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STATE OF THE ART REVIEW

Prevention of falls in older people living in the community

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ABSTRACT

The number of people living into older age (≥65 years) is rising rapidly. Older people are more likely to fall and this has adverse consequences for their quality of life and that of their families. Falls also pose a substantial financial burden on healthcare systems. Extensive research from systematic reviews and meta-analyses has established effective approaches for reducing falls among older people, although uncertainties and controversy remain. The evidence suggests that exercise based and tailored interventions are the most effective way to reduce falls and associated healthcare costs among older people in the community. This review integrates current knowledge on assessment and management strategies to prevent falls in older people living in the community. It summarizes known risk factors for falls in this population and presents assessment strategies that can be used to assess the risk of falls. It discusses the management of risks and interventions to reduce falls among older people in the community, as well as future directions and promising approaches.

Introduction

A fall is an event during which a person inadvertently comes to rest on the ground or other lower level.[1] According to the World Health Organization, 28-35% of older people (≥65 years) fall each year globally and prevalence increases with age.[1] Falls are the main cause of injury, injury related disability, and death in older people.[2] The severity of resulting injuries varies, and 40-60% of falls result in major lacerations, fractures, or traumatic brain injuries.[3] A longitudinal study found that 68% of people who fell reported some injury; healthcare was needed in 24% of cases, functional decline was reported by 35%, and social and physical activities were impaired for more than 15%.[4] Close to 95% of all hip fractures are caused by falls; 95% of patients with a hip fracture are discharged to nursing homes (about 40% of nursing home admissions are related to falls), and 20% of patients with a hip fracture die within a year.[5]

Falls have large economic costs globally.[1 6] The United Kingdom's NHS reported that fall related expenditure was about £4.6m ($6.6m; €5.7m)/day (£1.7bn/year),[7] and the annual costs were reported to be more than £2.3bn in 2013.[8] In the United States, the estimated direct medical cost of fall related injuries among older people in 2012 was $30bn[6]; almost 66% was spent on injuries that required hospital admission, 21% on injuries treated in emergency departments, and 13% on injuries treated in outpatient settings.[9]

Falls and the fear of falls also seriously reduce quality of life.[10] More than 60% of family care givers are afraid that their older relative will fall again.[11] Low falls self efficacy (a measure of fear of falls) is associated with an increased risk of subsequent falls, a decline in activities of daily living, and reduced quality of life.[12] Falls can trigger a cycle of fear of falls (>25% of cases), reduced physical activity, deconditioning, functional decline, impaired ability to perform daily activities, social isolation, reduced quality of life, depression, increased risk of subsequent falls, and institutionalization.[13-17] After a first fall, people have a 66% chance of having another fall within a year.[18]

SOURCES AND SELECTION CRITERIA

Studies were identified by a search of English language publications listed in PubMed, Medline, and the Cochrane Library from September 1994 to December 2015. Search terms included falls, falls prevention, falls epidemiology, fall risk assessment and/or management, and community dwelling elderly or older adults. In addition, falls risk assessment and management strategies were searched. Articles reviewed included systematic reviews and meta-analyses, experimental and observational studies, and clinical guidelines. We reviewed the literature identified and selected all articles that focused on risk factors, assessment, and management strategies or interventions (or both) to reduce falls in older people living in the community. Systematic evidence reviews, meta-analyses, and randomized clinical trials were prioritized. We then summarized the peer reviewed literature selected and abstracted the most clinical relevant information on the topic of falls prevention and management. Because of limitations on the number of citations to be included, we prioritized the works that were cited and cross referenced most often.

Table 1 | Common risk factors for falls in older people in the community

Risks	Examples	Reference
Previous falls	During the previous 12 months	22
Fear of falling	Low falls efficacy scale scores	12
Balance problems	Increased postural sway	25
Gait and mobility problems	Increased variability of step length, shorter single support time during dual task gait, timed up and go test time >12s	25 26
Pain	Lower limb and foot pain	27
Drugs	Polypharmacy (≥4), psychotropics, antidepressants, benzodiazepine	28
Cardiovascular conditions and syncope	Carotid sinus syndrome, vasovagal syncope, orthostatic and postprandial hypotension, arrhythmias	29
Cognitive impairment	Reductions in verbal ability, processing speed (executive function), and immediate memory	30
Urinary incontinence	Rushing to the bathroom at night	31
Stroke	Decreased paretic limb contribution to standing balance control, increased variability of step length, inability to step with the blocked limb	32
Diabetes	Peripheral neuropathy, as well as accelerated balance, somatosensory, visual, vestibular and cognitive function decline	33 34

Efforts to reduce and manage falls have been a focus of research into ageing for several decades.[19] This review summarizes the best available evidence on risk factors for falls in older people living in the community and how to assess the risk of falls. It discusses how to manage these risks, which interventions are most effective in reducing falls, and future directions in research and implementation.

Risk factors for falls in older people in the community

Falls result from interactions between multiple individual and environmental risk factors. Extensive research has identified many such risk factors in older people in the community, including previous falls, demographic characteristics (such as female sex, older age), health habits, pain, chronic diseases, medications, physical impairments, functional limitations, disabilities, and environmental barriers.[20-24]Table 1 lists some common risk factors for falls in this population.

