Assessment and management of falls in older people

Emily Kwan MD, Sharon E. Straus MD MSc

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Correspondence to:
Emily Kwan,
emily.kwan@utoronto.ca

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Worldwide, 30% of people aged 65 years or older who are living in the community fall each year, and among people aged 85 years or older, this proportion increases to nearly 40%.[1,2] Falls frequently have serious consequences in this population, with concomitant effects on the health care system. Falls are defined in numerous ways; one commonly used definition is that of the World Health Organization (WHO): "an event which results in a person coming to rest inadvertently on the ground or floor or other lower level."[3]

Of older people living in the community who fall, 12% to 42% will have a fall-related injury, with up to 20% requiring medical attention and 10% experiencing a fracture secondary to osteoporosis.[4] Older people who have a fall-induced fracture can experience devastating consequences. For example, up to 20% of patients with hip fracture die within the first year, and many survivors do not return to their previous level of functioning.[1,4–7] Other fall-related injuries include head injuries in older people.[8] Given the serious consequences of falls, physicians need to specifically ask about falling because many patients do not tell their physicians about their previous falls.[8] It is also essential that physicians appropriately assess and manage the care of patients who experience a fall. In this article, we present the evidence contained within high-quality systematic reviews pertaining to assessment of patients who have fallen and management of their subsequent care. A summary of the evidence appears in Box 1.

Key points

- A targeted history and physical examination, covering potential home hazards, cognitive and visual impairment, functional limitations, medications, orthostatic hypotension, and gait and balance abnormalities, can be used to identify risk factors for falls.
- No specific assessment tools have been shown to accurately predict the risk of falls.
- Numerous interventions (single and multicomponent) have been shown to decrease the risk of falls.
- At a minimum, patients who have experienced a fall should be encouraged to participate in an approved exercise program to help prevent further falls.

What causes older people to fall?

A clinical examination, addressing potential home hazards, medications, cognitive and visual impairment, functional limitations, orthostatic hypotension, and gait and balance abnormalities, can be used to identify risk factors for falls.

Various factors can increase a person's risk of falling (Table 1). Because the causes of falls are usually multiple, one approach to assessing these risk factors is through a targeted history and physical examination.

History

Older age (i.e., ≥ 65 yr) has been associated with an increased risk of falls. One systematic review[2] showed that among patients aged 65 through 74 years, the risk of falling was 31% per year, and among those 80 years of age and older, the risk of falling increased to 37% per year.

Box 1: Evidence used in this review

To identify relevant systematic reviews, we did a comprehensive search of the literature (i.e., MEDLINE, CINAHL, Embase, AgeLine and The Cochrane Library) for articles published between Jan. 1, 2005 and Sept. 30, 2012. We used the following terms in the search: "falls," "accidental falls," "aged," "geriatric," "elderly," "senior," "old age" and "older adult." We identified additional articles (which may be outside of the range of dates) by reviewing reference lists of previous articles and discussing the topic with experts. We included only articles that were published in English.

We included systematic reviews of studies assessing risk factors for falls, as well as studies evaluating interventions to prevent falls among older people (mean age ≥ 60 yr).

Two reviewers independently evaluated the systematic reviews using AMSTAR (a measurement tool for the assessment of multiple systematic reviews).[9] If multiple reviews on a single topic were identified, we included only those that were rated as high quality (defined as a score of ≥ 7 out of 11). If a particular topic was covered by only one review, that review was included even if it scored less than 7 on the AMSTAR tool.

