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Risk Assessment and Prevention of Falls in Older Community-Dwelling Adults
A Review

Cathleen S. Colón-Emeric, MD, MHS; Cara L. McDermott, PhD, PharmD; Deborah S. Lee, MD; Sarah D. Berry, MD, MPH

IMPORTANCE Falls are reported by more than 14 million US adults aged 65 years or older annually and can result in substantial morbidity, mortality, and health care expenditures.

OBSERVATIONS Falls result from age-related physiologic changes compounded by multiple intrinsic and extrinsic risk factors. Major modifiable risk factors among community-dwelling older adults include gait and balance disorders, orthostatic hypotension, sensory impairment, medications, and environmental hazards. Guidelines recommend that individuals who report a fall in the prior year, have concerns about falling, or have gait speed less than 0.8 to 1 m/s should receive fall prevention interventions. In a meta-analysis of 59 randomized clinical trials (RCTs) in average-risk to high-risk populations, exercise interventions to reduce falls were associated with 655 falls per 1000 patient-years in intervention groups vs 850 falls per 1000 patient-years in nonexercise control groups (rate ratio [RR] for falls, 0.77; 95% CI, 0.71-0.83; risk ratio for number of people who fall, 0.85; 95% CI, 0.81-0.89; risk difference, 7.2%; 95% CI, 5.2%-9.1%), with most trials assessing balance and functional exercises. In a meta-analysis of 43 RCTs of interventions that systematically assessed and addressed multiple risk factors among individuals at high risk, multifactorial interventions were associated with 1784 falls per 1000 patient-years in intervention groups vs 2317 falls per 1000 patient-years in control groups (RR, 0.77; 95% CI, 0.67-0.87) without a significant difference in the number of individuals who fell. Other interventions associated with decreased falls in meta-analysis of RCTs and quasi-randomized trials include surgery to remove cataracts (8 studies with 1834 patients; risk ratio [RR], 0.68; 95% CI, 0.48-0.96), multicomponent podiatry interventions (3 studies with 1358 patients; RR, 0.77; 95% CI, 0.61-0.99), and environmental modifications for individuals at high risk (12 studies with 5293 patients; RR, 0.74; 95% CI, 0.61-0.91). Meta-analysis of RCTs of programs to stop medications associated with falls have not found a significant reduction, although deprescribing is a component of many successful multifactorial interventions.

CONCLUSIONS AND RELEVANCE More than 25% of older adults fall each year, and falls are the leading cause of injury-related death in persons aged 65 years or older. Functional exercises to improve leg strength and balance are recommended for fall prevention in average-risk to high-risk populations. Multifactorial risk reduction based on a systematic clinical assessment for modifiable risk factors may reduce fall rates among those at high risk.

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Author Affiliations: Division of Geriatrics, Duke University, Durham, North Carolina (Colón-Emeric, McDermott); Durham VA Geriatric Research Education and Clinical Center, Durham, North Carolina (Colón-Emeric); Department of Medicine, Massachusetts General Hospital, Harvard Medical School, Boston (Lee); Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts (Berry); Marcus Institute for Aging Research & Department of Medicine, Hebrew SeniorLife, Boston, Massachusetts (Berry).

Corresponding Author: Cathleen S. Colón-Emeric, MD, MHS, Duke University, Box 3003 DUMC, Durham, NC 27710 (cathleen.colonemeric@duke.edu).

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Falls are among the most common and preventable causes of morbidity and mortality for older adults worldwide.[1-3] In a 2018 nationally representative telephone survey of individuals across all 50 states, the District of Columbia, and US territories, 27.5% of community dwellers aged 65 years or older (n = 13 685 662) reported falling in the last year. Among these individuals who fell, 59% were female and 41% were male, and 10.2% reported an injury with falling.[4] One of 5 falls among older adults leads to fractures or head injury.[5,6] Mortality from falls more than doubled in the US between 2000 and 2016 to rates of 1.2 per 1000 patient-years among persons aged 75 years or older.[7] The US Centers for Disease Control and Prevention (CDC) estimates that an older adult in the US dies from a fall every 20 minutes.[8,9] Health care expenditures related to falls in the US exceed $50 billion annually, accounting for 4.4% of Medicare hospital expenditures, 5.7% of physician and other health professional expenditures, and 11.8% of spending for home health services, long-term care facilities, and durable medical equipment.[10]

Fall rates increase substantially after age 65 years.[1] However, falls are associated with frailty at all ages[2] such that younger individuals (aged 50-65 years) with frailty have a risk of falls comparable with those in their seventh and eighth decades.[3] A national survey of falls resulting in an emergency department visit reported that 79% of falls occurred inside the home, most commonly in the bedroom (25%), on the stairs (22.9%), and in the bathroom (22.7%).[11] Fear of falling and fall-related activity restriction are highly prevalent (69.2% for fear of falling and 38.4% for fall-related activity restriction in a sample of community-dwelling adults older than age 60 years), and both concerns are associated with sarcopenia (odds ratio [OR], 8.1; 95% CI, 1.5-43.4) and depression (OR, 4.9; 95% CI, 1.1-22.7).[12]