Gait and balance

Gait and balance impairments are modifiable causes of falls; interventions to enhance musculoskeletal function are effective in preventing falls among older people in the community.[35 36] Slower gait is an indicator of fear of falls and disability; it is a risk factor for falls and is used to classify people as frail (gait speed <0.8 m/s and not able to walk more than 350 m in six minutes). People who are afraid of falling increase their level of co-contraction (activation of agonist and antagonist muscles such as the quadriceps and hamstrings). Increased co-contraction increases rigidness, which may reduce the risk of falls during low speed disturbances such as being pushed lightly. However, it also increases the risk of falls during high velocity disruptions such as tripping because it takes longer to replace the feet and the person may not be able to recover balance in time.[37]

Frailty and disability

Falls are related to other problems in older people such as frailty, disability, incontinence, and visual and cognitive impairment.[31-40] Markers of frailty, disability, and falls risk include not being able to complete more than seven chair rises in 30 seconds without using the hands, taking more than 50 seconds to climb 10 steps, and taking more than 30 seconds to get up from the floor.[41] Community ambulation cut-off points include being able to walk 50 m independently and safely within a reasonable time period, and to be able to walk 365 m independently and at least 30 m at 1.3 m/s.[41]

Other frailty indicators include the loss of 4.5 kg or more during the past year, exhaustion for three or more days a week, grip strength of less than 10.4 kg force for women and 14.5 kg force for men, and sitting quietly or lying down during most of the day.[42]

The association of falls with frailty and disability is bidirectional, and they have risk factors in common.[31] Falls can cause injuries that result in disability and lead to deconditioning and ultimately frailty. In the other direction, frail or disabled older adults may fall because of lack of balance or strength. In addition, disabilities (such as amputations) may predispose older people to falls. Thus, screening for and reducing the risk of falls affects the risk of frailty and disability and vice versa. Falls among frail older people are particularly worrying because the reduced physiologic capacities may increase complications and compromise recovery.[43]

Comorbid conditions

Acute or chronic medical problems such as osteoporosis, diabetes, urinary incontinence, and cardiovascular disease are also risk factors for falls.[44] Carotid sinus syndrome, vasovagal syncope, orthostatic and postprandial hypotension, arrhythmias (bradyarrhythmias and tachyarrhythmias) are common causes of syncope related falls in older people.[29] Orthostatic hypotension can cause older people to faint. A systolic drop of 20 mm Hg after one minute of standing may be particularly informative about the risk of falling in community dwelling older people with uncontrolled hypertension.[45]

Vitamin D deficiency is another suspected risk factor for falls in older people. Vitamin D is a regulator of calcium and phosphorus metabolism; its importance for bone health is well established and there has been increasing interest in the association between vitamin D and falls, but the results are controversial.[46 47] Some studies found an association between falls and vitamin D deficiency, but others that controlled for physical activity levels found no such association.[33]

Polypharmacy

Drugs are often prescribed for patients who fall, but polypharmacy, often defined as use of four or more prescription drugs, as well as use of specific drugs—including antidepressants, sedatives and hypnotics, neuroleptics and antipsychotics, antihypertensives, and anticonvulsants—have been linked to an increased risk of falls.[48-50]

Assessing the risk of falls

History and examination

Patients may not spontaneously report falls for several reasons, including the perception that a fall event may not be relevant unless it resulted in injury. A recent fall, two or more falls in the previous 12 months, difficulty

walking or balance problems, and lower limb pain indicate the need for a more detailed history and multifactorial assessment.[44]

Previous falls are predictors of future falls, so asking about previous falls is an important first step. It is then essential to investigate what caused the fall. An assessment of the circumstances of fall events (such as place, time, activity being performed, preceding symptoms) and their consequences (such as injuries, fear of falling, difficulty performing daily activities, activity restriction, pain) should be conducted.[51]

Next, an assessment of all prescribed and over-the-counter drugs should be undertaken and potential medication interactions evaluated. Finally, a history of relevant risk factors should be collected, including information on acute and chronic medical problems that are known contributors to falls. Specific points to cover are described in more detail below.

Drug review

Drugs may be needed to treat pain, syncope or orthostatic hypotension (or both), and other chronic conditions. However, they may increase the risk of falls. A drug review and reduction of the number or dose of drugs (or both) form part of the efforts to reduce falls.[44 52] Drug reviews should include evaluation of over-the-counter drug such as those with anticholinergic effects (for example, allergy and sleep drugs) and those that can promote movement disorders.[53]

Medical risk factors

Vision

Referral for ophthalmologic evaluation of visual acuity, depth, contrast sensitivity, and cataracts has been recommended by experts.[53]

Syncope

In addition, older people whose falls are suspected to be caused by syncope or are unexplained should undergo syncope related investigation.[54] It can be difficult to determine whether syncope had occurred because falls are often unwitnessed.[29 55] An in-depth syncope investigation is guided by an initial evaluation, detailed history, physical examination, biochemical and hematologic tests, electrocardiography, and echocardiography.[29] In some cases, it may also include carotid sinus massage, tilt table tests, 24 hour Holter electrocardiography, and electrophysiological studies for arrhythmias. Referral to specialized interdisciplinary units may be required.[56 57]

Cardiovascular

A study found that 44% of older people treated at an emergency department over a 28 day period had experienced a fall.[58] Seventy seven per cent of those with unexplained falls, recurrent falls, or unexplained loss of consciousness had cardiovascular problems including orthostatic hypotension (19%), carotid sinus hypersensitivity (73%), vasovagal hypersensitivity (15%), and arrhythmia (8%).[58] Cardiovascular causes of falls include vasovagal syncope, carotid sinus syndrome, arrhythmias, other cardiac abnormalities (such as stenosis, cardiomyopathy, ischemia, and infarction), and postprandial or orthostatic hypotension.[59] Assessment of orthostatic hypotension is a component of the multifactorial assessment of falls risk in older people.[60] The use of blood pressure measurements in the seated and standing position is common. However, a substantial proportion of patients with orthostatic hypotension may be misclassified if supine blood pressure is not assessed.[61 62] The need for repeated measurements in different positions and minutes apart may be burdensome, particularly in time constrained clinical settings.

