracy of the Clinical Examination

Among the 18 studies, we present LRs for the 9 studies with extractable data

Table 1. Details of Study Quality Criteria for Included Articles

		Quality Criterion*						
Source	Baseline Sample Size	Frequent Fall Ascertainment†	Loss to Follow-up Reported in <20% of Sample	Inclusion/ Exclusion Criteria Described	Risk Factors Defined Adequately	Fall Definition Provided	Generalizable Sampling Frame‡	Random or Systematic Sample
Bergland et al,[24] 2003	328	✓	✓	✓	✓	✓	✓	✓
Campbell et al,[25] 1989	761	✓	✓	✓	✓	✓	✓	✓
Chu et al,[26] 2005	1517	✓	✓	✓	✓	✓	✓	✓
Duncan et al,[27] 1992	221	✓	✓	✓	✓	✓	✓	✓
O'Loughlin et al,[28] 1993	417	✓	✓	✓	✓	✓	✓	✓
Stalenhoef et al,[29] 2002	311	✓	✓	✓	✓	✓	✓	✓
Tinetti et al,[22] 1988	336	✓	✓	✓	✓	✓	✓	✓
Tinetti et al,[30] 1995	1103	✓	✓	✓	✓	✓	✓	✓
Tromp et al,[31] 2001	1328	✓	✓	✓	✓	✓	✓	✓
Zhang et al,[32] 2004	1038	✓	✓	✓	✓	✓	✓	✓
Coleman et al,[33] 2004	2002		✓	✓	✓	✓	✓	✓
Luukinen et al,[34] 1995	788	✓		✓	✓	✓	✓	✓
Luukinen et al,[35] 1996	788	✓		✓	✓	✓	✓	✓
Teno et al,[36] 1990	736		✓	✓	✓	✓	✓	✓
van Bemmel et al,[37] 2005	599		✓	✓	✓	✓	✓	✓
Weiner et al,[38] 1998	309	✓	✓	✓	✓		✓	✓
Arden et al,[39] 1999	5552		✓	✓	✓		✓	✓
Gerdhem et al,[40] 2005	1044		✓	✓	✓		✓	✓
Summary§		13/18	16/18	18/18	18/18	15/18	18/18	18/18

*Adapted from previous criteria established by Stalenhoef et al.[23]
†Assessment at least once every 3 months.
‡Population, community, or primary care–based sample.
§Summary totals present number of studies meeting criteria divided by the total number of studies.

(TABLE 3). Patients underwent follow-up for 1 year in all but 1 study, in which patients underwent follow-up for 11 months.[36] Sample sizes ranged from 336 to 1517, with studies using "1 or more falls," "2 or more falls," or both as the dichotomous outcomes of interest. The samples ranged from 49% to 73% women, and the mean age ranged from 68 to 85 years. The incidence of 1 or more falls ranged from 19% to 44%; of 2 or more falls, from 5% to 17%. Synthesizing these estimates quantitatively gives a pretest probability for 1 or more falls in the next year of 27% (95% CI, 19%-36%) and a pretest probability for 2 or more falls in the next year of 10% (95% CI, 7%-15%). TABLE 4 and TABLE 5 present LRs for various historical features and physical findings from these studies.

Age

Three studies[28,31,36] provided data on the risk of falling that allowed us to calculate the effect of increasing age. Two of the studies provided data on the risk of falling at least once in the next year, but the odds ratio for age was not statistically significant in either ($P=.30$ and $P=.36$).[28,31] The risk was similar in the 2 studies: for patients aged 65 through 74 years, the fall probability was 31% to 32%; for those aged 70 through 74 years, 22% to 33%; for those aged 75 through 79 years, 25% to 36%; and for those 80 years or older, 34% to 37%. The third study found a statistically increased risk of falling at least once in the next 11 months among older patients (odds ratio per age category, 1.90; $P<.001$): ages 65 through 69 years, 14%; ages 70 through 74 years, 16%; ages 75 through 79 years, 24%; and ages 80 years and older, 34%.[36] Of the 11 studies that considered age in multivariate analyses,* only 4 found a positive association between age and future falls.[25,26,32,36]

*References 22, 24-26, 28-30, 32, 33, 35, 36.