Age-related declines in sensory input, central integration, and motor function result in a blunted compensatory response, such that when an older adult faces environmental hazards such as a loose rug they cannot quickly adjust their body position to prevent a fall. This impaired response is exacerbated by common comorbidities that occur with aging (eg, diabetes, arthritis, neurologic conditions such as Parkinson disease, stroke, and major neurocognitive disorders). Certain medications can affect balance and coordination through changes in blood pressure, drowsiness, dizziness, or blurry vision. Thus, clinicians across specialties and settings of care are likely to encounter patients at risk of falls. The cause of falls may be multifactorial, requiring careful assessment and intervention across multiple domains. This review will summarize current understanding of best practices for risk stratification, clinical assessment, and selection of risk reduction interventions (**Box 1**).

Box 1. Common Questions About Fall Prevention in Older Patients

What symptoms or signs predict increased risk of falls?
A history of falls (especially multiple falls), fear of falling, gait speed <0.8-1 m/s, and other features of frailty (unintentional weight loss, muscle weakness, exhaustion, low physical activity) predict increased falls risk. Certain comorbidities (neurologic conditions including cognitive impairment and Parkinson disease) and medication classes (psychoactive, anticholinergic, loop diuretics) are also associated with elevated risk of future falls.

What are some of the components of a multifactorial program?
Components of evidence-based multifactorial interventions include deprescribing, education, environmental modifications, orthostasis management, podiatry care, and physical rehabilitation or exercise.

What exercises decrease the risk of falls?
Functional exercises addressing balance and leg strength, and tai chi decrease the risk of falls in patients at average and increased falls risk.

Methods

For each of the categories of fall prevention interventions, we used Canadian Agency for Drugs and Technologies in Health Search filters in PubMed, CINAHL, Embase, MEDLINE, and Scopus for English-language articles published after the most recent Cochrane Systematic Review search (January 1, 2018 or 2019) through June 21, 2023. We limited the search to meta-analyses of studies conducted in community-dwelling older adults and randomized clinical trials (RCTs) published after the most recent meta-analysis. Furthermore, we reviewed clinical practice guidelines and the CDC Compendium of Fall Prevention Interventions. For all sections we focused on high-quality prospective cohort studies, large pragmatic (ie, designed to evaluate the effectiveness of interventions under routine practice conditions) RCTs, and systematic reviews and meta-analyses of RCT efficacy trials. Where possible we used nationally representative surveys to obtain estimates of fall and injury frequency.

From intervention meta-analyses we abstracted fall rate (total number of falls per 1000 patient-years), risk of falls (proportion of participants sustaining 1 or more falls), and risk of fall-related injuries (proportion of participants sustaining a fracture and/or other injury requiring medical attention) when available. To estimate risk differences (RDs) from meta-analysis results, we used the overall control group rate when available and then applied the summary rate ratio (RR) and associated 95% CIs.

Risk Factors for Falls

Risk factors for falls can be intrinsic or extrinsic to the patient. **Box 2** lists common intrinsic risk factors stratified by odds ratio (OR). Major risk factors for 2 or more falls over 6 to 12 months are generally related to neurologic diseases (eg, Parkinson disease [OR, 3.79; 95% CI, 1.00-14.30], stroke [OR, 2.94; 95% CI, 1.77-4.87], and major neurocognitive disorders such as dementia [OR, 3.65; 95% CI, 1.71-7.79]), which may not be modifiable.[13,14] Factors defining the frailty phenotype (unintentional weight loss, self-reported exhaustion, muscle weakness, slow walking speed, and low physical activity) are associated with falls in an additive manner (3 or more factors vs no factors: OR, 1.84; 95% CI, 1.43-2.38; 1-2 factors vs no factors: OR, 1.25; 95% CI, 1.01-1.53).[15] Other moderate risk factors, including visual and hearing impairment, pain, and orthostatic hypotension, are potentially modifiable. Body mass index (BMI) has a U-shaped association with falls, with individuals with a BMI (calculated as weight in kilograms divided by height in meters squared) of 18.5 or lower or greater than or equal to 37 at greatest risk.[16] Both

Box 2. Intrinsic Risk Factors for Falls in Older Adults by Odds Ratio (OR) Category

Major (OR >2)
Peripheral neuropathy
Parkinson disease
Cognitive impairment
Stroke
Gait abnormality
Vertigo/dizziness

Moderate (OR 1.5-2.0)
Arthritis
Frailty (unintentional weight loss, self-reported exhaustion, muscle weakness, slow walking speed, low physical activity)
Orthostatic hypotension
Urinary incontinence
Visual impairment
Hearing impairment
Pain

Minor (OR <1.5)
Diabetes
Heart disease
Low BMI (≤18.5)
High BMI (≥37)

BMI indicates body mass index (calculated as weight in kilograms divided by height in meters squared).

low BMI and high BMI are hypothesized to increase falls risk due to associated sarcopenia, whereas obesity may also increase falls risk through impaired postural stability and deconditioning due to decreased physical activity.