Cerebrovascular

Older people who have a stroke have an increased risk of falls because of sequelae such as decreased strength and balance, contralateral neglect (lack of attention and awareness of the side of the body opposite to the affected hemisphere of the brain), perceptual (for example, proprioception) and visual problems.[63] A study on the incidence and consequences of falls in older people with stroke found that 73% (n=79) fell at home within six months of discharge.[64]

Diabetes

People with type 2 diabetes have an increased risk of falls compared with those without type 2 diabetes (odds ratio 2.0, 95% confidence interval 1.2 to 3.4).[33] Falls in older people with type 2 diabetes are often associated with diabetic peripheral neuropathy, as well as accelerated balance, somatosensory, visual, vestibular, and cognitive function decline.[33 34]

The prevalence of falls is directly associated with the number of chronic medical conditions such as cardiovascular problems, diabetes, chronic obstructive pulmonary disease, depression, and arthritis. Older women who have at least one chronic condition have an increased chance of having a fall compared with those with no chronic conditions (odds ratio 1.8, 1.4 to 2.3).[65]

Functional and mobility assessment

Evaluation of functional and mobility impairments can identify the need for referral and guide tailored rehabilitation interventions. In-depth evaluation of mobility requires appropriate expertise (for example, the involvement of physiotherapists).[52] Detection of gait abnormalities on the basis of performance tests can help identify older people who are likely to benefit from more detailed assessment and management of mobility impairments. Several tests are available to assess function and mobility (eg, gait and balance), the most commonly used of which are summarized below.

Timed up and go test

The timed up and go (TUG) test involves timing how long it takes someone to get up from an armchair, walk 3 m, turn around, come back, and sit on the same chair.[66 67] The test is fairly easy to administer and takes less than five minutes.[44] It has been shown to be a reliable and valid indicator of falls risk.[68 69] In general, TUG times >12 seconds are associated with increased risk of falls. A study found that older adults who had had a previous fall took 22 s (stand-

ard deviation 9) to complete the TUG, while non-fallers took 8 s (2) to complete the test (F=23; P<0.001).[70] Using a cut-off value of 13.5 s, TUG had a sensitivity of 80% and specificity of 100%. However, the test does not provide in-depth gait information, and cut-off values indicative of an abnormal result vary. Reference values are available for different age groups and for people with certain health conditions. For example, average times for community dwelling older adults were 8 s (95% confidence interval 7 to 9) for people 60-69 years old, 9 s (8 to 10) for people 70-79 years old, and 11 s (10 to 13) for people 80-99 years old.[71] There is no consensus on what constitutes optimal times or scores for identifying those who would benefit from in-depth mobility assessment.[72]

Short physical performance battery

The short physical performance battery (SPPB) involves a timed 4 m walk at usual pace, a timed repeated chair sit to stand test, and balance tests with feet side by side, semi-tandem, and full tandem for 10 seconds.[73] The test can be easily administered in a variety of contexts and settings by medical assistants and trained staff after minimal training, and it takes about 10 minutes to complete. The SPPB has been found to be a reliable and valid measure of mobility that is predictive of falls, physical disability, hospital admission, nursing home admission, and mortality.[73 74] SPPB scores ≤9 indicate mobility impairment.[73] The SPPB can be used to identify older people with mobility limitations who are likely to benefit from moderate intensity physical exercise programs.[75 76] For example, mobility disability was considerably reduced in older people with SPPB ≤7 at baseline who participated in the LIFE trial.[75 76]

Usual or preferred walking speed

This is an item in the SPPB score, a determinant of the TUG time and of the six minute walking test, and it a frailty phenotype.[77] The preferred walking speed is predictive of a wide range of adverse health outcomes, including falls.[78] The association between walking speed and falls is non-linear, with a greater risk of outdoor falls among faster walkers, and greater risk of indoor falls among slow walkers.[78] There has been interest in the use of walking speed as an overall health indicator for older adults.[79] However, it remains to be determined whether walking speed in isolation could serve as a screening test for falls risk.[80]

Berg balance test

The Berg balance test offers a comprehensive assessment of static and dynamic balance. It is commonly used in the rehabilitation setting. It involves the assessment of performance on 14 tasks—namely: sit-to-stand, standing unsupported, sitting unsupported, stand-to-sit, transfers, standing with eyes closed, standing with feet together, reaching forward with an outstretched arm, retrieving an object from the floor, turning the trunk with feet fixed, turning 360°, stool stepping, tandem standing, and standing on one limb.[81-83] However, its value and feasibility as a screening tool remain to be established.[24]

Tinetti balance assessment

This assessment has a balance and a gait session.[84] The balance session includes evaluations of sitting and standing balance, ability to rise from sitting on a chair, responses to being nudged, turning ability, and sitting down ability. The gait session includes evaluations of hesitancy, step length and height, foot clearance, step symmetry, continuity, path, trunk motion, and base of support. Scores vary from 0 to 2 for each component. The maximum scores are 16 for balance and 12 for gait (28 total score). Scores ≤18 indicate high risk for falls, scores between 19 and 23 indicate moderate risk, and scores ≥24 indicate low risk.