Baseline History of Falls

Each of the 11 studies that evaluated a history of falls found in multivariate analyses that prior falls predict future falls.[24,26,28,29,31,33-37,40] Four studies had extractable data for calculating LRs. In 1 study, a history of at least 1 fall in the year prior to baseline was associated with an increased risk of at least 1 fall in the next year (LR, 2.8; 95% CI, 2.1-3.8).[26] In 2 studies derived from the same cohort, a history of 1 or more falls during the previous year was associated with 2 or more falls in the next year (LR range, 2.3-2.4).[34,35] In a fourth study, a history of 1 fall in the previous month was associated with 1 or more falls in the subsequent 11 months (LR, 3.8; 95% CI, 2.2-6.4).[36]

Orthostatic Hypotension

Orthostatic hypotension is inferred as an obvious risk factor for falls, but 4 studies[25,26,31,35] with multivariate analyses found no association when other

Table 2. Risk Factor Domains of Multivariate Analysis Assessed in Included Articles

	Risk Factor Domain*					
Source	Orthostatic Hypotension	Visual Impairment	Gait/Balance Impairment	Medications	Limitations in ADL	Cognitive Impairment
Bergland et al,[24] 2003		+	+	–	–	–
Campbell et al,[25] 1989	–	–	+	+	+	–
Chu et al,[26] 2005	–	–	+	–	–	+
Duncan et al,[27] 1992			+			?
O'Loughlin et al,[28] 1993			+	–	–	
Stalenhoef et al,[29] 2002		–	+		–	–
Tinetti et al,[22] 1988		–	+	+	–	+
Tinetti et al,[30] 1995		–	–	–		–
Tromp et al,[31] 2001	–	+	–	+	+	–
Zhang et al,[32] 2004			–			
Coleman et al,[33] 2004		+	+	–		
Luukinen et al,[34] 1995			+	+		
Luukinen et al,[35] 1996	–	–	–		–	–
Teno et al,[36] 1990		–	–		–	
van Bemmel et al,[37] 2005					+	?
Weiner et al,[38] 1998			?	+		?
Arden et al,[39] 1999	?		?	?		
Gerdhem et al,[40] 2005		–	+	+		
Summary†	0/4	3/11	10/15	6/11	3/10	2/8

Abbreviation: ADL, activities of daily living.
*A blank space indicates that the study did not adjust for the risk factor; a symbol, that the study considered or adjusted for the risk factor in multivariate analysis. + Indicates that the risk factor was significant at the .05 level and represented an increased risk for falls; –, that the risk factor was either nonsignificant, failed to meet a cutoff for inclusion in multivariate analysis, or was associated with a reduced risk of falls (1 instance only, "heart medicine," see O'Loughlin et al[28]); and ?, that risk factor was not a primary focus of analysis and results were not reported (the factor could have been statistically significant or nonsignificant).
†Summary totals represent the number of studies with statistically significant results for a risk factor divided by total number of studies that considered or adjusted for that risk factor in multivariate analysis (studies marked with ? not included).

Table 3. List of Studies With Extractable Data

Author	Baseline Sample Size	Women, No. (%)	Age, Mean (SD), y	Follow-up Duration	No. of Falls Analyzed	Incidence, %	
						≥1 Falls	≥2 Falls
Campbell et al,[25] 1989	761	465 (61)	≥70	1 y	≥1	35	NA
Chu et al,[26] 2005	1517	NR (49)	73.2 (6.3)	1 y	≥1/≥2	19	5
Tinetti et al,[22] 1988	336	185 (55)	78.3 (5.1)	1 y	≥1	32	17
Tinetti et al,[30] 1995	1103	NR (73)	79.7 (5.2)	1 y	≥2	NA	10
Zhang et al,[32] 2004	1038	445 (51)*	67.5 (5.3)	1 y	≥1	22	NA
Luukinen et al,[34] 1995	751†	478 (63)	76.1 (4.9)	1 y	≥2	NA	11
Luukinen et al,[35] 1996	811†	512 (63)	76.1 (4.9)	1 y	≥2	NA	11
Teno et al,[36] 1990	736	NR (67)	76.5 (6.9)	11 mo	≥1	22	NA
van Bemmel et al,[37] 2005	599	322 (67)‡	85	1 y	≥1	44	NA

Abbreviations: NA, not applicable; NR, not reported.
*Percentage of women not reported at baseline; proportion at 1-year follow-up (445/879) used as a surrogate.
†Samples for Luukinen et al[35] and Luukinen et al[32] derived from the same cohort (Heikki Luukinen, MD, written communication, January 12, 2006).
‡Percentage of women not reported at baseline; proportion at 1-year follow-up (322/480) used as a surrogate.

common risk factors were considered (Table 2). One study found that an increase in pulse rate of less than 6 per minute, measured 30 seconds after standing up, predicts falls (LR, 1.4; 95% CI, 1.0-1.9),[35] but the association was weak.