Table 1 (part 1 of 2): Studies evaluating risk factors for falls

Risk factor; study	Study design	No. of studies in review	Total no. of participants	Summary of results
Age				
Ganz et al.[2]	Systematic review of prospective cohort studies	18 (3 studies of age)	19 178	• For first and second studies combined, probability of falls by age category: 65–74 yr, 31%–32%; 70–74 yr, 22%–33%; 75–79 yr, 25%–36%; ≥ 80 yr, 34%–37% • For third study, increased risk of falling at least once in next 11 mo among older patients (OR per age category 1.90; $p < 0.001$) • Probability of falls, by age category: 65–69 yr, 14%; 70–74 yr, 16%; 75–79 yr, 24%; ≥ 80 yr, 34%
Previous falls				
Ganz et al.[2]	Systematic review of prospective cohort studies	18 (11 studies of history of falls, 4 with extractable data)	19 178	Occurrence of fall in past year associated with subsequent falls (LR range 2.3–3.8)
Cognitive impairment				
Ganz et al.[2]	Systematic review of prospective cohort studies	18 (8 studies of cognitive impairment, 2 with extractable data)	19 178	• In first study, presence of ≥ 5 errors on Short Portable Mental Status Questionnaire associated with ≥ 1 falls (LR 4.2, 95% CI 1.9–9.6) • In second study, history of dementia associated with ≥ 1 falls (LR 17, 95% CI 1.9–149) and with ≥ 2 falls (LR 13, 95% CI 2.3–79)
Visual impairment				
Ganz et al.[2]	Systematic review of prospective cohort studies	18 (11 studies of visual impairment, 3 studies showed significant results)	19 178	• For first and second studies, visual impairment increased the likelihood of a fall (OR 1.6 and 2.0, respectively • For third study, using Bailey–Lovie charts to measure visual acuity, each additional letter read correctly off the chart at baseline was associated with lower risk of falls (OR 0.96)
Medications				
Woolcott et al.[10]	Meta-analysis of cohort, cross-sectional, case–control studies	22	79 081	• Antidepressants, OR 1.68 (95% CI 1.47–1.91) • Antihypertensive agents, OR 1.24 (95% CI 1.01–1.50) • Benzodiazepines, OR 1.57 (95% CI 1.43–1.72) • Diuretics, OR 1.07 (95% CI 1.01–1.14) • Neuroleptics and antipsychotics, OR 1.59 (95% CI 1.37–1.83) • NSAIDs, OR 1.21 (95% CI 1.01–1.44) • Sedatives and hypnotics, OR 1.47 (95% CI 1.35–1.62) Updated Bayesian adjusted estimates: • Antidepressants, OR 1.36 (95% CI 1.13–1.76) • Benzodiazepines, OR 1.41 (95% CI 1.20–1.71
Hegeman et al.[11]	Systematic review of case–control, prospective and cross-sectional studies	13 (12 with extractable OR values)	209 015	NSAIDs, OR range 1.13 (95% CI 0.93–1.38) to 4.35 (95% CI 1.79–10.91)
Sterke et al.[12]	Systematic review of prospective cohort studies	17	61 392	Large range of OR and RR values for various combinations of psychoactive medications (antidepressants, tranquilizers, antipsychotics, benzodiazepines) used for patients with dementia living in nursing homes: • From 17 studies, OR range 1.13–5.67 and RR range 1.32–10.3 • Multiple drugs (3/3 studies: n = 177–282, RR range 1.30–10.3), antidepressants (10/12 studies: n = 78–2428, range of effect sizes 1.1–7.6) and antianxiety drugs (2/2 studies: n = 2015, RR 1.32 and n = 18 855, OR 1.22) increase fall risk • Evidence for other psychoactive drug classes is limited (antipsychotics), inconclusive (sedatives) or no association (hypnotics)

Continued

Table 1 (part 2 of 2): Studies evaluating risk factors for falls

Risk factor; study	Study design	No. of studies in review	Total no. of participants	Summary of results
Medications (cont'd)				
Kim et al.[13]	Meta-analysis of RCTs	40 total studies		
		22 studies of cholinesterase inhibitors in analysis of falls	9882 (for cholinesterase inhibitors)	Cholinesterase inhibitors: syncope, OR 1.53 (95% CI 1.02–2.30)
		14 studies of memantine, with 13 in analysis of falls	3583 (for memantine)	Memantine: fewer fractures, OR 0.21 (95% CI 0.05–0.85)
Functional limitations, disabilities in ADLs				
Bloch et al.[14]	Meta-analysis of RCTs and observational studies (cohort, cross-sectional, case–control)	177	19 178	• Any impairment in ADLs, OR 2.26 (95% CI 2.09–2.45) • Any impairment in instrumental ADLs, OR 2.10 (95% CI 1.68–2.64)
Ganz et al.[2]	Systematic review of prospective cohort studies	18 (10 studies specifically on impairment of ADLs, 3 studies showed significant results)	19 178	2 studies reported LR values: • In first study, inability to rise from chair of knee height without using chair arms was associated with increased risk of ≥ 1 falls among men (LR 4.3, 95% CI 2.3–7.9); not significant in women • In second study, presence of ≥ 5 of 11 physical impairments (mostly ADLs) was associated with increased risk of ≥ 1 falls (LR 1.9, 95% CI 1.4–2.6)
Home hazards				
Letts et al.[15]	Meta-analysis of cohort and cross-sectional studies	100	25 145	• Various indoor and outdoor home hazards (e.g., bathroom, environmental) were associated with increased risk of falls (OR 1.15, 95% CI 0.97–1.36) • Use of mobility aids was associated with significantly increased risk of falls in community (OR 2.07, 95% CI 1.59–2.71) and institutional settings (OR 1.77, 95% CI 1.66–1.89)
Orthostatic hypotension				
Ganz et al.[2]	Systematic review of prospective cohort studies	18 (4 studies specific to orthostatic hypotension)	19 178	• In 4 studies, no association between orthostatic hypotension and falls when other risk factors were considered • In 1 study, increase in pulse (< 6 beats/min) measured 30 s after standing up was weakly associated with falls (LR 1.4, 95% CI 1.0–1.9)
Balance impairment				
Muir et al.[16]	Meta-analysis of prospective studies	23	60 602	Overall fall risk, OR 1.98 (95% CI 1.60–2.46)
Impairment of gait or balance				
Ganz et al.[2]	Systematic review of prospective cohort studies	18 (15 studies on impairment of gait or balance)	19 178	• Of 15 studies found, 4 reported LR for clinically detected abnormality of gait or balance (LR range 1.7–2.4) • For presence of lower-extremity disability (i.e., reported problem with strength, sensation or balance), LR 1.8 (95% CI 1.5–2.2)

