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Falls and Their Prevention in Elderly People: What Does the Evidence Show?

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Falls are a common and complex geriatric syndrome that cause considerable mortality, morbidity, reduced functioning, and premature nursing home admissions. Falls have multiple precipitating causes and predisposing risk factors, which make their diagnosis, treatment, and prevention a difficult clinical challenge. A fall may be the first indicator of an acute problem (infection, postural hypotension, cardiac arrhythmia), may stem from a chronic disease (parkinsonism, dementia, diabetic neuropathy), or simply may be a marker for the progression of ''normal'' age-related changes in vision, gait, and strength. Moreover, most falls that are experienced by older persons have multifactorial and interacting predisposing and precipitating causes (eg, a trip over an electrical cord contributed to by a gait disorder and poor vision). Fig. 1 provides the complex relationship between selected risk factors, underlying causes, precipitating events, and falls.

Identifying effective interventions to prevent falls and fall-related injuries among older adults is a major area of research and policy development in geriatrics. Several published clinical guidelines review the evidence for fall prevention strategies and provide recommendations for assessment and intervention. In the past few years there has been a major increase in the number of randomized controlled trials that have evaluated various fall prevention interventions. Meta-analysis of these trials has provided more evidence on efficacy. These clinical guidelines and the extensive fall prevention literature provide much needed insight into the difficult clinical challenge of fall prevention. This article provides a brief overview of the

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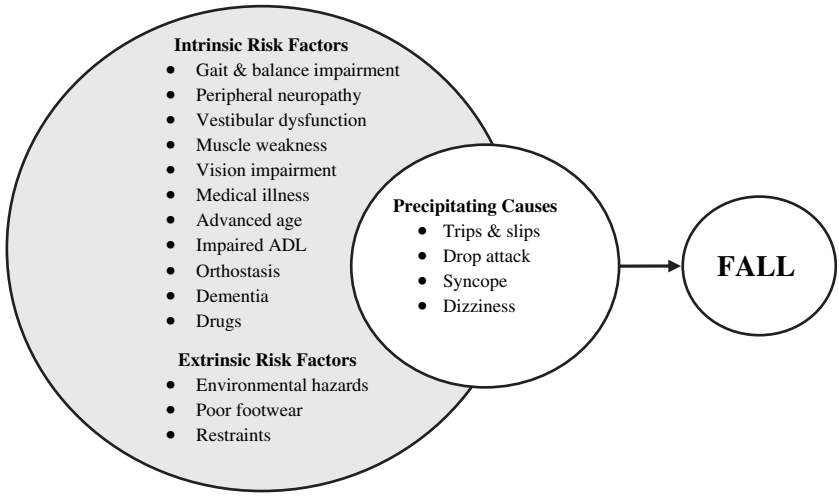

Fig. 1. The multifactorial and interacting causes of falls.

epidemiology of falls, their major causes and risk factors, the types of available fall prevention interventions, and a review of the latest evidence on the efficacy of these interventions.

Epidemiology

Falls are extremely common among older adults. Each year about one out of three people older than age 65 years who is living in the community falls; this rate increases with advanced age and is higher among people who are living in institutional settings. Falls cause considerable mortality and morbidity. About three fourths of deaths that are due to falls in the United States occur in the 13% of the population that is aged 65 and older [1]. Fall-related mortality increases dramatically with advancing age, especially in populations older than age 70 years. The estimated 1% of fallers who sustain a hip fracture have a 20% to 30% mortality within 1 year of the fracture [2]. The propensity for fall-related injury in elderly persons is due to a high prevalence of clinical diseases (eg, osteoporosis) and age-related physiologic changes (eg, slowed protective reflexes) that make even a mild fall particularly dangerous. Although most falls produce no serious injury, between 5% and 10% of community-dwelling older persons who fall each year do sustain a serious injury, such as a fracture, head injury, or serious laceration [3,4]. Fall-related injuries often are associated with considerable long-term morbidity. Among community-dwelling fallers with hip fractures, between 25% and 75% do not recover their prefracture level of function in ambulation or activities of daily living [2].