Medications are the most common modifiable extrinsic risk factor for falls; nonhospitalized persons aged 75 years or older are prescribed a mean (SD) of 2.2 (1.5) fall risk–increasing medications and a mean (SD) of 2.0 (1.6) medications associated with orthostasis.[17] High-quality studies suggest an association between environmental hazards and recurrent falls[18] (OR, 1.38; 95% CI, 1.03-1.87), particularly when the hazard interferes with function (eg, low seats).[19] Poor lighting and tripping hazards (eg, rugs) are other common environmental risk factors.[20] Walking barefoot or in stockings markedly increases the risk of falls over 2 years (OR, 11.2; 95% CI, 2.4-51.8; absolute risk not reported), while athletic shoes and sneakers are associated with a lower risk of falls compared with other footwear.[21]

Assessment and Diagnosis

As described in a 2021 systematic review of clinical practice guidelines for fall prevention,[22] most clinical practice guidelines suggest risk stratification for adults aged 65 years or older using a combination of fall history (eg, "Have you fallen in last 12 months?"), subjective fear of falling, and a mobility screening test such as gait speed measurement (**Video 1**) or Timed Up and Go (TUG) test (**Video 2**).

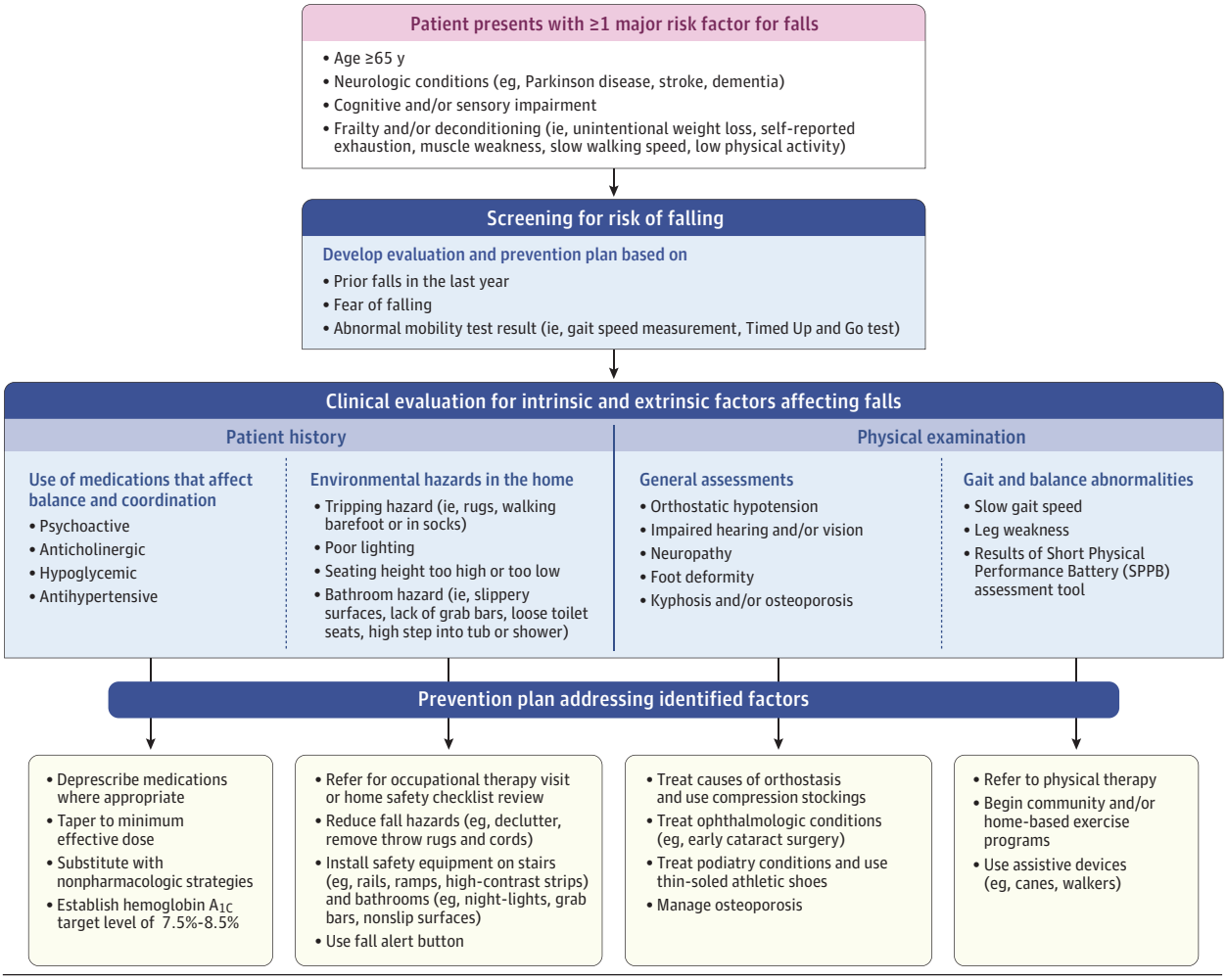
Prior fall history is consistently one of the most reliable estimators of falls in the next 6 to 24 months across multiple cohort studies; in a large prospective cohort study of UK adults older than 50 years, the RR of a fall in the next 2 years was 1.7 (95% CI, 1.55-1.79; absolute risk not reported) among those reporting a prior fall compared with those without prior fall after adjustment for age and sex.[23,24] Fear of falling is also associated with subsequent falls in those without prior fall; in a US cohort of 2520 adults aged 65 to 84 years, those with fear of falling were significantly more likely to fall in the next 20 months (32.6%) compared with those without fear of falls (17.9%; RD, 14.7%; $P < .001$).[25] In a cohort of 1776 older adults in a US health plan, self-report of 2 or more falls in the last year, but not prior injurious falls or fear of falling, was independently associated with fall-related injuries over the next 12 months after adjusting for age, prior fall with injury in past 12 months, and the Elixhauser Comorbidity Index (incidence rate ratio [IRR], 1.56; 95% CI, 1.25-1.94).[26]