Note: ADLs = activities of daily living, CI = confidence interval, LR = likelihood ratio, NSAID = nonsteroidal anti-inflammatory drug, OR = odds ratio, RCT = randomized controlled trial, RR = relative risk.

The clinician's interview with the patient (or a caregiver) at the time of presentation should focus on eliciting information about previous falls and their causes, as well as any previous injuries resulting from such falls. The occurrence of a fall increases the risk of additional falls within the next year.[2] Symptoms that may cause falls, such as dizziness and palpitations, should also be elicited, as they may be related to potential causes of the fall, such as arrhythmias. Similarly, during the assessment, any injuries due to the current fall should be determined.

Other aspects of the patient's medical history may provide additional clues about risk factors for falls. For example, in their systematic review, Ganz and colleagues[2] identified 2 studies in which cognitive impairment increased the likelihood of a fall (likelihood ratio [LR] 4.2, 95% confidence interval [CI] 1.9–9.6; LR 13, 95% CI 2.3–79, respectively). In addition, visual impairment may slightly increase the likelihood of a fall (LR range 1.6–2.0).[2] Other comorbidities that have been linked with increased risk of falls include Parkinson disease, arthritis of the knees, sensory impairment, and any comorbidity that impairs gait or balance (e.g., stroke).[2]

Several medications have been found to increase the risk of falls, so it can be helpful to obtain an accurate medication history. For example, in a systematic review of 22 cohort, cross-sectional and case–control studies, the use of various types of drugs was shown to increase the risk of falls among people aged 60 years and older:[10] for sedatives and hypnotics (not including benzodiazepines), odds ratio (OR) 1.47 (95% CI 1.35–1.62); for neuroleptics and antipsychotics, OR 1.59 (95% CI 1.37–1.83); for antidepressants, OR 1.68 (95% CI 1.47–1.91); and for benzodiazepines, OR 1.57 (95% CI 1.43–1.72). Systematic reviews of observational studies involving other medications have shown similar increased risks of falls: for nonsteroidal anti-inflammatory drugs, OR 1.21 (95% CI 1.01–1.44); and for antihypertensive medications, OR 1.24 (95% CI 1.01–1.50).[10–12] Use of cognitive enhancers (i.e., cholinesterase inhibitors) increased the risk of syncope, which may lead to falls (OR 1.53, 95% CI 1.02–2.30).[13]

Assessment of the patient's functional status should include an assessment of activities of daily living (ADLs) (e.g., bathing, toileting, feeding, dressing, grooming and ambulation) and instrumental ADLs (e.g., use of the telephone, shopping, food preparation, managing own finances, housekeeping, laundry and transportation). A systematic review of randomized controlled trials and observational studies showed that the presence of any difficulties with ADLs was associated with an increased risk of falling (for ADLs, OR 2.26, 95% CI 2.09–2.45; for instrumental ADLs, OR 2.10, 95% CI 1.68– 2.64).[14]

The social history should address the patient's living conditions, including various environmental factors and hazards, both indoors and outdoors, such as rugs, bathroom equipment, lighting, bath rails, clutter, wet surfaces, gait aids, assistive devices, weather conditions and footwear. One systematic review of cohort and cross-sectional studies showed an increased risk of falls in the presence of mobility aids in both the community (OR 2.07, 95% CI 1.59–2.71) and institutional settings such as retirement homes and long-term care facilities (OR 1.77, 95% CI 1.66–1.89). It was concluded that home hazards increased the risk of falling (OR 1.15, 95% CI 0.97–1.36).[15]

Physical examination

The physical examination should focus on injuries related to the fall, as well as factors that may have contributed to its occurrence. In particular, positional blood pressure (both supine and standing) can be assessed to check for orthostatic hypotension, defined as a drop in systolic blood pressure of 20 mm Hg or in diastolic blood pressure of 10 mm Hg at 1 to 3 minutes after the patient repositions from supine to standing. One study found orthostatic hypotension to predict falls when there was a pulse rate that was less than an increase of 6 beats/min measured 30 seconds after standing up.[2]

A full neurologic examination with a focus on strength, reflexes, sensory and gait should be done. A clinically detected abnormality of gait or balance may increase the likelihood of a fall (LR range 1.7–2.4).[2,16] In their systematic review, Ganz and colleagues[2] found one prospective cohort study showing that the presence of any lower extremity disability increased the likelihood of falling (LR 1.8, 95% CI 1.5–2.2). In another systematic review of cohort and cross-sectional studies, Letts and associates[15] found that mobility aids were associated with an increased risk of falls both in the community and in institutions.