In addition to death and physical injuries, falls can produce other serious consequences. Repeated falls are a common reason for the admission of previously independent elderly persons to long-term care institutions. Fear of falling also has been recognized as a negative consequence of falls. Surveys have reported that between 30% and 73% of older persons who have fallen acknowledge a fear of falling [5–7]. This postfall anxiety syndrome can result in self-imposed activity restrictions among home-living [6,8] and institutionalized elderly fallers [9]. Loss of confidence in the ability to ambulate safely can result in further functional decline [10], depression, feelings of helplessness, and social isolation.

Causes and risk factors

Table 1 summarizes the major causes of falls and their relative frequencies as reported in 12 studies: six were conducted among institutionalized populations and six were conducted among community-living populations [11]. Although the accuracy of these findings is limited by several factors (including differences in classification methods, patient recall, and the multifactorial nature of many falls), these data provide useful general information about the reasons for falls among older adults. So-called ''accidents,'' or falls that are triggered by environmental hazards, make up the largest fall cause category, and account for 25% to 45% in most series. In actuality, few ''accidental falls'' result from environmental hazards alone, but rather are the result of interactions between hazards or hazardous activities and increased individual susceptibility from accumulated effects of age and disease. For instance, age-associated changes in posture control, muscle strength, and step height can impair a person's ability to avoid a fall after an unexpected trip or while reaching or bending. These types of falls are more common in community-living populations, probably because of the greater attention to creating hazard-free environments in institutions. The other major fall causes are related more directly to age-related changes or specific diseases. Overall, frail, high-risk populations tend to have more of these medical-related falls than do healthier populations.

Because a single specific cause for falling often cannot be identified and because falls are usually multifactorial in their origin, many investigators have performed epidemiologic case-control studies to identify specific risk factors. A risk factor is defined as a characteristic that is found significantly more often in individuals who subsequently experience an adverse event than in individuals who do not experience the event. Although there are some differences in risk factors between community-living and institutionalized populations, most overlap. An analysis of the 16 fall risk factor studies that reported quantitative risk data summarized the relative risks of falls for persons with each risk factor [11]. Eight of these studies were conducted in community-dwelling populations and 8 were conducted in nursing home

Table 1
Causes of falls in older persons: summary of 12 large studies

Cause	Mean (%)[a]	Range[b]
Accident and environment related	31	1–53
Gait and balance disorders or weakness	17	4–39
Dizziness and vertigo	13	0–30
Drop attack	9	0–52
Confusion	5	0–14
Postural hypotension	3	0–24
Visual disorder	2	0–5
Syncope	0.3	0–3
Other specified causes[c]	15	2–39
Unknown	5	0–21

Summary of 12 studies [11,26–36].

[a] Mean percent calculated from the 3628 reported falls.

[b] Ranges indicate the percentage reported in each of the 12 studies.

[c] This category includes arthritis, acute illness, drugs, alcohol, pain, epilepsy, and falling from bed.

populations. The ranks and mean relative risk data for the most commonly reported risk factors are listed in Table 2. Some of these are involved directly in causing falls (eg, weakness, gait and balance disorder), whereas others are more markers of other underlying causes (eg, previous falls, assistive device, age >80 years).

Among these studies, leg weakness (detected by functional testing or manual muscle examination) was identified as the most potent risk factor associated with falls, and increased the odds of falling, on average, by more

Table 2
Risk Factors for falls identified in 16 studies examining multiple risk factors: results of univariate analysis

Risk factor	Significant/total[a]	Mean RR-OR[b]	Range
Lower extremity weakness	10/11	4.4	1.5–10.3
History of falls	12/13	3.0	1.7–7.0
Gait deficit	10/12	2.9	1.3–5.6
Balance deficit	8/11	2.9	1.6–5.4
Use assistive device	8/8	2.6	1.2–4.6
Visual deficit	6/12	2.5	1.6–3.5
Arthritis	3/7	2.4	1.9–2.9
Impaired ADL	8/9	2.3	1.5–3.1
Depression	3/6	2.2	1.7–2.5
Cognitive impairment	4/11	1.8	1.0–2.3
Age >80 y	5/8	1.7	1.1–2.5

[a] Number of studies with significant odds ratio or relative risk ratio in univariate analysis/total number of studies that included each factor.