Visual Impairment

Three of 11 studies that considered visual impairment in a multivariate analysis predicting falls reported statistically significant results (Table 2),[24,31,33] but none of the 3 studies had extractable data for calculating LRs. In these 3 studies, odds ratios for future falls ranged from 1.6 for a patient's report of inability to recognize someone's face at a distance of 4 m (with glasses or contacts where needed)[31] to 2.0 for a patient's report of inability to read a newspaper (with glasses if needed).[24] The third study used Bailey-Lovie charts to measure visual acuity and found that each additional letter read correctly off the chart at baseline was associated with a lower risk of falls (odds ratio, 0.96).[33] While patients and their families are concerned about nighttime falls (eg, on the way to the bathroom), no study separately assessed night vision.

Impairment of Gait or Balance

Of 15 studies with relevant information on impairment of gait or balance, 10 reported statistically significant results (Table 2),[22,24-29,33,34,40] of which only 4 had extractable data for calculating LRs. The presence of at least 6 of 7 gait or balance abnormalities led to an increased risk of a fall (LR, 1.9; 95% CI, 1.4-2.6), as did the presence of lower-extremity disability (ie, reported problem with strength, sensation, or balance) (LR, 1.8; 95% CI, 1.5-2.2).[22] Anteroposterior body sway was associated with 1 or more falls,[25] but this measure requires specialized equipment typically not available in office practice. A patient's self-perceived mobility problem predicts the occurrence of 1 or more falls (LR, 1.7; 95% CI, 1.5-1.9), as does inability to perform a tandem stand (ie, inability to stand while keeping the heel of one shoe touching the toe of the other for 10 seconds without foot movement or manual support) (LR, 2.0; 95% CI, 1.7-2.4).[26] The same study found a self-perceived mobility problem to predict 2 or more falls (LR, 2.0; 95% CI, 1.7-2.4), as did inability to perform a tandem walk test (ie, inability to walk with the heel of one foot touching the toe of the next over 2 m) (LR, 2.4; 95% CI, 2.0-2.9). Taking more than 13 seconds to walk 10 m predicts recurrent falls with about the same LR as perceived mobility problems (LR, 2.0; 95% CI, 1.5-2.7).[34]

Medications

Eleven studies reported relevant data on medication use (Table 2),† of which 1 reported a decreased rate of falls with "heart medicine" (but did not have extractable data for LRs)[28] and 6 reported an increased risk of falls with other variables.[22,25,31,34,38,40] Three of these 6 studies had extractable data for calculating LRs. In 1 study, patients taking a benzodiazepine, phenothiazine, or antidepressant had a markedly increased risk of 1 or more falls (LR, 27; 95% CI, 3.6-207).[22] In a different study, the general category of psychotropic medications increased the risk of 1 or more falls among women (LR, 1.7; 95% CI, 1.3-2.2), as did taking 4 or more medications (LR, 1.9; 95% CI, 1.4-2.5), but statistically significant results were not found for men, likely due to the smaller sample size of men in the study.[25] In a third study, use of benzodiazepines or antidepressants was associated with multiple (≥2) falls (LR, 1.8; 95% CI, 1.4-2.2).[34]

Impairment in Basic/Instrumental Activities of Daily Living

Ten studies considered or included limitations in basic and/or instrumental activities of daily living in multivariate analysis.[22,24-26,28,29,31,35-37] Of these 10 studies, 3 reported significant results,[25,31,37] of which 2 had extractable data for calculating LRs.[25,37] The inability to rise from a chair of knee height without using the chair arms was associated with an increased risk of 1 or more falls among men (LR, 4.3; 95% CI, 2.3-7.9); in women, the association was

†References 22, 24-26, 28, 30, 31, 33, 34, 38, 40.

not a significant risk factor in multivariate analysis.[25] Another study showed that 5 or more of 11 physical impairments (mostly activities of daily living) was associated with an increased risk of 1 or more falls (LR 1.9; 95% CI, 1.4-2.6).[37]

Cognitive Impairment

Of 8 studies with relevant data on cognitive impairment (Table 1),[22,24-26,29-31,35] 2 reported significant results, both of which had extractable data for calculating LRs. One study found that 5 or more errors on the Short Portable Mental Status Questionnaire[21] was associated with 1 or more falls (LR, 4.2; 95% CI, 1.9-9.6).[22] Another study reported that a history of dementia was associated with 1 or more falls (LR, 17; 95% CI, 1.9-149) and with 2 or more falls (LR, 13; 95% CI, 2.3-79).[26]

Who Should Be Screened for Risk of Falls, and How?