Are there any tools to help assess the risk of falling?

Systematic reviews have identified several tools to assess the risk of falls, including the Tinetti Gait and Balance Assessment Tool, the Berg Balance Scale, the Timed Up and Go test, and the one-legged and tandem stance assessments.[17–19] According to the systematic reviews, these tools poorly predict patients who will or will not fall.[17–19]

What interventions are effective for preventing falls?

Management of falls is complex. There have been numerous studies in different settings (i.e., community, acute hospital or long-term care) that have considered a combination of interventions such as an exercise program, medication review, home assessment and vitamin D supplementation for groups of older people. The causes of falls are usually multiple, and management should be tailored to each patient depending on the history and physical examination. It is unclear whether a single- or multiple-intervention approach should be used for patients who fall. Based on existing evidence, a specified exercise regimen should always be included in the management, but there is support for other interventions such as home assessments and treatment of first-time cataracts.

We identified 19 recent systematic reviews of interventions to prevent falls.[20–38] These reviews included studies involving older patients living in various settings (e.g., the community, acute care hospitals and long-term care institutions). Both single and multiple interventions have been tested. Numerous individuals can be involved in the assessment and management of falls, including caregivers, family members, pharmacists, physicians, and occupational and physical therapists.

Community

Tables 2 and 3 outline interventions for preventing falls among older adults. For those living in the community, the following single interventions have been found to be effective: home assessment (best if led by an occupational therapist),[21] and various exercise programs including the Otago Exercise Programme[20] (Box 2) (associated with reduced fall rates), tai chi,[22,23] group exercises, home-based exercises, and exercise training with either gait, balance or functional training.

Fear of falling declined following single interventions such as tai chi, use of hip protectors or exercise interventions, and after programs based on combinations of these interventions.[24] A multicomponent group exercise intervention showed benefit, with decreases in both the rate of falls and the risk of falling.[23] Multicomponent home-based exercise also decreased the rate of falls (rate reduction 0.68, 95% CI 0.58–0.80).[23]

Several interventions have been associated with a reduction in the rate of falls (e.g., tai chi, exercise training, multicomponent interventions, home safety assessment, gradual withdrawal of psychotropic medication, use of an antislip shoe device for icy conditions, multifaceted podiatry) or the risk of falling (e.g., multicomponent home-based exercise programs, tai chi, home safety assessment).[23] No reduction in the rate of falls or the risk of falling has been shown with vitamin D supplementation as a single intervention for older adults living in the community.[23] Similarly, a recent systematic review of randomized trials assessing strength and resistance training found no reduction in the rate or the risk of falling.[25] Cognitive behavioural interventions also had no significant effect on the rate or the risk of falling.[23] Treatment of vision problems (via single-lens glasses) resulted in an increase in the rate of falls and the risk of falling. Among women, surgery for first-time cataracts reduced the rate of falls, but surgery for second-time cataracts did not.[23]

Six recent systematic reviews of multicomponent interventions in older adults living in the community assessed various combinations of interventions, including combinations of exercises (balance, aerobic and/or strengthening exercises), vitamin D supplementation, home assessment, comprehensive geriatric assessment, reviews of vision and medications, and follow-up by an occupational therapist and physiotherapist.[21–24,26,27] It was unclear whether a multicomponent intervention was better than a single intervention for reducing falls.[27] One systematic review indicated that multicomponent interventions may have benefit in terms of reducing the rate of falls but not the risk of falling.[23] Similarly, it is unclear from studies of multicomponent interventions which interventions might be most effective in preventing falls.

Retirement homes and long-term care

Two systematic reviews[28,29] examined studies of interventions to prevent falls among those living in retirement homes or long-term care institutions. Vitamin D supplementation was associated with a reduction in the rate of falls but did not reduce the risk of falling (rate ratio 0.72, 95% CI 0.55–0.95, risk ratio 0.98, 95% CI 0.89–1.09).[28] Studies of multicomponent interventions were done in both reviews. One review[29] showed some efficacy but did not provide a compiled average in risk for all studies used. The other review[28] initially showed no significant reduction in rate of falls or risk of falling, but post hoc analysis did show significance.