Performance oriented mobility assessment

Performance oriented mobility assessment (POMA) is another clinical approach for assessing balance and gait.[84] People are observed while performing mobility tasks and receive scores based on balance and gait abilities on 16 items. It takes about 10-15 minutes to complete. The POMA offers more detailed information on mobility components than the TUG, but the time taken to complete it may limits its use as a screening tool.

Home and environmental assessment

Home assessments and client education are an integral part of comprehensive falls prevention programs.[36-85] Home visits are an opportunity to identify medication use habits and environmental hazards, to observe activities of daily living, and to provide education for patients and families. Low cost home modifications can significantly reduce fall related injuries.[36 86] Although home modifications are often components of multifactorial interventions, specific data on their effectiveness in reducing fall related injuries are limited. However, a cluster randomized trial (842 households) in 2015 reported that home modification reduced the rate of injuries from falls by 39% compared with a waiting list control group (relative rate 0·61, 0·41 to 0·91).[87] Home environment assessment checklists are available,[88-90] and they are designed to identify:

- Environmental hazards that can be removed or avoided, including tripping obstacles such as cords, rugs, and furniture; slippery surfaces; and poorly illuminated areas
- Accessories that can be installed and furniture that can be modified to facilitate transfer or walking including ramps, proper height toilet seats and beds, grab bars next to the toilet and shower, and railings along walking pathways
- The need and opportunities for use of assistive gadgets and devices, such as extended reaching gadgets, falls monitoring devices, medical staff or rescue alert systems.

Managing risks and interventions to reduce falls

Multidisciplinary risk assessment followed by tailored multifactorial interventions including exercise has been shown to significantly reduce falls among older people in the community.[19-92] Statistically significant reductions in falls have been observed in interventional trials and meta-analyses as well as reductions in healthcare related costs when older people at risk of falling are identified and interventions are

implemented.[36-95] In the following section, we present evidence on how to manage the risk and interventions shown to reduce falls, including exercise based interventions; management of pain, chronic conditions, and medication; education and behavioral counseling; vision correction; vitamin D and calcium supplementation; and multifactorial interventions.

Exercise based interventions

On the basis of a systematic review,[35] the 2012 US Preventive Services Task Force (USPSTF) recommended exercise and physiotherapy to prevent falls in older people at risk in the community.[96] It should be noted that cognitive impairment not only increases the risk of falls but may also adversely affect adherence to interventions and the effectiveness of such interventions. Fall prevention results from trials in cognitively intact older people should not be generalized to those with cognitive impairment.[40 97] The American Geriatrics Society/British Geriatrics Society (AGS/BGS) guideline acknowledged the lack of sufficient evidence to recommend for or against multifactorial or single interventions to prevent falls in community dwelling older people with known dementia.[44]

A systematic review of randomized trials of interventions to reduce falls in older people living in the community published in 2012 also supported the beneficial effect of exercise interventions in reducing the number of falls and the number of participants who fell.[36] Data from more than 3500 participants from 16 trials showed that group exercise classes with multiple components (such as balance retraining and muscle strengthening) reduced the rate of falls (prevalence) in the groups that exercised compared with the groups that did not exercise (rate ratio 0.71, 0.63 to 0.82). Tai Chi—an exercise intervention that involves movements that emphasize weight shifting, balance, postural alignment, and coordination—was associated with a 28% (0% to 48%) reduction in the rate of falls and a 29% (13% to 43%) reduction in the risk of falling.[36] Home based exercises containing multiple exercise categories also resulted in a significant reduction in the rate of falls (rate ratio 0.68, 0.58 to 0.80) and risk of falling (risk ratio 0.78, 0.64 to 0.94).[36]

The bipedal posture and gait evolved as an adaptation for survival, but it is unstable by nature.[98] Walking is a controlled fall avoided by subsequent steps. Exercising in a standing or unsupported sitting position (for example, on a stool or exercise ball) trains balance. Balance challenges such as one leg stance and center of pressure displacements observed in Tai Chi practice increase instability, promote neuromuscular training and adaptation, improve balance, and reduce falls risk in older people.[99]

A 2013 systematic review and meta-analysis of randomized controlled trials evaluated the effect of fall prevention exercise programs on fall related injuries in community dwelling older people.[100] A total of 17 studies involving more than 4000 participants with data on injurious falls, serious falls, and fall related fractures were included. Data analyses of 10 trials showed a reduction in injurious falls in the groups that exercised compared with the groups that did not exercise (rate ratio 0.93, 0.51 to 0.77).[100]

In 2010 the US Centers for Disease Control (CDC) published a compendium of effective fall prevention interventions for older people in the community,[92] and it was updated in 2015.[101] The compendium is a report that includes information on interventions and published evidence of their effectiveness in reducing falls among older adults living in the community. Information for the updated 2015 compendium was gathered from published randomized controlled interventions that found a reduction in falls among people aged 60 years or more living in the community. It includes exercise based interventions and it summarizes program characteristics and effectiveness data. Some of the interventions, such as the Otago Exercise Program,[102] are individualized and delivered by physiotherapists in the home setting. Older people identified as at risk of falls by primary care physicians or geriatricians can be referred to physiotherapists for implementation of the Otago Exercise Program. Implementation of the Otago Exercise Program in New Zealand has reduced falls by 46% (rate ratio 0.54, 0.32 to 0.90), and the net cost of implementation was $NZ140 ($95; £67; €84) per fall prevented.[103-105]

Other interventions include group based exercise programs such as Tai Chi: Moving for Better Balance,[106 107] and community programs such as a Matter of Balance,[108] which focuses on reducing fear of falling, increasing activity levels, adapting the environment to reduce falls risk, and exercising to increase strength and balance.