Gait speed is consistently lower among individuals with falls compared with those who have not fallen across 11 cohort studies.[27-30] In a prospective study of community dwellers with and without cognitive impairment, 19% of those with gait speed less than 0.9 m/s experienced a fall within 12 months compared with 13% of those with faster gait speed,[31] and most clinical practice guidelines suggest using a threshold of less than 0.8 to 1 m/s for referral for fall prevention interventions. Gait speed is easily measured using a stopwatch or commercial application as the time it takes an individual to walk at least 4 m at their usual speed following a 2 m start-up, with the distance in meters divided by the time in seconds (Video 1). The TUG test is also suggested by guidelines as a rapid way for clinicians to screen for leg strength and gait abnormalities (Video 2). However, prospective cohort studies have reported that the timed component of the TUG has little or no discriminative ability in identifying who will and will not fall in the next 6 to 12 months.[28,32]

For those with prior falls, fear of falling, and/or abnormal gait screening test, guidelines recommend a targeted clinical assessment to identify modifiable factors in multiple domains (**Figure**). Recommended physical examination includes assessments for sensory impairment (eg, hearing, vision, neuropathy), orthostasis, foot deformities, and gait abnormalities. A more detailed gait and balance evaluation to guide need for assistive devices such as canes and walkers and/or rehabilitation services can be completed in primary care using the Short Physical Performance Battery (gait speed measurement [part 1], 3-stage balance test [part 2], and chair stand test [part 3]) (**Video 3**), or by referral to a physical therapist. Practice guidelines suggest concurrent screening for osteoporosis because fractures of the hip, wrist, humerus, and pelvis are the most frequent serious injuries associated with falls.[22]

Recommended history includes assessment of home environmental hazards and fall risk–increasing medication use. Psychoactive, anticholinergic, cardiovascular, and analgesic medications are associated with falls through sedation, orthostatic hypotension, or other mechanisms (**Table 1**).[33-41,43] The Beers criteria for medications that may be potentially harmful in older adults note that anticholinergics, antidepressants, antiepileptics, antipsychotics, benzodiazepines, nonbenzodiazepine anxiolytics, benzodiazepine receptor agonists (eg, zaleplon, zolpidem), and opioids should be used with caution in older adults, particularly among those with a history of falls.[35] Over-the-counter medications such as nonselective antihistamines (eg, diphenhydramine) may cause sedation and

Figure. Approach to Screening, Evaluation, and Prevention of Falls in Community-Dwelling Older Adults



dizziness. Use of aspirin and other nonsteroidal anti-inflammatory drugs is associated with falls requiring medical treatment,[42] likely due to increased probability of bleeding. Meta-analyses of cohort studies among older adults prescribed cardiovascular medications suggest the greatest odds of falling are associated with loop diuretics.[44] Patients with initiation within the last 30 days and those with longer duration of use of loop diuretics were at highest risk, although the loop diuretic dose was not associated with higher fall risk.[38] Use of β-blockers, α-blockers, and sodium-glucose cotransport 2 inhibitors is associated with increased odds of orthostatic hypotension, which may exacerbate fall risk for individuals with other risk factors.[45] Prescriptions for gabapentinoid medications (eg, gabapentin and pregabalin) for pain have increased substantially over the last decade, and their use is associated with increased falls in older adults, particularly when combined with opiates.[46,47]

Prevention

General categories of interventions tested for fall prevention include exercise programs to improve leg strength and balance, vision interventions, home environmental modification, deprescribing programs, podiatry interventions, multifactorial interventions (ie, systematic risk factor assessment followed by tailored intervention targeting multiple modifiable factors), and multicomponent interventions (ie, fixed combinations of interventions provided to all patients).