[b] Relative risk ratio (RR) calculated for prospective studies. Odds ratio (OR) calculated for retrospective studies.

Data from Rubenstein LZ, Josephson KR. The epidemiology of falls and syncope. Clin Geriatr Med 2002;18:141–58.

than four times (4.4; range, 1.5–10.3). A recent meta-analysis that examined the relationship between muscle weakness and falls among purely prospective studies reported that leg weakness had a combined odds ratio of 1.76 for any fall and 3.06 for recurrent falls [12]. In addition to having a strong association with falls, leg weakness is common in older persons. As a group, healthy older people score 20% to 40% lower on strength tests than do young adults [13], and the prevalence of detectable leg weakness ranges from 57% among residents of an intermediate-care facility [14] to more than 80% among residents of a skilled nursing facility [15]. Weakness often stems from deconditioning that is due to limited physical activity or prolonged bed rest together with chronic debilitating medical conditions, such as heart failure, stroke, or pulmonary disease.

Individuals who have fallen have a threefold increased risk of falling again. Although recurrent falls in an individual frequently are due to the same underlying cause (eg, gait disorder, orthostatic hypotension), they also can be an indication of disease progression (eg, parkinsonism, dementia) or a new acute problem (eg, infection, dehydration).

Gait and balance disorders also are common among older adults, and affect between 20% and 50% of people who are older than 65 years [16,17]. Among nursing home populations, nearly three quarters of residents require assistance with ambulation or are completely unable to ambulate [18]. Gait and balance impairments were a significant risk factor for falls, and were associated with about a threefold increased risk for falling; the use of an assistive device for ambulation was associated with a 2.6-fold increased risk for falling.

Visual impairment increases the risk for falling about 2.5 times. At least 18% of noninstitutionalized persons who are 70 years and older have substantial visual impairment [19]. The primary causes include cataracts, glaucoma, and macular degeneration.

Arthritis, the most common chronic condition in persons 70 years and older in the United States [19], increases the risk for falling about 2.4 times. The relationship between arthritis and falls most likely is related to the gait impairment and weakness that often are associated with arthritis.

Functional impairment, usually indicated by the inability to perform basic activities of daily living (ADLs; eg, dressing, bathing, eating), doubles the risk for falling. In the community, ADL impairment affects 20% of persons who are older than age 70 [19]. In the nursing home setting, the prevalence of functional impairment is much higher; 96% of nursing home residents require assistance with bathing and 45% require assistance with eating [18].

Depression is associated with about a twofold increased risk for falling. Although the relationship between depression and falls is not well studied, depression may result in inattention to the environment, or cause more risk-taking behaviors. Conversely, it may be a reaction to previous fall-related morbidity and not be an actual causative risk at all. Additionally, psychotropic medications increase fall risk [20,21]. Common risk factors

have been identified for depression and falls (ie, poor self-rated health, cognitive impairment, functional impairment, slow gait speed) [22]. Mild depressive symptoms occur in close to one quarter of the older population, and about 5% of this population suffers major depression [23].