Acute care hospitals

Two systematic reviews[28,30] examined studies of multicomponent interventions to prevent falls among patients admitted to acute care hospitals. These interventions reduced the rate of falls and the risk of falling relative to usual care (rate ratio 0.60, 95% CI 0.51–0.72; risk ratio 0.85, 95% CI 0.77–0.95).[28] There was a small but significant benefit with a multicomponent intervention (including exercise) that differed from "usual hospital care."[30]

Table 2 (part 1 of 4): Studies evaluating interventions for preventing falls among older people, by setting

Setting; study	Study design	No. of studies in review	Total no. of participants	Intervention	Outcome
Community					
Thomas et al.[20]	Systematic review of RCTs and controlled trials with masked assessment of outcome	7	1 503	Otago Exercise Programme v. usual care or social visits	• Lower risk of death (relative risk 0.45, 95% CI 0.25 to 0.80) • Lower fall rate (incidence rate ratio 0.68, 95% CI 0.56 to 0.79) • Risk of serious injury from fall (relative risk 1.05, 95% CI 0.91 to 1.22)
Clemson et al.[21]	Meta-analysis of RCTs	6	3 298	Home assessment and modification, including hazard reduction, behavioural changes, footwear, ADLs, instrumental ADLs, mobility, home visits, home modifications, vision assessment	Lower risk of falls associated with home assessment (relative risk 0.79, 95% CI 0.65 to 0.97)
Gillespie et al.[22]	Systematic review of RCTs and quasi-RCTs	111	55 303	Exercise interventions combined with 13 other approaches, including education, home safety intervention, and supplementation with vitamin D and calcium	• Multicomponent group exercise associated with reduced rate of falls and risk of falling (rate ratio 0.78, 95% CI 0.71 to 0.86; relative risk 0.83, 95% CI 0.72 to 0.97) • Tai chi associated with reduced risk of falling (rate ratio 0.63, 95% CI 0.52 to 0.78; relative risk 0.65, 95% CI 0.51 to 0.82) • Individually prescribed multicomponent home-based exercise associated with reduced risk of falling (rate ratio 0.66, 95% CI 0.53 to 0.82; relative risk 0.77, 95% CI 0.61 to 0.97) • Assessment and multifactorial intervention associated with reduced rate of falls (rate ratio 0.75, 95% CI 0.65 to 0.86) • Vitamin D not associated with reduced rate of falls (rate ratio 0.95, 95% CI 0.80 to 1.14; relative risk 0.96, 95% CI 0.92 to 1.01)
Gillespie et al.[23]	Systematic review of RCTs and quasi-RCTs	159	79 193	Numerous approaches, including single interventions (59 trials) and multifactorial approaches (40 trials)	• Group and home-based exercise programs and home safety interventions associated with reduced rate of falls and risk of falling • Multifactorial assessment and intervention programs associated with reduced rate of falls but no reduction in risk of falling • Tai chi associated with reduced risk of falling • Vitamin D supplementation did not appear to reduce falls but may be effective in people with lower vitamin D levels before treatment • See Table 3 for further details
Zijlstra et al.[24]	Systematic review of RCTs	19	Unavailable	Home-based multifactorial programs and single interventions (i.e., tai chi, exercise, hip protector intervention)	Reduction in fear of falling among older adults living in the community

Continued

Table 2 (part 2 of 4): Studies evaluating interventions for preventing falls among older people, by setting

Setting; study	Study design	No. of studies in review	Total no. of participants	Intervention	Outcome
Community cont'd					
Orr et al.[25]	Systematic review of RCTs	29	2 174	Progressive resistive training v. usual daily activity, usual care or activities that enhance blinding of intervention	Intervention needs further evaluation; limited evidence that progressive resistive training in isolation improves balance
Michael et al.[26]	Systematic review of RCTs	47	152	Various primary care interventions to prevent falls in people at higher risk of falling, including comprehensive multifactorial assessment and management, exercise and physical therapy interventions, and vitamin D supplementation	• Reduced risk of falling with multifactorial assessments and provision of medical and social care (relative risk 0.75, 95% CI 0.58 to 0.99) • Reduced risk of falling with vitamin D supplementation (pooled relative risk 0.83, 95% CI 0.75 to 0.91) • Reduced risk of falling with exercise and physical therapy (pooled relative risk 0.87, 95% CI 0.81 to 0.94) • No reduction in risk of falling with noncomprehensive multifactorial assessment and referral or limited management (relative risk 1.04, 95% CI 0.98 to 1.10) • No significant finding for hip protectors (relative risk 0.89, 95% CI 0.75 to 1.06), clinical education and vision correction
Campbell and Robertson[27]	Meta-regression of RCTs	14	5 968	Single and multifactorial interventions**	For populations at risk, targeted single interventions were as effective as multifactorial interventions; possibly more acceptable and more cost-effective Reduction of falls similar with single and multicomponent interventions: • Single component, pooled rate ratio 0.77 (95% CI 0.67 to 0.89) • Multicomponent, rate ratio 0.78 (95% CI 0.68 to 0.89)
Nursing care facilities					
Cameron et al.[28]*	Systematic review of RCTs	41	25 422	Multifactorial interventions (combinations of exercise, medications, environmental modification, knowledge, and measures to address other factors such as incontinence, fluid intake, nutrition, psychological concerns, vitamin D levels) and single-factor interventions (e.g., medications, exercise, knowledge)	• Multifactorial interventions in hospital setting reduced rate of falls (rate ratio 0.69, 95% CI 0.49 to 0.96) and risk of falling (risk ratio 0.73, 95% CI 0.56 to 0.96) • Vitamin D supplementation effective in reducing rate of falls in nursing care facilities (rate ratio 0.72, 95% CI 0.55 to 0.95) but not risk of falling (risk ratio 0.98, 95% CI 0.89 to 1.09) • Supervised exercise appeared effective in subacute care hospital setting (risk ratio 0.44, 95% CI 0.20 to 0.97) • Inconsistent results for nursing care with supervised exercise intervention • Multifactorial intervention in nursing home: no significant reduction in rate of falls (rate ratio 0.82, 95% CI 0.62 to 1.08) or risk of falling (risk ratio 0.93, 95% CI 0.86 to 1.01), but post hoc analysis showed that multifactorial intervention reduced rate of falls (rate ratio 0.60, 95% CI 0.51 to 0.72) and risk of falling (risk ratio 0.85, 95% CI 0.77 to 0.95)