All older adults can be efficiently screened for fall risk. A previsit questionnaire filled out by the patient or caregiver can elicit a history of previous falls.[19] When patients have fallen in the past year (LR range, 2.3-2.8), they are at high risk for another fall, and the clinician is no longer "screening" but instead moving to a multifactorial falls risk assessment for prevention that includes orthostatic vital signs, visual acuity testing, gait and balance testing, medication review, and review of basic and instrumental activities of daily living, cognition, and environmental hazards in the home. We detailed one approach to performing this evaluation in the section on multifactorial evaluation of patients at high risk of falls.

For screening patients older than 65 years who have not already fallen, the literature we reviewed suggests that the pretest probability of a fall in the upcoming year ranges from 19% to 36%. If a patient has not fallen in the previous year, the domain of gait and balance offers the highest potential yield from screening, for 2 reasons. First, risk factors for gait and balance were the most-studied set of risk fac-

Table 4. Risk Factors for 1 or More Falls in 12 Months

Source/Finding	LR (95% CI) Positive	LR (95% CI) Negative
Campbell et al,[25] 1989		
Women (N = 465; 152 with falls)		
History		
Taking ≥4 medications	1.9 (1.4-2.5)	0.76 (0.66-0.87)
Taking psychotropic medication	1.7 (1.3-2.2)	0.75 (0.64-0.87)
Physical examination		
Evidence of previous stroke on neurologic examination	15 (3.6-67)	0.91 (0.86-0.96)
Anteroposterior body sway measured by Wright-Codoc ataxiameter (average of 3 recordings of 1 min each)	2.0 (1.5-2.7)	0.76 (0.66-0.87)
Signs of knee arthritis using method of Forman et al[47]	1.3 (1.1-1.6)	0.79 (0.65-0.95)
Men (N = 296; 68 with falls)		
Physical examination		
Unable to rise from a chair of knee height without using chair arms	4.3 (2.3-7.9)	0.77 (0.66-0.90)
Anteroposterior body sway measured by Wright-Codoc ataxiameter (average of 3 recordings of 1 min each)	2.3 (1.6-3.3)	0.69 (0.56-0.86)
Signs of knee arthritis using method of Forman et al[47]	1.6 (1.3-2.0)	0.54 (0.37-0.78)
Chu et al,[26] 2005 (N = 1517; 294 with falls)		
History		
Dementia	17 (1.9-149)	0.99 (0.97-1.0)
Parkinson disease	5.0 (1.5-16)	0.98 (0.97-1.0)
≥1 falls in the year prior to baseline	2.8 (2.1-3.8)	0.86 (0.81-0.92)
Self-perceived mobility problem	1.7 (1.5-1.9)	0.69 (0.60-0.78)
Physical examination		
Unable to perform tandem stand (ie, unable to maintain position for 10 s without foot movement or manual support)	2.0 (1.7-2.4)	0.74 (0.67-0.82)
Tinetti et al,[22] 1988 (N = 336; 108 with falls)		
History		
Taking benzodiazepine, phenothiazine, or antidepressant	27 (3.6-207)	0.88 (0.82-0.95)
Lower-extremity disability (reported problem with strength, sensation, or balance)	1.8 (1.5-2.2)	0.52 (0.39-0.69)
Physical examination		
Cognitive impairment (≥5 errors on SPMSQ[21])	4.2 (1.9-9.6)	0.88 (0.81-0.96)
Palmomental reflex	2.8 (1.8-4.4)	0.77 (0.67-0.89)
6-7 (out of 7) gait/balance abnormalities*	1.9 (1.4-2.6)	0.70 (0.58-0.85)
Foot problem (moderate or severe bunions, toe deformities, ulcers, or deformed nails)	1.3 (0.97-1.7)	0.85 (0.70-1.0)
Zhang et al,[32] 2004 (N = 434 men; 80 with falls)		
History		
Type A personality (scored ≥17 on Chinese version of Maeda Type A scale)	1.5 (1.2-1.9)	0.73 (0.57-0.93)
Teno et al,[36] 1990 (N = 586; 127 with falls)†		
History		
Fall in month prior to baseline	3.8 (2.2-6.4)	0.84 (0.77-0.92)
≥2 stumbles in month prior to baseline	2.0 (1.2-3.3)	0.90 (0.81-0.99)
≥4 days in bed during month prior to baseline	3.7 (1.6-8.6)	0.94 (0.89-0.99)
Self-report of decline in health status in year prior to baseline	2.0 (1.5-2.9)	0.80 (0.70-0.92)
van Bemmel et al,[37] 2005 (N = 480; 212 with falls)		
History and physical examination		
≥5 (out of 11) physical impairments‡	1.9 (1.4-2.6)	0.79 (0.71-0.89)