Cognitive impairment almost doubles the risk for falling. In a recent study among residents of 59 nursing homes, the unadjusted fall rate for residents who had dementia was 4.05 falls per year compared with 2.33 falls per year for residents who did not have dementia ($P < .0001$; adjusted relative risk, 1.74) [24]. Confusion and cognitive impairment are cited frequently as causes of falls, and may reflect an underlying systemic or metabolic process (eg, electrolyte imbalance, fever), as well as a dementing illness. Dementia can increase falls by impairing judgment, visuospatial perception, and orientation ability. Falls also occur when demented residents wander, attempt to get out of wheelchairs, or climb over bed side rails. Cognitive impairment affects between 5% and 15% of persons who are older than age 65, and the prevalence increases with age and among institutionalized populations.

The risk for falls also is nearly double for individuals who are older than the age of 80. This is probably due to the increasing prevalence of multiple risk factors associated with age.

The relationship between medication use and falls also has been examined in many studies. A meta-analysis [20,21] found a significantly increased risk from psychotropic medication (odds ratio [OR], 1.7), class 1a antiarrhythmic medications (OR, 1.6), digoxin (OR, 1.2), and diuretics (OR, 1.1). Several studies also showed a strong relationship between the use of three or more medications and the risk for falls [15,15–26]. Although the sizes of these odds ratios are not as large as those for the previous set of risk factors, they are statistically and clinically significant.

Several of the studies (see Table 2) used multivariate analysis to understand better the possible interactions between the individual risk factors and to rank their relative importance. The risk factors and relative ranks that emerged from these analyses were similar to the univariate factors, although the size of risk was altered for some of them. Muscle weakness remained the dominant risk factor with a fourfold increased risk for falls (range, 3.0–5.9), and balance deficits and history of falls still were associated with about a threefold increased risk for falls. Cognitive impairment, age greater than 80 years, and visual impairments increased in magnitude to about a threefold increased risk, whereas gait deficits declined to a twofold increased risk for falls in the multivariate analyses [11].

Many other case-control studies have examined the relationship between falls and single possible risk factors in isolation. For example, several studies examined the relationship of leg strength alone and fall status without exploring other possibly confounding risk factors. Gehlsen and Whaley [27] reported that healthy older persons with a history of falling had significantly weaker leg strength than did nonfallers. Whipple and colleagues [28]

examined knee and ankle strength, and reported that weakness at both joints was significantly more common among institutionalized fallers than nonfallers. They also performed gait analysis of 49 nursing home patients, and found that fallers had significantly slower gait speed and shorter stride length than did nonfallers [29]. Studenski and colleagues [30] found that outpatients with impaired mobility had a significantly higher rate of recurrent falls over a 6-month period. Other studies have compared measures of dynamic balance in older fallers and nonfallers. Deficit in the ability to control lateral stability was associated with an increased risk for falling in a healthy ambulatory population [31]. Other single-variable risk factor studies documented significant relationships between falls and single leg stance [32], postprandial hypotension [33], impaired depth perception [34], musculoskeletal pain [35], and foot problems [36], to name only a few.

Probably as important as identifying risk factors for falling *per se* is identifying risk factors for injurious falls, because most falls do not result in injury. Risk factors that are associated with injurious falls have been identified by several research groups [29,37–39]. Among community-living populations, risk factors that were identified as increasing the likelihood of an injurious fall include having a previous fall with a fracture, being Caucasian, having impaired cognitive function, and having impaired balance. A survey of elderly Medicaid enrollees revealed that the risk for hip fracture increased twofold for community-living elderly persons and nursing home residents who were taking psychotropic medications [40]. Narcotic analgesics, anticonvulsants, and antidepressants were identified as independent risk factors for injurious falls among community-living older adults who received care in emergency departments [39]. Among nursing home residents, lower extremity weakness, female sex, poor vision and hearing, disorientation, number of falls, impaired balance, dizziness, low body mass, and use of mechanical restraints have been identified as increasing the risk for an injurious fall [41–44]. Surprisingly, patients who were functionally independent and not depressed also had a greater risk for injury [44], probably because they were more active. Taken together, the risk factors for injurious falls are the same as for falls in general, with the addition of female sex and low body mass (both probably largely related to osteoporosis), and higher activity level.