A nationwide training program was established in New Zealand for the delivery of the Otago Exercise Program and Tai Chi.[109] The programs were delivered to 30 000 older adults. The main barriers encountered were funding, consistency and fidelity of delivery, availability of providers, and attrition; the presentation of clear evidence, protocols, and quality assessments; training and supervision of other professionals by physiotherapists to deliver the programs, and patient education. Implementation of the programs resulted in decreased claims for compensation for injuries resulting from falls (no specific data presented).[109] The CDC compendium includes several other programs that involve one hour classes delivered one to three times a week for 16 weeks to over one year. Details and the full list of programs are available at: http://www.cdc.gov/HomeandRecreationalSafety/Falls/compendium.html.

Another recommended program called Stepping On is a multifaceted program to reduce falls and increase self confidence in older people.[110] It includes information on falls risks, strength and balance exercises, home hazards, safe footwear, vision and falls, safety in a public places, community mobility, coping after a fall, and the importance of drug reviews.

Because exercise programs reduce the risk of falls and have other effects—such as reducing functional decline, mobility disability, frailty, and fear of falls, as well as increasing socialization and self esteem—older people should be encouraged to exercise. After screening and assessment for falls risk, older people without contraindications in whom exercise is deemed safe should be referred to programs. Figure 1 shows a decision tree for referral to an exercise program aimed at reducing falls among older people in the community.

Pain, chronic conditions, and medication management

Pain is also a potentially modifiable risk factor for falls, but systematic assessment and management of pain are

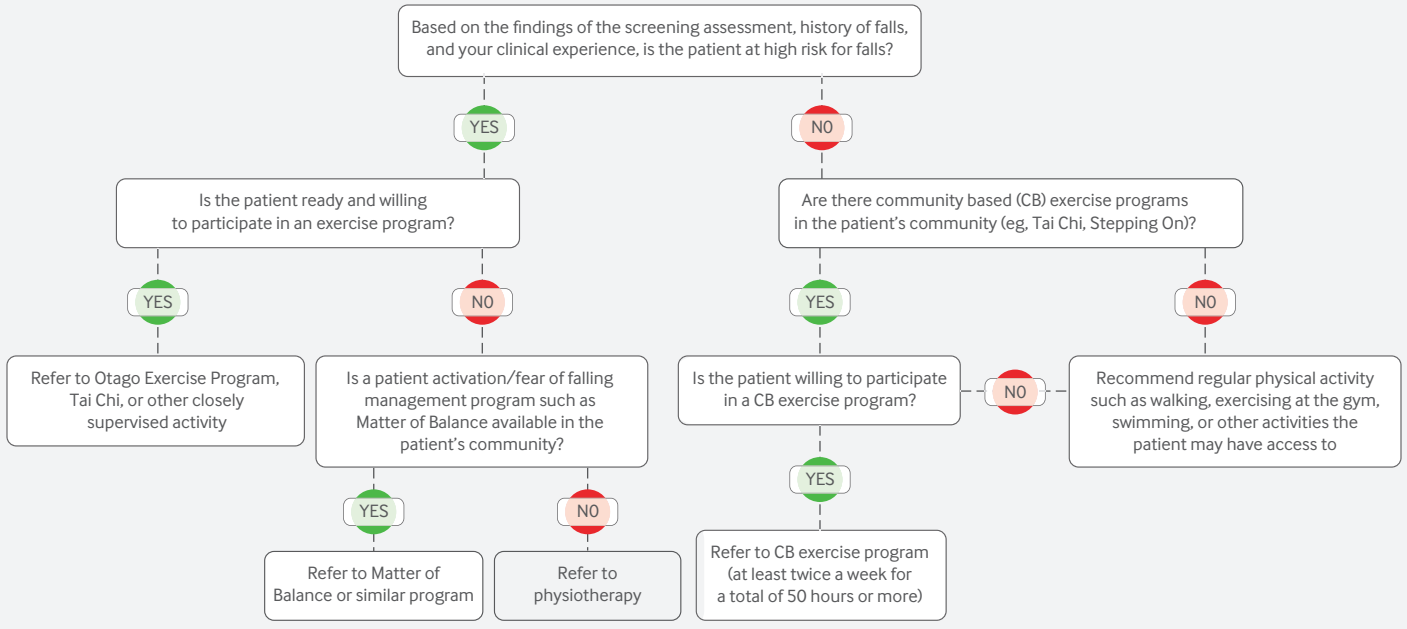

Fig 1 | Exercise referral decision tree for patients

not explicit components of traditional assessment and management programs in primary medical care.[27 111] Research aimed at evaluating the impact of pain assessment and control in the management of falls is warranted.