Exercise Interventions

In a meta-analysis of 64 RCTs (14 306 individuals), participants in exercise interventions experienced 655 falls per 1000 patient-years vs 850 falls per 1000 patient-years in nonexercise control groups (RR for falls, 0.77; 95% CI, 0.71-0.83; RR for number of patients who fall, 0.85; 95% CI, 0.81-0.89, absolute risk reduction 7.2%; 95% CI, 5.2%-9.1%).[48-50] Interventions varied in intensity and duration; however, meta-regression suggested that a minimum dose of 50 hours was required to achieve effective fall prevention.[51] Most trials have tested functional exercises (ie, focusing on movements done in daily life), which improve leg strength and balance, tai chi, and combined balance plus resistance training (**Table 2**).[23-26] Evidence is inconclusive for resistance training alone, yoga, and dance training (ie, constant fluid dynamic movement using a variety of patterns and speeds). In a meta-analysis of 2 RCTs (441 participants), walking programs alone were ineffective for fall prevention compared with usual care and may

Table 1. Commonly Prescribed Classes of Potentially Fall-Risk Increasing Drugs[a]

Medication class	Studies, No.	Participants, No.	Unadjusted pooled OR (95% CI)[b]	Adjusted pooled OR (95% CI)[b]	Potential alternatives	Notes
Psychoactive and anticholinergic medications						
Antidepressants[33,b]	22	69 189	Not provided	1.48 (1.24-1.77)	Use lowest effective dose and avoid agents with high anticholinergic activity, such as tricyclic antidepressants and paroxetine.[34] Consider CBT	Mixed effects by class; SNRI may have larger effect size than SSRI[35]
Anxiolytics[33,b]	14	141 287	Not provided	1.40 (1.18-1.66)	CBT; selective serotonin reuptake inhibitor at lowest effective dose	Synergistic risk with other CNS-active agents, especially opioids[36]
Sedative hypnotics[33]	18	336 871	2.05 (1.95-2.15)	Not provided	Sleep hygiene, CBT insomnia[37]; limited evidence for melatonin	
Antipsychotics[33,b]	16	133 463	Not provided	2.30 (1.24-4.26)	Avoid except in bipolar disorder, schizophrenia, psychosis	
Cardiovascular medications						
Antihypertensives[38]	28	33 333	1.38 (1.19-1.56)	0.90 (0.72-1.12)	Titrate to lowest effective dose	Transient increased risk at initiation or dose increase in multiple cohort studies[39,40]
β-Blockers[38]	16	435 065	0.96 (0.87-1.06)	0.88 (0.80-0.97)	Titrate to lowest effective dose	
Loop diuretics[38]	3	331 424	1.58 (1.52-1.65)	1.36 (1.17-1.57)	Titrate to lowest effective dose, avoid use for venous stasis or as an antihypertensive without other indication (eg, heart failure)	
Digoxin[38]	4	1123	2.06 (1.56-2.74)	Not provided	For atrial fibrillation consider β-blockers, calcium channel blockers, antiarrhythmic	
Analgesics						
NSAIDs[41]	26	397 027	1.31 (1.11-1.55)	1.09 (0.96-1.23)	Acetaminophen (paracetamol) <3000 mg daily for pain	Aspirin highest risk[42]
Antiepileptics[41,b]	6	19 120	2.55 (1.84-3.52)	2.42 (0.98-6.03)	For neuropathic pain consider topical NSAID or lidocaine	
Opiates[41,b]	22	424 376	1.51 (1.15-1.91)	1.60 (1.35-1.91)	Lowest dose and duration possible	Risk increased in combination with other CNS-acting agents[43]

Abbreviations: CBT, cognitive behavioral therapy; CNS, central nervous system; OR, odds ratio; NSAIDs, nonsteroidal anti-inflammatory drugs; SNRI, serotonin and norepinephrine reuptake inhibitors; SSRI, selective serotonin reuptake inhibitors.

[a] Meta-analyses included studies of older adults in the community and from other settings (eg, long-term care).

[b] Meta-analyses did not provide a summarized risk of falls in the included studies. Because absolute fall risk is highly dependent on age, cognition, frailty status, and other comorbidities, only odds ratios are provided here.

increase falls but with wide CIs (RR, 1.14; 95% CI, 0.66-1.97; RD, 11.9% more falls in the walking groups).[49] In a meta-analyses of 20 RCTs, long-term (>1 year) moderate intensity exercise training programs (mean frequency 3 times per week, 50 minutes per session) targeting other outcomes (eg, cardiovascular disease, deconditioning) were associated with a reduction in falls (RD, 5.8%; 95% CI, 1.0%-10.1%) and injuries (RD, 5.5%; 95% CI, 2.5%-8.0%) without an effect on overall mortality or all-cause hospitalization.[52] There is no evidence that fall prevention efficacy differs by mode of delivery (individual, group), level of fall risk, or age group. A meta-analysis of 7 RCTs including individuals with cognitive impairment (781 participants) reported that group or home exercise was associated with a lower RR of falls (RR, 0.68; 95% CI, 0.51-0.91) compared with nonexercise controls, but conclusions are limited by heterogeneity and inclusion of studies with higher risk of bias.[53,54] Exercise programs appear to be safe with a low injury rate (2 per 1000 participant-years; 95% CI, 0-5 per 1000 participant-years).[55] A meta-analyses of 20 exercise trials using technology-based programs (websites, mobile applications, or an exergame such as Wii Fit) found associations with improved balance and performance tests compared with traditional exercise interventions or control interventions, especially when combined with resistance training.[56] However, most trials are of low to moderate quality with fall rates as a secondary outcome.[56-58]