Beyond identifying individual risk factors, it is important to understand the interaction and probable synergism between multiple risk factors. Several studies showed that the risk for falling increases dramatically as the number of risk factors increases [14,15,37,45]. In their survey of community-living elderly persons, Tinetti and colleagues [45] reported that the percentage of persons falling increased from 27%, among those with none or one risk factor, to 78% among those with four or more risk factors. Their identified risk factors included sedative use, decreased cognition, leg and foot disabilities, gait and balance impairments, and the presence of primitive reflexes. Similar results were found among an institutionalized population [14]. In another study, Nevitt and colleagues [37] reported that the

percentage of community-living persons with recurrent falls increased from 10% to 69% as the number of risk factors increased from one to four or more. Their identified risk factors included white race, a history of falls, arthritis, parkinsonism, difficulty rising, and poor tandem gait. In a study by Robbins and colleagues [15] that involved an institutionalized and outpatient population, many individual risk factors were related significantly to falls. Multivariate analysis simplified the model so that maximum predictive accuracy could be obtained using only three risk factors (ie, hip weakness assessed manually, unstable balance, and taking four or more prescribed medications) in a branching logic, algorithmic fashion. With this model the predicted 1-year risk for falling ranged from 12% for persons with none of the three risk factors to 100% for persons with all three risk factors.

In summary, studies have shown that it is possible to identify persons who are at a substantially increased risk for sustaining a fall or fall-related injury by detecting the presence of risk factors. Many, if not all, of these risk factors are amenable to treatment or rehabilitative approaches to ameliorate them. Consequently, risk factor identification seems to be a promising first step in developing effective fall-prevention programs that are targeted to high-risk patients. To assist clinicians in the assessment of fall risk, evidence-based clinical practice guidelines on fall prevention and treatment were published by the American and British Geriatrics Societies [46]. Among other things, the guidelines recommend that a fall risk assessment be an integral part of primary health care for older persons, with the intensity of the assessment tailored to the target population (eg, low-risk versus high-risk individuals). Several published fall risk assessment tools are available for quantifying fall risk for older persons at home and in institutional settings. An analytic review of these assessment tools recommended several that seem to be valid and potentially useful [47].

Although the importance of fall risk factor identification is accepted generally, the question of how best to modify these risk factors to prevent falls continues to be a challenge for clinicians and researchers.

Prevention strategies

In general, fall prevention interventions can be categorized into several broad categories: multidimensional fall risk assessment coupled with risk reduction, exercise programs of various types, environmental assessment and modification, multifactorial interventions, and institutional interventions. Although the goal of preventing falls is common to each type of intervention, the approach taken by each is different.

Multidimensional fall risk assessment and risk reduction

The objectives of the multidimensional fall risk assessment is to identify risk factors for future falls and to implement appropriate interventions to

reduce fall risk. The multidimensional fall risk assessment can be comprehensive or focused, depending on the target population. Comprehensive multidimensional fall risk assessment is most appropriate for high-risk individuals (eg, those who have just fallen or have multiple risk factors for falls), whereas a focused assessment generally is more appropriate for individuals of average risk (eg, independent community-living elderly populations).

Clinical guidelines [46] recommend that a comprehensive multidimensional fall risk assessment should include the following: a history of fall circumstances and medical problems; review of medications; mobility assessment; an examination of vision, gait and balance, and lower extremity joint function; a basic neurologic examination, including muscle strength and mental status; and assessment of cardiovascular status. Other components of the fall risk assessment can include functional performance tests and an environmental assessment of the individual's living location. Comprehensive multidimensional fall risk assessment usually is performed in a clinical setting (eg, clinic, day hospital, nursing home), often by a multidisciplinary team. Following the assessment a detailed plan for therapy usually is developed and implemented.

This model of multidimensional fall risk assessment and risk reduction has been used in successful fall prevention trials for older patients who did or did not have cognitive impairment who presented to an emergency department after a fall [48,49], and for residents of a long-term care facility who experienced a fall [50].