Abbreviations: CI, confidence interval; LR, likelihood ratio; SPMSQ, Short Portable Mental Status Questionnaire.
*Possible abnormalities included (1) unsteady sitting down, (2) unable to stand on 1 leg unsupported, (3) unsteady turning, (4) unsteady after gentle push on sternum, (5) increased trunk sway, (6) unable to increase walking pace, and (7) increased path deviation.
†Study lasted only 11 months.
‡Physical impairments included ability on 8 items from history: ability to rise from a chair, get out of bed, use the toilet, wash oneself, dress oneself, do some light housework, prepare food, walk around in one's home. Three items from physical examination included ability to rise from a chair without using the chair arms, top half (vs bottom half) of walking speed over a 3-m distance, and use/no use of a walking device.

Table 5. Risk Factors for 2 or More Falls in 12 Months

Finding	LR (95% CI) Positive	Negative
Chu et al,[26] 2005 (N = 1517; 72 with recurrent falls)		
History		
Dementia	13 (2.3-79)	0.97 (0.94-1.0)
Stroke	3.2 (1.9-5.4)	0.87 (0.78-0.97)
Unable to complete tandem walk test as defined by Chu et al[48]	2.4 (2.0-2.9)	0.51 (0.38-0.68)
Self-perceived mobility problem	2.0 (1.7-2.4)	0.48 (0.34-0.68)
Osteoarthritis of the knees	2.0 (1.0-3.9)	0.94 (0.87-1.0)
Tinetti et al,[30] 1995 (N = 927; 96 with recurrent falls)		
Physical examination		
Needs >10 s to do 3 chair stands†	2.3 (1.8-2.9)	0.66 (0.54-0.80)
Any impairment in arm strength on manual muscle testing (scored good, fair, poor)[49]	1.9 (1.4-2.4)	0.74 (0.62-0.89)
Luukinen et al,[34] 1995 (N = 751; 85 with recurrent falls)*		
History		
History of ≥1 falls during previous year	2.3 (1.8-2.9)	0.60 (0.47-0.76)
Psychotropic (benzodiazepine or antidepressant)	1.8 (1.4-2.2)	0.67 (0.53-0.85)
Physical examination		
Vibration sense absent and pain sense on knees reduced‡	2.1 (1.5-3.1)	0.80 (0.69-0.93)
Slow gait over 10-m walk (<0.77 m/s)	2.0 (1.5-2.7)	0.73 (0.61-0.88)
Luukinen et al,[35] 1996 (N = 811; 88 with recurrent falls)*		
History		
Frequent fear of falling	2.6 (1.9-3.5)	0.70 (0.59-0.84)
≥1 Falls during the previous year	2.4 (1.9-3.0)	0.61 (0.49-0.76)
Dizziness	1.5 (1.3-1.8)	0.61 (0.45-0.82)
Female	1.3 (1.2-1.5)	0.50 (0.32-0.77)
Physical examination		
Poor pulse increase (<6/min) 30 s after standing up	1.4 (1.0-1.9)	0.85 (0.72-1.0)