Continued

Table 2 (part 3 of 4): Studies evaluating interventions for preventing falls among older people, by setting

Setting; study	Study design	No. of studies in review	Total no. of participants	Intervention	Outcome
Nursing care facilities cont'd					
Cusimano et al.[29]†	RCTs	5	2 395	Multifaceted programs (i.e., combinations of education, environmental modification, home assessments, review of drug regimen, exercise sessions and programs, personal educational consultation, gait aid maintenance, vision assessment, use of hip protectors)	Some efficacy described for multifaceted programs. No combined data of the trials.
Hospital, acute care					
de Morton et al.[30]	Systematic review of RCTs and controlled clinical trials	9	4 223	Multidisciplinary interventions; only those that included exercise were compared with "usual hospital care"	Small but significant increase in discharge home from hospital with multidisciplinary interventions (relative risk 1.08, 95% CI 1.03 to 1.14; number needed to treat 16, 95% CI 11 to 43)
Mixed setting (community, institutions, acute care hospitals)					
Kalyani et al.[31]	Meta-analysis of RCTs	10	2 932	Vitamin D (200–1000 IU daily) v. calcium or placebo	• Reduction in risk of falling (relative risk 0.86, 95% CI 0.79 to 0.93) • Post hoc analysis with 7 additional studies without explicit definition of falling (i.e., total 17 studies) yielded smaller benefit (relative risk 0.92, 95% CI 0.87 to 0.98), with significant intergroup differences favouring adjunctive calcium over no calcium
Bischoff-Ferrari et al.[32]‡	Meta-analysis of RCTs	8††	2 426	Vitamin D (700–1000 IU daily)	• Reduction in risk of falling (pooled relative risk 0.81, 95% CI 0.71 to 0.92) • Achieved serum 25(OH)D concentrations of 60 nmol/L or more (pooled relative risk 0.77, 95% CI 0.65 to 0.90) • Active forms of Vitamin D (pooled relative risk 0.78, 95% CI 0.64 to 0.94)
Murad et al.[33]	Meta-analysis of RCTs	26	45 782	Vitamin D (200–1000 IU daily)	Reduction in risk of at least 1 fall (OR 0.86, 95% CI 0.77 to 0.96), not significant in vitamin D supplementation without co-administration of calcium
Low et al.[34]§	Meta-analysis of RCTs	7	1 972	Tai chi as single intervention	Potential reduction in fall rate or risk of falls among older adults; no pooled data
Sitjà-Rabert et al.[35]§	Meta-analysis of RCTs	16‡‡	957	Whole-body vibration programs	• Improved isometric strength of knee muscle 18.30 Nm (95% CI 7.95 to 28.65), muscle power 10.44 W (95% CI 2.85 to 18.03) • No significant difference for comparison with conventional exercise, but significant difference for comparison with control group
Gates et al.[36]¶	Meta-analysis of RCTs and quasi-RCTs	19	6 397	Multifactorial fall prevention programs§§	• Decrease in number of people who fell (combined relative risk 0.91, 95% CI 0.82 to 1.02) • No reduction in fall-related injuries (combined relative risk 0.90, 95% CI 0.68 to 1.20)

Continued

Table 2 (part 4 of 4): Studies evaluating interventions for preventing falls among older people, by setting