Focused multidimensional fall risk assessment is used often to screen older populations to identify those who are appropriate for targeted interventions (eg, exercise programs, assistive devices, comprehensive fall risk assessment). Typically, this model of risk assessment includes simple performance-based tests of gait, balance, mobility, or strength, such as the Timed Up-and-Go test [51], the Performance Oriented Mobility Index [52], and the one-leg standing balance test [53]. Evaluations of vision, cognition, orthostatic blood pressure, and a review of medications also are included often. Focused multidimensional fall risk assessment has been performed frequently by nurses or therapists in clinics and in the home.

Exercise interventions

Numerous studies have shown that exercise can improve important fall risk factors, such as muscle weakness, poor balance, and gait impairment in healthy [54–56] and impaired older adults [57,58]. Consequently, exercise has become a widely studied fall prevention intervention. Different exercise models have been evaluated, including group [58–64] and individualized home programs [65–69], among healthy and impaired populations.

Group exercise programs that are designed as fall prevention interventions typically are held two or three times per week for about an hour, and are supervised by a physical therapist or trained exercise instructor.

Most group programs have included a combination of exercises to improve flexibility, strength, and balance, and some level of aerobic conditioning. Progressive strength training generally focuses on lower and upper extremity large muscle groups, and may use body weight, ankle weights, elastic bands, or weight machines for resistance. Balance training often includes a range of static and dynamic exercises (eg, standing on one foot, tandem stand, ball games, movement to music) and functional activities (eg, reaching, bending, transferring). To improve aerobic conditioning, exercise programs have used whole body exercises, walking and stair climbing and stationary bicycles. Although performed in a group setting, exercises usually are individualized to the participant's abilities.

Home exercise programs also are supervised by trained exercise professionals, but participants perform the exercises alone in their homes. In most published studies, participants attended a series of group meetings to learn and practice the exercises, and then were instructed to perform the exercises at home [66–68]. In other studies, a physical therapist or nurse visited participants at home several times over the course of the intervention to provide instruction and motivation to perform the exercises [65,69]. In both models, the participant performed the exercises unsupervised and kept a diary. Home exercise programs typically include the same types of exercises as do the group programs, only fewer and often at a lower intensity. Home exercise programs also incorporated a walking program frequently.

Tai chi is another type of exercise that has been studied as a means of improving balance and reducing the risk for falling. Tai chi consists of a series of slow, rhythmic movements that require trunk rotation, dynamic weight shifting, and coordination between upper and lower extremity movements. Tai chi has been studied as group [62–64] and home programs [67].

Environmental assessment and modification

Environmental assessment and modification is another promising fall prevention strategy, which is used as a means of identifying and removing potential hazards (eg, clutter, poor lighting, throw rugs) and for modifying the environment to improve mobility and safety (eg, installation of grab bars, raised toilet seats, lowered bed height). Several self-administered home safety checklists [70], which are designed for use by older people in their homes, assist in identifying important hazards and offer suggestions for improving safety. These checklists are most appropriate for use with average risk and cognitively intact older adults. For higher-risk populations, several fall prevention interventions [71–73] have used trained professionals, such as nurses or occupational therapists, to perform home environmental assessments. An in-home assessment provides an opportunity for the health care professional to observe how an older person functions within the home, which may help to identify safety problems that may not be identified with a self-administered checklist or interview.

In institutional settings, environmental safety policies and practices are generally in place to protect patients and staff. Important safety issues for hospitals and nursing homes include adequate lighting and handrails in hallways, close monitoring for spilled liquids on the floors, unobstructed walkways, appropriate assistive devices in bathrooms (eg, grab bars, shower chairs, raised toilet seats), furniture that is easy to rise from, and proper bed height.