Deprescribing Fall Risk Medications

Most patients (65%-93%) who seek medical treatment for a fall-related injury have an active prescription for at least 1 medication that increases the risk of falling.[59] However, there is little evidence that deprescribing programs without attention to other risk factors are associated with reduced falls.[60,61] In a meta-analysis of 5 RCTs (1305 patients), programs that attempted to reduce or discontinue use of drugs associated with increased risk of falls compared with usual care were not associated with lower fall rate (RR, 0.98; 95% CI, 0.63-1.51), incidence of falls (RD, 0.01; 95% CI, −0.06 to 0.09; RR, 1.04; 95% CI, 0.86-1.26) or rate of fall-related injuries (RR, 0.89; 95% CI, 0.57-1.39) over 6 to 12 months.[62] However, many successful multifactorial interventions (described in Multifactorial Interventions) include deprescribing as a core component.

Vision Interventions

In a meta-analysis of 8 RCTs and quasi-randomized trials including 1834 patients with visually significant bilateral cataracts, the first cataract surgery was associated with a reduction in fall risk (RR, 0.68; 95% CI, 0.48-0.96; absolute benefit not reported),[63] while surgery on the second eye showed no additional benefit.[63,64] One of 2 clinical trials among 545 patients randomized to expedited (4 weeks) vs longer (12 months) waiting time for cataract surgery demonstrated

Table 2. Summary of Meta-Analyses of Randomized Clinical Trials of Exercise Interventions to Reduce Falls Compared With Usual Care or Nonactivity Interventions[a]

Exercise type	Populations studied	Studies, No.	Participants, No.	Estimated falls per 1000 patient-years[b]			Estimated patients who fall per 1000 patient-years[b]			Estimated injuries per 1000 patient-years[b]		
				Intervention, No. (95% CI)	Control	RR (95% CI)	Intervention, No. (95% CI)	Control	RD, % (95% CI)	Intervention, No. (95% CI)	Control	RD, % (95% CI)
Overall, all types[23,24]	Aged ≥60 y, multinational, unselected to high-risk populations, community	64	14 306	655 (604-706)	850	0.77 (0.71-0.83)	408 (389-428)	480	7.2 (5.2-9.1)	Fractures 47 (36-61)	64	1.7 (0.3-2.8)
Balance and functional exercise[23,24]	Aged ≥60 y, multinational, unselected to high-risk populations, community	39	7989	646 (595-689)	850	0.76 (0.70-0.81)	418 (394-437)	480	6.2 (4.3-8.6)	Fractures 29 (16-49)	64	3.5 (1.5-4.8)
Tai chi[24,25]	Aged ≥60 y, multinational, sarcopenia/frailty, moderate to high risk, community and institutionalized	9	3196	689 (570-842)	850	0.81 (0.67-0.99)	384 (336-437)	480	9.6 (4.3-14.4)	NA	NA	NA
Long-term cardiovascular/endurance training (>1 y, mean 17 mo)[26]	Aged >59 y, N. America, Europe, Oceania, unselected populations, cancer survivors, cardiology, community and institutionalized	40	21 868	NA	NA	NA	422 (379-470)	480	5.8 (1.0-10.1)	Overall injuries 156 (131-186)	211	5.5 (2.5-8.0)

Abbreviations: NA, not applicable; RD, risk difference; RR, rate ratio.

[a] Absolute risk reductions assume the population has the average risk observed across study control groups, which enrolled a mix of average-risk to high-risk participants.

[b] The CIs for controls were not reported.

a significant reduction in falls with earlier treatment of cataracts. Other studies of vision-related interventions did not consider falls as an outcome but have reported improvements in balance, gait, or step accuracy, suggesting that an improvement in these end points may be associated with reduced fall risk.[65]

Environmental Modification and Assistive Devices

Fall-hazard reduction in the home (eg, installation of lighting, nonslip steps that provide high traction, reducing clutter and trip hazards) is associated with lower fall rates among older adults at high risk (12 studies; 5293 patients; rate reduction, 0.74; 95% CI, 0.61-0.91; absolute rate not reported).[66] There is a significant interaction by baseline fall risk, with the rate reduction largest among patients at higher risk (9 studies; 1513 participants; rate reduction, 0.62; 95% CI, 0.56-0.70; absolute rate not reported) compared with patients selected without attention to risk level (6 studies; 3780 patients; rate reduction, 1.05; 95% CI, 0.96-1.16; absolute rate not available).[66] A 2021 RCT in New Zealand studied fall injuries after the following home improvements: adding rails by steps, grab bars in the bathroom permanently affixed to the wall, nonslip bathmats, high-visibility slip-resistant step edges spanning the entire stair on outside stairs, fixing elevated edges of carpets/mats, slip-resistant surfacing for outside surfaces such as decks, fixing window catches to prevent falls from windows, and improving lighting from durable solar sources. This study reported a 40% reduction in home fall injuries among individuals in 256 enrolled households (RD, 57 falls per 1000 persons over a mean of 2.3 years of follow-up; 95% CI, 3 per 1000 to 92 per 1000 persons).[67] Although no clinical trials of assistive device prescription (eg, canes, walkers) were identified as a standalone intervention for fall prevention, assistive devices are a common component of multifactorial interventions, described in Multifactorial Interventions.