Setting; study	Study design	No. of studies in review	Total no. of participants	Intervention	Outcome
Mixed setting (community, institutions, acute care hospitals) cont'd					
Vaapio et al.[37]	Systematic review of RCTs	12	2 357	Fall prevention intervention with assessment of quality of life	• Positive effect on quality of life in only a few studies • Quality of life domains included physical function, social function, vitality, mental health, environmental domain • No pooled data
Fairhall et al.[38]§	Systematic review and meta-analysis of RCTs	19	3 616	Exercise interventions, with measurement of participation in intervention and effect on participation in life roles	• Pooled estimate of effect of exercise on participation: (Hedges' *g* 0.16 (95% CI 0.04 to 0.27, *p* = 0.006)¶¶ • Point estimate of effect of multifaceted intervention with exercise component on participation: Hedges' *g* 0.25 (95% CI –0.04 to 0.53, *p* = 0.09) • Effect of exercise as a single intervention: Hedges' *g* 0.09 (95% CI –0.01 to 0.19, *p* = 0.07)

Note: ADLs = activities of daily living, CI = confidence interval, RCT = randomized controlled trial.
*Nursing care facilities and hospitals (acute and subacute [subacute defined as care provided to patients still in need of medical and nursing services]), analyzed separately.
†Residential care, including nursing homes.
‡Community rehabilitation and acute care hospitals.
§Community and long-term care settings.
¶Emergency department, primary care and community settings.
**Includes various combinations of home assessments, comprehensive geriatric assessments, hospital-based medical assessments, diagnostic home visits, Stepping On program (group sessions for balance and strengthening exercises, home and community environmental and behavioural safety measures, encouragement of regular review of vision and medications, follow-up home visit by occupational therapist), specific exercise program (i.e., physiotherapy and occupational therapy, tai chi and balance training, Otago Exercise Programme), medication withdrawal v. social visits or no intervention or usual care.
††2 RCTs examined active forms of vitamin D.
‡‡16 studies included in the qualitative synthesis and 10 studies included in the quantitative synthesis (meta-analysis).
§§Includes various combinations of occupational therapy, home assessment, risk assessment, geriatric assessment, gait and balance exam, cardiovascular assessment, drug review, vision, psychological assessment, personal care aids, self-management group session, counselling, motivational video, standardized and individualized fall prevention, other assessments including foot, positional transfer, function, lower limb disability, alcohol use, hearing v. "usual care" or no intervention.
¶¶Hedges' *g* calculates effect size and measures based on a standardized difference.

Mixed settings

Eight recent systematic reviews[31–38] evaluated interventions to prevent falls among patients living in various settings, including the community, acute care hospitals and long-term care institutions. Studies of vitamin D supplementation showed a benefit in reducing the risk of falls.[31–33] Tai chi also decreased the risk but not the rate of falling.[34] A systematic review on whole-body vibration programs (combined with strength and dynamic exercises) have shown some benefit compared with a control group (which did the same exercise as the intervention group but without a vibration platform) but not compared with a conventional group (which performed specific exercises based on guidelines of the American College of Sports Medicine).[35] Similar to the results of studies involving community-dwelling older adults, multicomponent interventions to prevent falls in all settings decreased the number of falls and injuries from falls (relative risk 0.91, 95% CI 0.82–1.02, and in number of fall-related injuries relative risk 0.90, 95% CI 0.68–1.20).[36] One systematic review found an improvement in patients' quality of life with evaluation of the extent to which measurement of a person's participation in interventions to prevent falls (as assessed by the individual's functioning in his or her various life roles) was reported in trials of such interventions.[37] Another systematic review concluded that participation in exercise may improve participation in life roles (i.e., social interaction; employment; use of transportation; and community, social and civic life).[38]

How can this review be applied in practice?

On the basis of the evidence reviewed, we suggest that assessment of a patient who has fallen should incorporate the history and physical

examination as described. This assessment can then be used to target implementation of strategies to prevent falls in the future. Exercise interventions such as tai chi and the Otago Exercise Programme have been shown to be beneficial and should be considered. A stepwise management plan that is applicable to all those at risk for falling is challenging to outline because individuals have different reasons for falling.

Interventions to address prevention have also been studied. In both primary and secondary prevention of falls, exercise has been proven to

Table 3 (part 1 of 2): Interventions for preventing falls among older people living in the community (Gillespie et al.[23])