Multifactorial interventions

Multifactorial interventions are those that combine several fall prevention strategies into a coordinated program. Generally, multifactorial interventions include some degree of fall risk assessment, followed by one or more risk factor modification strategies, such as exercise, education, or environmental modification. One of the first multifactorial interventions that was described in the literature included a focused in-home risk assessment that was performed by a nurse and a physical therapist to identify selected fall risk factors (ie, postural hypotension, medication, impairments in mobility, vision, hearing, gait, balance, strength, and environmental hazards), followed by targeted interventions (ie, medication adjustment, environmental modifications, behavioral instructions, and exercise) [74]. Other multifactorial interventions that are designed for community-dwelling older adults have combined home environmental assessment, exercise, and cognitive-behavioral group education [71,75].

In residential care and nursing home facilities, multifactorial interventions often include prevention strategies for residents (eg, exercise, medication review, hip protectors), fall prevention education for staff, and facility-level environmental modifications [76–79]. On a subacute hospital ward, a multifactorial intervention included a falls risk alert card to identify high-risk patients, a fall prevention information brochure and education sessions for patients, balance exercises, and hip protectors [80].

Institutional interventions

Fall risk assessment tools are used commonly in institutional settings to identify persons who are at greatest risk for sustaining a fall or fall-related injury, and to isolate specific risk factors that are amenable to intervention. There are many published assessment tools [47] that are used to assist health professions better target limited resources to those who would benefit most from preventive interventions. These instruments typically rank a person's risk for falling as "high," "medium," or "low" based on the presence or absence of risk factors, such as cognitive impairment, mobility dysfunction, incontinence, acute/chronic illnesses, sensory deficits, medication use, and history of falling. The tools may or may not include physical assessments in addition to questions that rely on self-report. Most screening tools are

brief and generally are administered by a nurse on admission to hospital or a nursing home, and usually are updated on a regular basis or when there is a change in health status. Once a patient has been identified as being at a high risk for falling, a nursing care plan usually is developed that includes interventions that are aimed at injury prevention. Such interventions can include indicating on the medical chart and the patient's door that the patient is at a high risk for falls; moving high-risk patients to rooms that are close to the nursing station to increase observation; periodic reassessment of patients following new episodes of illness or change in medication; lowering side rails and bed height for patients who climb out of bed; increasing nurse-to-patient ratio; use of bed and chair alarms; and fall prevention education for patients and staff.

Until recently, the most common "devices" that were used in nursing homes and hospitals to prevent falls were physical restraints, such as soft restraining vests and bed rails. Over the past decade there has been a major move away from the use of physical restraints because research has shown that the adverse affects of physical restraints on functional status and quality of life outweigh any potential benefit in preventing falls. Specifically, there is evidence to suggest that physical restraints may contribute to falls, injuries, and death [81,82].

Other promising strategies that are aimed at reducing falls and fall-related injuries in nursing homes include the use of vitamin D and calcium supplements to enhance bone and muscle strength [83,84], and the use of special hip protectors (worn in under garments shielding the greater trochanter of the hip) to prevent hip fractures that are due to falling [85,86].

Effectiveness of fall prevention strategies

The recent heightened interest in finding effective fall prevention strategies has resulted in the publication of numerous studies. Studies have targeted healthy older adults; individuals who are at-risk for falling; community-living, hospitalized, and institutionalized populations; as well as caregivers and the home or institutional environment. Many intervention strategies have been evaluated, often unique to the study site, and there is great variation in duration and intensity of the intervention, outcome measurements, and length of follow-up. This diversity in the published literature has made it difficult to determine which type of intervention is most effective for preventing falls, and which target group of older adults will benefit most from which type of intervention. Fortunately, several study groups have performed meta-analyses of randomized controlled trials to assess the relative effectiveness of specific types of fall prevention interventions [87–89].