Orthostatic hypotension may occur during transfers (for example, getting up from bed or from a chair) and exercise. Clinical management of orthostatic hypotension includes hydration and salt intake, positional related adaptive behavior, drugs (such as vasodilators), and elimination or reduction of drugs for cardiovascular disease.[61 112] All drugs—including sedative hypnotics, anxiolytics, antidepressants, and antipsychotics—should be reviewed with a view to reducing their number or dose.[44] It is essential to reduce psychotropics progressively to minimize withdrawal symptoms.[113 114]

The rate of falls can be reduced by tapering and discontinuing drugs[115] as part of individual[116] or multifactorial interventions.[35 44] A study evaluating the effectiveness of psychotropic drug withdrawal found that after 44 weeks the risk of having a fall was 66% lower in the drug withdrawal group than in the group taking their original drugs (relative rate 0.34, 0.16 to 0.74).[116] However, the value of reducing or withdrawing drugs as a standalone intervention for preventing falls in older people has been questioned.[35 96] Long term withdrawal of drugs that increase the risk of falling, including benzodiazepines, may be challenging.[116] Easy to use clinical decision making tools to help physicians and patients weigh up the benefits of the use of drugs for specific conditions against the risk of increasing falls are lacking.

Education and behavioral counseling

Education and behavioral counseling includes educating older people and their families about falls and the clinical, behavioral, psychological, and acute risk factors for falls. Clinical education and behavioral counseling is not recommended as a standalone intervention.[35 36]

Vision correction

It is unclear whether vision correction is an essential component of multifactorial interventions for falls prevention.[117] Older women who had cataract surgery for the first eye showed a reduction in the rate of falls (rate ratio 0.66, 0.45 to 0.96; P=0.03),[118] but the 2010 systematic review for the USPSTF[35] found that surgical and non-surgical vision correction did not reduce the risk of falling and raised concerns about an increased risk of falls.[119] As with improved mobility, improved vision may increase activity levels or reduce attention levels (or both) increasing opportunities for falls. This should not stop healthcare providers from recommending exercise and proper vision correction because the benefits of improved physical function and vision for the overall quality of life of patients outweigh the risks. Vision correction needs to be used in conjunction with other interventions to reduce the risk of falls.

Vitamin D and calcium supplementation

Supplementation with vitamin D and calcium is another strategy for reducing the risk of falls. In 2009 a meta-analysis of seven randomized controlled trials with about 1900 participants linked 700-1000 IU of vitamin D supplementation to a lower risk of falls compared with those who did not take vitamin D (pooled relative risk 0.81, 0.71 to 0.92).

The USPSTF reviewed nine vitamin D supplementation randomized trials and found that a median oral daily dose of 800 IU of vitamin D with or without calcium was associated with a 17% (11% to 23%) reduced risk of falling in the intervention group (6-36 months of follow-up), and the USPSTF recommended vitamin D supplementation to prevent falls in community dwelling older adults.[96]

By contrast, a systematic review and meta-analysis in 2012 reported that in general vitamin D supplementation was not associated with lower fall rates in community dwelling older people (rate ratio 1.0, 0.90 to 1.11), but it reduced the rate of falls and risk of falling in subgroups

with low vitamin D levels at baseline compared with those who did not receive vitamin D supplementation.[36] Analyses of 804 participants with low vitamin D levels at baseline from four trials showed that fewer people fell in the group who received vitamin D supplements than in the group who did not received vitamin D supplements (relative risk 0.70, 0.56 to 0.87).[120-123] The review concluded that vitamin D supplementation reduced falls only in people with lower vitamin D levels.[36]

The American Geriatrics Society workgroup on vitamin D supplementation for older adults graded the quality of evidence from clinical trials and meta-analyses of vitamin D supplementation to reduce falls and fractures in older people.[124] The workgroup recommended minimum daily supplementation with 1000 IU of vitamin D plus 1000-1200 mg of calcium to prevent falls and fractures in older people in the community or institutional settings.[124]. Similarly, a meta-analysis conducted for the USPSTF to evaluate vitamin D supplementation with or without calcium for preventing cancer and fractures found that combined vitamin D and calcium supplementation reduced the risk of fractures in older people in the community (relative risk, 0.89, 0.76 to 1.04) [125] However, one of the trials reported adverse effects of supplementation including renal and urinary tract stones.[125] The Institute of Medicine's dietary reference intake for calcium and vitamin D to maintain bone health and calcium metabolism is 600 IU for people aged 51-70 years and 800 IU for those aged 70 years or more.[126] These are the same values as those proposed by the 2012 USPSTF for falls prevention,[96] but the 2014 AGS recommendation for older adults is for at least 1000 IU per day and the AGS concluded that there are currently insufficient data to support vitamin D supplementation without calcium.[124]

The Institute of Medicine (IOM) recommended dietary allowance for calcium is 1000 mg for people aged 51-70 years and 1200 mg for those 70 years or more.[126] A meta-analysis found that combined vitamin D and calcium supplementation of institutionalized older people was associated with reduced risk of fractures (relative risk 0.71, 0.57 to 0.89), but results in community dwelling people did not reach statistical significance (0.89, 0.76 to 1.04).[125] A dose dependent benefit of vitamin D supplementation has been found for hip and non-vertebral fractures in older adults, with a median vitamin D intake of 800 IU/day in community dwelling older people being associated with a reduction in hip fracture risk (relative risk 0.68, 0.48 to 0.96).[127]