Intervention	Rate of falls*			Risk of falling*		
	Rate ratio (95% CI)	No. of participants	No. of trials	Relative risk (95% CI)	No. of participants	No. of trials
Exercise						
Tai chi	0.72 (0.52–1.00)	1 563	5	0.71 (0.57–0.87)	1 625	6
Strength and resistance training	1.80 (0.84–3.87)	64	1	0.77 (0.52–1.14)	120	1
Walking groups	NR	NR	NR	0.95 (0.77–1.18)	222	1
Any exercise interventions	NR	NR	NR	Risk of fall-related fracture: 0.34 (0.18–0.63)	810	6
Multicomponent group exercise (combination of 2 or more categories of exercise)	0.71 (0.63–0.82)	3 622	16	0.85 (0.76–0.96)	5 333	22
Multicomponent home-based exercise	0.68 (0.58–0.80)	951	7	0.78 (0.64–0.94)	714	6
Exercise training including only one of gait, balance or functional training	0.72 (0.55–0.94)	519	4	0.81 (0.62–1.97)	453	3
Vitamin D						
Vitamin D supplementation	1.00 (0.90–1.11)	9 324	7	0.96 (0.89–1.03)	26 747	13
Vitamin D supplementation in people with low vitamin D levels	0.57 (0.37–0.89)	260	2	0.70 (0.56–0.87)	804	4
Home assessment						
Home safety assessment and modification interventions						
Overall	0.81 (0.68–0.97)	4 208	6	0.88 (0.80–0.96)	4 051	7
Led by occupational therapist	0.69 (0.55–0.86)	1 443	4	0.79 (0.70–0.91)	1 153	5
Not led by occupational therapist	0.91 (0.75–1.11)	3 075	4	0.94 (0.85–1.05)	2 975	3
Vision						
Treatment of vision problems	1.57 (1.19–2.06)	616	1	1.54 (1.24–1.91)	616	1
Vision intervention: multifocal to single-lens glasses	Rates of falls and outside falls reduced in those who regularly took part in outside activities	597	1	Risk of all falls and outside falls increased in group with little participation in outside activities	597	1
First cataract surgery (women only)	0.66 (0.45–0.95)	306	1	0.95 (0.68–1.33) Risk of fall-related fracture: 0.33 (0.10–1.05)	306	1
Second cataract surgery	0.68 (0.39–1.17)	239	1	1.06 (0.69–1.63)	239	1

Continued

Table 3 (part 2 of 2): Interventions for preventing falls among older people living in the community (Gillespie et al.[23])

Intervention	Rate of falls*			Risk of falling*		
	Rate ratio (95% CI)	No. of participants	No. of trials	Relative risk (95% CI)	No. of participants	No. of trials
Other						
Multifactorial interventions	0.76 (0.67–0.86)	9 503	19	0.93 (0.86–1.02)	13 617	34
Oral nutritional supplement	NR	NR	NR	0.95 (0.83–1.08)	1 902	3
Gradual withdrawal of psychotropic medication	0.34 (0.16–0.73)	93	1	0.61 (0.32–1.17)	93	1
Medication review and modification	1.01 (0.81–1.25)	186	1	1.03(0.81–1.31)	445	2
Pacemakers (to treat carotid sinus hypersensitivity)	0.73 (0.57–0.93)	349	3	0.78 (0.18–3.39)	171	1
Antislip shoe device for icy conditions	0.42 (0.22–0.78)	109	1	0.56 (0.23–1.38)	40	1
Multifaceted podiatry (foot and ankle exercises)	0.64 (0.45–0.91)	305	1	No reduction	305	1
Cognitive behavioural interventions	1.00 (0.37–2.72)	120	1	1.11 (0.80–1.54)	350	2
Education about fall prevention for patients	0.33 (0.09–1.20)	45	1	0.88 (0.75–1.03)	2 555	4
Professional development for family physicians,† with patient self-assessment, and medication review and modification	NR	NR	NR	0.61 (0.41–0.91)	659	1

Note: CI = confidence interval, NR = not reported.
*Unless stated otherwise.
†Included face-to-face education by a clinical pharmacist, feedback on prescribing practices and financial rewards.

be beneficial and should be recommended. Further consideration of interventions is dependent on the patient's setting.

Gaps in knowledge

Although we found information about numerous risk factors for falls, evidence is lacking about tools for assessing the risk of falls that are accurate, precise and easy to use. Optimal management for patients who have had falls is also unclear. Although many high-quality systematic reviews of interventions to prevent falls have been conducted, none have ranked all of the available interventions using a network meta-analysis approach; our group has undertaken such a study, which is currently in progress.[40] Similarly, it is unclear whether a single intervention is as good as a multicomponent approach for preventing falls. In addition, although exercise has been shown to be beneficial for patients who have had a fall, the types of exercise and the requirements of each exercise component in a multicomponent intervention vary.

Box 2: Otago Exercise Programme[39]

The Otago Exercise Programme is a system of home-based exercises combining progressively more difficult leg-strengthening and balance-retraining exercises to prevent falls in older people living in the community. It also includes a walking plan. The program is usually delivered by a physiotherapist.

Conclusion

Falls are common among older people and can have devastating consequences. Physicians should ask patients about falls during a comprehensive assessment and include an assessment for relevant risk factors. When a patient has a fall, through a careful history and physical examination, the clinician may be able to identify risk factors that can be targeted for interventions to prevent future falls. At a minimum, older patients who have experienced a fall should be counselled about starting an exercise program (e.g., tai chi or the Otago Exercise Programme) to prevent falls and associated fractures.

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Affiliations: Section of Geriatrics (Kwan), Department of Medicine, University of Calgary, Calgary, Alta.; Division of Geriatrics (Kwan), Department of Medicine (Straus), University of Toronto, Toronto, Ont.

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