Abbreviations: CI, confidence interval; LR, likelihood ratio.
*Samples for Luukinen et al[35] and Luukinen et al[32] derived from the same cohort (Heikki Luukinen, MD, written communication, January 12, 2006).
†"Get up and sit down in a chair 3 times in a row."[30]
‡"Vibration sense was assessed with a tuning fork as normal, reduced, or absent on the knees and metatarsals. Pain sense was assessed as normal or reduced by pricking gently with a needle at the level of the knees. The sense at the level of the sternum was used as a reference for these examinations."[34]

tors for future falls, giving us more confidence in our findings. Second, when gait and balance risk factors were studied, they more frequently predicted future falls than other domains, suggesting that assessment of gait and balance should remain a mainstay of screening. To screen patients for a gait or balance problem, a previsit questionnaire could ask patients whether they have noticed any problems with gait, balance, or mobility (LR range, 1.7-2.0). A "yes" answer to this question could make the patient "high risk" depending on the patient's pretest probability of falls. For the remaining domains (orthostatic hypotension, visual impairment, medication review, activities of daily living, and cognitive impairment) we do not recommend that physicians screen all patients if the only purpose is to determine risk of falling. These domains were less frequently (or not at all) independently associated with falls in the studies we examined. While increasing age intuitively makes sense as a risk factor for future falls, age as an unadjusted predictor of falls was not significant in 2 of 3 studies that provided the raw data by age group. When age is adjusted for other variables in a multivariable analysis, age was not as important as the history of falls or of gait and balance abnormalities in predicting falls. Thus, the fall rate is high among all age groups older than 65 years, but age alone does not reliably identify patients most likely to fall.

In this study, we specifically examined only clinical findings that were statistically significant in multivariate analyses. We did this to find variables that best predict falls, rather than to determine "root causes" of falls. In other words, clinical findings that were not significant in multivariate analyses (eg, orthostatic hypotension) may still be important causes of falls, but they failed to predict falls as often as other variables, perhaps because of a shared causal pathway (such as psychotropic medications causing orthostatic hypotension leading to falls) or because of confounding (patients with orthostatic hypotension also had coexisting balance impairment, which predicted falls).

Some limitations apply to our results. First, selective reporting of positive findings is a known problem in the medical literature,[50] which may have caused us to overestimate the true importance of the risk factors we present. Second, 2 studies we reviewed[29,31] mentioned that the "oldest old" were less likely to participate, and this finding may apply to other studies we reviewed as well. These "oldest old" individuals may be more likely to have cognitive and physical impairments,[31] so the data we present may apply to a somewhat healthier population than to the average community-dwelling patient. Third, individuals with cognitive impairment are less likely to recall falling,[51] potentially biasing the association of cognitive impairment and future falls toward no effect. Fourth, not all studies that met our criteria had data available to calculate LRs; thus, the particular historical features and physical findings for which we present LRs are not representative of all potentially effective approaches to screening.

SCENARIO RESOLUTION

This patient is likely to be at high risk for falls. Given a pretest probability of one third (pretest odds, 1:2), an LR of approximately 2 for self-reported mobility problem (lack of balance), and some additional increased risk associated with benzodiazepine use, her posttest probability of falling is at least 50%.

THE BOTTOM LINE

In this literature review, the pretest probability of falling at least once in any given year for individuals 65 years and older was 27% (95% CI, 19%-36%). Since the pretest probability of 1 or more falls in the next year ranges from one fifth to one third for an average older patient (pretest odds, 1:4 to 1:2), a clinical finding with a positive LR of 2 to 4 is enough to give the patient a posttest odds of 1:1, or a 50% chance of falling within the next year. Findings that would bring patients to a 50% annual fall risk include having fallen either in the past year (LR range, 2.3-2.8) or in the past month (LR, 3.8) or a clinically detected abnormality of gait or balance (LR range, 1.7-2.4).

Falls are a treatable geriatric syndrome. Screening for fall risk is as easy as asking, "Have you had any falls in the past year?" and then inquiring about gait or balance problems if the patient has not had a fall. Screening is the first step in preventing future falls and the major injuries that can result from falling. By performing a multifactorial fall assessment on a patient who screens positive and then treating the patient's risk factors for falling, falls can be reduced by 30% to 40%.[5] Medicare typically covers the services needed to treat patients' risk factors, including physical therapy for gait and balance problems, home evaluation of activities of daily living and environmental hazards, eye examinations, and further medical workup for cognitive impairment. Most information can be obtained via a previsit questionnaire,[19] by trained office staff, or both, allowing the clinician to focus on a more thorough evaluation of high-risk patients.

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Study concept and design: Ganz, Bao, Shekelle, Rubenstein.
Acquisition of data: Ganz, Bao.
Analysis and interpretation of data: Ganz, Rubenstein.
Drafting of the manuscript: Ganz.
Critical revision of the manuscript for important intellectual content: Ganz, Bao, Shekelle, Rubenstein.
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