Multifactorial interventions

Multifactorial interventions are interventions that target multiple risk factors using multiple approaches. For example, a multifactorial intervention may address the risk of falls by delivering a group exercise program, a drug review, vitamin D supplementation, and home risk assessment and modifications. Several studies indicate that multifactorial interventions reduce falls in older people in the community. A landmark randomized controlled trials published in 1994 reported lower risk of falls in people 70 years or more who lived in the community after participation in a multifactorial intervention (rate ratio 0.69, 0.52 to 0.90); the intervention group (n=153) was 78 (5) years old, 69% were women, and the age and proportion of women in the control group (n=148) was the same as in the intervention group.[60] Another randomized controlled trials published in 1994 randomized 1559 older people to a group that received nurse assessments and interventions to reduce risks for falls and disability (intervention group, n=635), or to a group that received a general health promotion visit (visit only group, n=317), or to a group that received usual care (usual care group, n=607).[128] After one year, the prevalence of falls was 28% in the intervention group, 30% in the visit only group, and 37% in the usual care group. The difference between the intervention and the usual care group was statistically significant (P>0.001). After two years, the prevalence of falls in the groups (30% on average) was not significantly different.[128]

A systematic review in 2012 included an analysis of multifactorial interventions in participants who received various combinations of interventions on the basis of individual assessments.[36] A total of 19 trials were included and the analysis showed a 14% reduction (14% to 33%) in the rate of falls.

By contrast, other reviews have not found multifactorial interventions to be effective.[35 36] A 2010 systematic review to support the USPSTF efforts analyzed data from 19 multifactorial falls risk assessment and management trials with 7099 participants. All trials except for one included older people at high risk of falling and the control groups received usual care or education (or both). Overall the authors found no significant difference in the risk of falls (risk ratio 0.94, 0.87 to 1.02).[35] Analysis of six comprehensive (defined as complete and active management of fall risk factors and conditions identified in the multifactorial assessment, including provision of case managers or home nurses) trials (2010 participants) resulted in a borderline reduction in falls risk (risk ratio 0.89, 0.76 to 1.03). However, an analysis of the remaining 13 non-comprehensive trials (4312 participants), which included interventions that provided only referrals, limited management, or knowledge found no reduction in the risk of falls (risk ratio 0.98, 0.88 to 1.08). The review noted that the analysis was affected by methodological problems and stated that data from future trials could alter the significance of analyses.

Taking into consideration the results of this 2010 review,[35] the 2012 USPSTF recommendations stated that in-depth multifactorial risk assessment with comprehensive management of falls risks should not be performed automatically, but that individual circumstances could serve as a rationale for multifactorial assessment and intervention.[96] The recommendations recognized that the lack of consistent findings does not mean that some interventions could not produce important benefits. However, there was uncertainty regarding which combinations of interventions, as well as which combinations of at risk older people would benefit the most.[96]

Heterogeneity among studies poses major challenges for systematic reviews and meta-analyses seeking to synthesize and interpret evidence on falls prevention in community dwelling older people. Substantial dif-

Author/agency	Jurisdiction	Falls risk assessment and management components								
		History, balance, strength, exercise interventions	Gait	Function	Vision	Pain	Medications	Cognition	Home/ environment	Multifactorial interventions
Feder et al[137] 2000	UK	+	+	+	–	–	+	–	+/–	+
Moreland et al[138] 2003	Canada	+	+	+	+	–	+	+	+	+
ACSQHC[139 140] 2009/2011	Australia	+	+	+	+	+	+	+	+	+
Campbell and Robertson[109] 2010	New Zealand	+	–	–	+	–	+	–	+	+
AGS/BGS[43 44] 2010	US and UK	+	+	+	+	–	+	+	+	+
Moyer et al/ USPSTF[96] 2012	US	+	+	+	–	–	–	–	–	+/–
Stevens and Phelan/CDC[141] 2013	US	+	+	+	+	–	+	+	+	+

Fig 2| Components included in sample guidelines for falls prevention among older people in the community published since 2000. ACSQHC=Australian Commission on Safety and Quality in Health Care; AGS/BGS=American Geriatrics Society/British Geriatrics Society; USPSTF=US Preventive Services Task Force; CDC=Centers for Disease Control and Prevention; STEADI=Stopping Elderly Accidents, Deaths, and Injuries[44-141]

ferences have been documented in the methods used to characterize at risk older people, recruitment settings, intervention type, components, intensity and duration, and methods to ascertain outcomes. All considered, multifactorial interventions seem to be effective in reducing falls in the community, at least among older people at high risk.

Emerging treatments

The use of technology to reduce the risk of falls is increasing. One such technology, exergaming (videogame based exercises), is now being evaluated for its ability to reduce falls in older people. Exergames are games with remote controls and motion sensors that require the players to move while playing a video game. Depending on the game, exergames can also provide immediate feedback to players about the quality of movement and workout intensity through accelerometer technology that tracks body movements. Because exergaming is an emerging technology well controlled randomized trials with adequate sample sizes examining its ability to reduce falls are lacking. Preliminary findings using less rigorous study designs show promise for exergaming. For instance, the Nintendo Wii gaming system could train and increase balance, improve physical performance, increase lower limb strength, and reduce falls among older people.[129-132] A study that used a non-randomized two-group pre-post design found that an unsupervised Nintendo Wii videogame based balance retraining program for 30 minutes, three times a week for six weeks, significantly improved timed up and go, left single leg balance, lateral reach, and gait speed compared with the comparison group.[133] Furthermore, a randomized trial with 60 participants living in a nursing home found a significantly greater improvement in physiological assessment scores (P=0.004) and significantly greater decrease in the number of falls (P<0.001) in the Wii Fit training group compared with the conventional exercise group.[134]

Guidelines

Despite the availability of guidelines, it has been reported that only 8% of physicians in Colorado, US use falls prevention clinical guidelines from recognized organizations.[135] Barriers included lack of time, competing patient needs and priorities, and lack of educational materials. Low adherence to guidelines is not unique to falls prevention. A recent study evaluated adherence to asthma management guidelines including assessment of asthma control, factors affecting control, self management support, and prescription of drugs.[136] Adherence was highest for drug prescription (70-88%) and lowest for self management support (3%). Figure 2 details some of the guidelines on falls prevention among older people in the community published since 2000.