Foot and Podiatry Care

Multicomponent podiatry interventions including podiatry examination, custom footwear, orthoses if indicated, education, and home-based foot and ankle exercises were associated with decreased fall rate compared with usual care (3 studies; 1358 patients; RR, 0.77; 95% CI, 0.61-0.99; absolute difference not available).[68] A meta-analysis of 7 observational studies (156 participants) found an association with textured or vibrational insoles and improved balance in older adults[69] but did not assess fall risk. Multifactorial interventions that include podiatry as a potential component were also associated with decreased fall risk (4 studies; 1964 patients; RR, 0.73; 95% CI, 0.54-0.98; absolute difference not available). In a single RCT (n = 121), there was no benefit to routine podiatric care with the provision of extra depth footwear compared with routine podiatric care alone (RR, 1.58; 95% CI, 0.69-3.60).[68]

Multifactorial Interventions

Because falls result from multiple intrinsic and extrinsic factors, combining multiple types of interventions has been hypothesized to be an effective fall reduction strategy.[70,71] In a multifactorial trial, each patient is systematically evaluated for modifiable risk factors and then receives a tailored intervention to address these factors. Multifactorial trials have typically enrolled a higher-risk population (ie, patients presenting with 1 or more falls at baseline), while other intervention types described previously (eg, exercise) frequently include

Table 3. Summary of the Evidence for Multifactorial and Multicomponent Interventions on Falls Risk[a]

Intervention type	Components of the intervention	Studies, No.	Participants, No.	Estimated falls per 1000 patient-years			Estimated patients who fall per 1000 patient-years			Estimated injuries per 1000 patient-years		
				Intervention	Control	RR (95% CI)	Intervention	Control	RD, % (95% CI)	Intervention	Control	RD, % (95% CI)
Multifactorial	Individual risk factor assessment and modification (assistive technology, deprescribing, education, environmental modifications, orthostasis management)[b]	43	5853	1784	2317	0.77 (0.67 to 0.87)	454	472	1.8 (−0.02 to 4.7)	115	126	1.1 (−1.3 to 3.1)
Multicomponent	Fixed combination of interventions for all participants, generally exercise plus environmental modification, education	17	3060	1206	1630	0.74 (0.61 to 0.91)	243	297	5.4 (3.0 to 7.7)	317	333	1.6 (−11.7 to 11.0)

Abbreviations: RD, risk difference; RR, rate ratio.

[a] Absolute risk reductions assume the population has the average risk observed across study control groups, which typically enrolled high-risk participants.

[b] Assistive technology includes provision of hip protectors, assisted devices, podiatry intervention, and/or aids of hearing or vision.

unselected or individuals at average risk. In a meta-analysis of 43 RCTs (15 673 patients) in which multifactorial risk reduction was largely implemented by study staff (ie, most studies were efficacy trials conducted in ideal circumstances), multifactorial fall risk interventions were associated with a reduced rate of falls (1784 per 1000 patient-years vs 2317 per 1000 patient-years; RR, 0.77; 95% CI, 0.67-0.87). While multifactorial interventions are associated with reduced numbers of total falls, there was no reduction in the number of individuals with at least 1 fall.

The implementation of multifactorial interventions in clinical practice is time consuming and complex, and more recent effectiveness studies (ie, multifactorial interventions implemented by existing staff in clinical practice) have shown mixed results.[22] In a large nonrandomized dissemination project[72] in 58 regions of Connecticut, primary care clinicians and staff in home care, outpatient rehabilitation, and senior centers were educated on multifactorial fall reduction strategies. The adjusted rates of serious fall-related injuries among individuals aged 70 years or older were lower in intervention regions (74.2 per 1000 patient-years) than in 53 control regions (83.3 per 1000 patient-years) following the initiative despite similar rates at baseline (adjusted RR, 0.91; 95% bayesian credibility interval, 0.88-0.94).[72] More recent randomized effectiveness trials have revealed implementation barriers. Strategies to Reduce Injuries and Develop Confidence in Elders (STRIDE)[73] was a cluster RCT conducted in 86 US primary care practices including 5451 community-dwelling adults identified as at high risk for falls. Practice nurses trained as falls care managers assessed patients for modifiable risk factors and developed individualized care plans. Over a follow-up period of up to 44 months, the reduction in rate of a first serious fall injury was similar to the larger Connecticut Collaborative but did not meet the prespecified minimal clinically important difference (4.9 events per 100 patient-years of follow-up in intervention group vs 5.3 per 100 patient-years in control group; hazard ratio [HR], 0.92; 95% CI, 0.80-1.06; $P = .25$). Fall rates in both groups were lower than anticipated suggesting that the null result may be due in part to healthy volunteer bias. Negative findings were also attributed to lower levels of patient engagement and adherence monitoring in this pragmatic trial; for example, only one-third of participants taking fall risk–increasing drugs reduced those medications, and participants frequently opted for less intensive interventions (eg, home exercises vs physical therapy).[74] The Prevention of Fall Injury Trial (PreFIT)[75] was a multicenter cluster RCT including 9803 community-dwelling adults across 63 general practices in Europe. Sites were randomized to falls-risk screening followed by a targeted balance and functional training exercise program, a multifactorial fall prevention intervention delivered by practice staff or control group. Over 18 months, the targeted exercise group had small gains in quality of life, but neither intervention reduced fall or fracture rates compared with advice by mail alone.