A recent meta-analysis [89] of randomized controlled trials of fall prevention interventions that were published through 2002 assessed the overall effectiveness of the overall interventions, as well as the relative effectiveness of intervention components: multidimensional risk assessment

and management, exercise, environmental modifications, and education. The results of this meta-analysis indicate that the most effective fall prevention strategy used individualized multidimensional risk assessment combined with interventions that were directed toward reducing these risks. When analyzed as a group, interventions that used multidimensional risk assessment and risk reduction decreased the risk for falling by 18% and reduced the average number of falls by 43%. The next most effective single intervention that was identified in this meta-analysis was exercise that was intended to improve balance, strength, flexibility, or endurance. Overall, exercise interventions reduced the risk for falls by 12% and the mean number of falls by 19% [89]. Exercise was effective in reducing falls when used alone and when included as part of a multifactorial intervention. Exercise programs that were effective include Tai chi [62,67], balance and gait training, and strength building [60,65,66,76,79]. Although studies did not demonstrate that home modification alone reduces falls, several multifactorial interventions that included home modification were effective, particularly among individuals who had a history of falls [71–73,90].

Since this meta-analysis, many new trials of fall prevention interventions have been published, and these largely have been confirmatory of the conclusions of the meta-analyses. Randomized trials that have been most effective in reducing fall rates have involved multifactorial intervention programs, which is consistent with the concept that falls usually are the result of interactions between multiple intrinsic and extrinsic risk factors. The most effective interventions generally have included risk assessment; tailored exercise or physical therapy to improve gait, balance, and strength; medication management; and other elements, such as education about fall risk factors, referrals to health care providers for treatment of chronic conditions that may contribute to fall risk, and having vision assessed and corrected [48,73,75,90,91]. Another fall prevention intervention that seems to be effective in reducing fall rates is medication review and modification [92,93], particularly as part of a multicomponent intervention.

A meta-analysis [83] of five randomized controlled trials reported that vitamin D supplementation seems to reduce the risk for falls by more than 20% among ambulatory or institutionalized older adults. The hypothesized mechanism is from a direct beneficial effect of vitamin D on neuromuscular function; however, the studies did not measure vitamin D levels at baseline, so it is not clear whether this apparent benefit stemmed from treating a deficiency or from a pharmacologic effect of the vitamin D in nondeficient individuals.

Although hip protectors seem to be effective in preventing hip fracture in nursing home settings, their effect in community populations has not been demonstrated. This is likely because of poor patient compliance rates in the community. A meta-analysis [94] of six randomized trials concluded that hip protectors seem to reduce the risk for hip fracture in selected high-risk populations where compliance can be monitored closely.

Considerations in designing fall prevention strategies

From the above discussion it can be seen that fall prevention is a multifaceted endeavor. This stems from the multifactorial causes of falls, multiple contributing risk factors, fragility and lack of responsiveness by many older persons to interventions, and the double-edged effect of many intervention strategies that may increase one fall risk factor while reducing another. For example, although exercise is, and should be, encouraged as a positive goal that leads to higher function and quality of life, increased activity also provides additional opportunity for falling. The interaction between falls, activity levels, frailty, and injury needs to be studied much more carefully.

Another issue has to do with the trade-off of targeting interventions only to those who are most likely to benefit. Although the impact per person enrolled is higher when narrowly targeting interventions, the population that is served by the intervention may be overly small and may have little overall effect on global fall rates.

Finally, there are subgroups of individuals that have multiple or irreversible risk factors (eg, blindness, dementia, progressive neurologic diseases) for which it often is extremely difficult to devise effective interventions other than through dramatic limitation of physical activity. For these individuals the risks for falling must be weighed carefully against the not insubstantial risks of limiting activity.

Summary

A large proportion of falls and fall injuries in older people is due to multiple risk factors, many of which probably can be modified or eliminated with targeted fall prevention interventions. These interventions must be feasible, sustainable, and cost effective to be practical for widespread use. The most promising prevention strategies involve multidimensional fall risk assessment and exercise interventions. Incorporating these intervention strategies whenever feasible into a fall prevention program seems to be the most effective means for fall prevention in older adults.

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