Multicomponent Interventions

Multicomponent trials test fixed combinations of fall prevention interventions for all participants, typically exercise plus environmental modification or education (**Table 3**). Meta-analysis of 17 multicomponent interventions estimated risk reductions similar to those observed in multifactorial trials (1206 per 100 patient-years vs 1630 per 1000 patient-years, RR 0.74; 95% CI, 0.61-0.91) (Table 3). As reported in meta-analyses of multifactorial interventions,[76] the

meta-analyses of multicomponent interventions showed no improvement in the number of individuals with at least 1 fall.

Pragmatic Trials Targeting Physical Activity or Function

Several pragmatic trials targeting physical activity and function have reported falls reduction as a secondary outcome. For example, the ProAct 65+ study in the UK[77] focused on community-dwelling adults who had had less than 3 falls in the past year and who were already meeting recommended levels of physical activity. Participants (n = 1256) were randomized to home or group-based exercise to increase activity levels from moderate to vigorous or usual care. The study found a reduction in injurious falls for the group-based exercise group compared with usual care during the 12 months of the intervention (IRR, 0.55; 95% CI, 0.31-0.96), but the number of individuals who fell was similar in the intervention group (5 of 377 [13.2%]) vs the usual care group (66 of 454 [14.5%]). The decrease in fall rate persisted during the 12-month follow-up period (IRR, 0.73; 95% CI, 0.54-0.99), with a reduction in individuals who fell in the intervention group (59 of 230 [25.6%]) vs the usual care group (76 of 252 [30.2%]).[77] The CAPABLE program is a 10-session home-based interprofessional intervention to address participant-identified functional goals for low-income community-dwelling adults older than 50 years requiring help in at least 1 activity of daily living (ADL). There are currently 33 implementation sites across 17 US states. In all 6 sites reporting data, implementation has been associated with significant reduction in ADL and instrumental ADL needs, and 4 of 6 sites reported improvements in confidence in doing ADLs without falling.[78] However, the effect on fall rates remains unclear.

Practical Considerations and Application of Evidence

While pragmatic studies have highlighted the challenges of implementing fall prevention in the general population, there are a growing number of resources available for patients and clinicians. Gait and balance training by physical therapy is generally covered by Medicare. Durable medical equipment such as canes, walkers, and commode chairs are covered under Medicare Part B for specific diagnoses with a 20% co-pay, and some Medicare Advantage plans also cover additional home safety equipment such as tub chairs and grab bars, although plans vary widely. Many older adults are able to access balance and functional exercise classes through community-funded programs or Silver Sneakers, a fitness program for adults aged 65 years or older that provides access to gyms, community exercise classes, and exercise videos, and is fully covered by most Medicare Advantage and some other insurance plans.[79] A retrospective cohort study in Washington state found an association between intermittent Silver Sneakers use and lower falls risk compared with nonusers (HR, 0.93; 95% CI, 0.90–0.97; absolute benefit not reported).[80] Free online fall exercise programs are available for those in rural areas or those without reliable transportation[81] although effectiveness data are lacking. Home safety evaluations by occupational therapy can be ordered for homebound older adults who are receiving skilled home care services. Home safety checklists are available for patients and families to use to identify environmental hazards, although their effectiveness is unclear. Some state Medicaid and Veterans Affairs beneficiaries have access to subsidy programs to make home safety modifications such as adding ramps, railings, and grab bars. The CDC offers a clinician toolkit and patient education materials,[82] and many state or area councils on aging curate lists of local fall prevention community resources.

Limitations

This review has limitations. First, some relevant studies may have been missed. Second, the review is limited by the quality of the evidence; most RCTs of fall prevention are single-blind studies, and recall bias commonly affects outcome assessment. Third, because of the multifactorial nature of falls, study populations are heterogeneous, resulting in wider CIs and challenges in generalizing the evidence. Fourth, the review focused on community-dwelling older adults; evidence for fall prevention in other settings (ie, hospitals, long-term care facilities) was not considered.

Conclusions

More than 1 in 4 older adults will fall each year, and falls are the leading cause of injury-related death in persons aged 65 years or older. Functional exercises which improve leg strength and balance remain the first line for prevention in average-risk to high-risk populations. Multifactorial risk reduction based on a systematic clinical assessment for modifiable risk factors may reduce fall rates among those at high risk.

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