The AGS/BGS guidelines recommend that healthcare providers ask all older people or their caregivers at least once a year about falls, frequency of falling, and difficulties in gait and balance.[44] A gait and balance evaluation should be conducted in those with a history of falls in the past 12 months.[44] Examinations should include:

- A detailed assessment of gait, balance, mobility, and the function and muscle strength of the lower extremity joints
- Evaluation of neurological and cognitive function
- Assessment of lower extremity peripheral nerves, proprioception, reflexes, cortical, extrapyramidal and cerebellar function, and cardiovascular status
- Assessment of visual acuity
- Examination of the feet and footwear
- Assessment of activities of daily living including use of adaptive equipment and mobility aids
- Assessment of current activity levels, perceived functional ability, and fear of falls.[44]

Challenges and next steps

Multifactorial comprehensive risk assessment coupled with targeted management of risk factors is a recommended approach for the reduction of falls among older adults in the community.[91] However, broad implementation of this approach in the community remains challenging for several reasons, including:

- Time constraints in the context of competing clinical demands
- Care fragmentation and need for coordinated effort for effective integration of assessment, intervention, and monitoring activities involving multiple health professionals from different disciplines
- Financial difficulties
- Inadequate knowledge and skills of health professionals.[142-146]

Despite these challenges the healthcare community needs to find ways to perform comprehensive and sensitive falls risk assessments and interventions on a regular basis in different populations.[147]

Many activities relevant for falls prevention can be offered in local community settings, including home assessments and modification services, exercise classes, and education programs. However, in general, the offer of these programs is based on grants with end dates. Older people need access to ongoing sustainable programs in the community. Links between healthcare and community programs for falls prevention also need to be established.[148-150] A recent article highlighted potential strategies to integrate evidence based exercise programs for reducing falls into routine clinical and community programs.[151] Potential solutions included:

- Conducting additional translational research in communities where the programs are to be offered, including assessment of training materials for people delivering the program and monitoring of delivery fidelity
- Increasing efforts by professional organizations and the public health sector to make clinicians aware of the evidence based exercise programs available in the community
- Increasing support (for example, from Medicare and Medicaid and private insurers) for evidence based exercise programs to reduce falls in the community because currently most programs are self supported by fees and therefore have limited access and exclude populations with limited financial resources
- Improving communication and collaboration between clinicians and providers. Healthcare systems need to include intermediaries (such as health coaches or case managers) to help bridge the gap between clinical care and community programs streamlining referrals.

Efforts to ensure solid referral links and communication within the clinical setting and between the clinical and the community settings are necessary. If time and human resource constraints exist in the care setting, referrals should be made to ancillary clinical or community agencies that can offer functional fitness assessments and evidence based intervention programs. However, clinicians should be aware that referral does not guarantee delivery of effective interventions.[152] Falls prevention trials in which interventions were limited to referral or provision of information were less effective than those in which interventions involved direct management of risk factors.[35 36]

In those at risk (such as those with self reported previous falls, balance impairment, mobility and gait impairments, or fear of falls), falls history, gait, balance, and mobility should be evaluated as part of yearly physical examinations to ensure early identification of functional decline and early referral to intervention. Exercise has a well established role in falls prevention. The specific types and amount of exercise are still to be determined,[142] but healthcare providers should recommend exercises that are adequate for their patients' capabilities (from closely supervised physiotherapy or rehabilitation for those with mobility impairments to gym based activities or community based programs for those who are more able and independent).

Brief mobility performance screening tests play an important role in identifying older adults who may benefit from different types of exercise interventions. Further evaluation is needed to identify the best set of mobility tests for falls risk screening. Technologic advances have led to development of new methods and measures of gait and balance relevant to falls risk assessment, including quantitative temporo-spatial parameters of gait obtained while performing single tasks (such as walking) or dual tasks (such as walking while performing an attention demanding cognitive task).[153-157] Additional work will help to determine the clinical value of measures of gait parameters in the context of falls prevention in the community and help decide whether these tests can be used as screening tools or whether they should be reserved for those at high risk of falls.

Conclusion

Multifactorial, exercise based, tailored interventions are the most effective way to reduce falls and the resulting healthcare costs in community dwelling older people.[19 93] Thus, healthcare providers need to identify those at risk of falls and refer them for comprehensive assessment and evidence based multifactorial interventions including exercises. One of the problems with multifactorial interventions is that the positive effects cannot be attributed to any specific intervention but to the overall combination.

Substantial interdisciplinary research provides the basis for effective recommendations that may help clinicians reduce falls among older people in the community. However, implementation of recommendations into practice is poor. Enhanced knowledge by healthcare and by falls prevention programs is also needed for optimum screening, assessment, intervention, coordination of care delivery, and monitoring of falls reduction programs for older people in the community. Older people at risk of falls are often at risk of other geriatric syndromes, including frailty and disability, thus interventions to reduce fall events could benefit other outcomes. Efforts at integrating sets of recommendations for related conditions may prove useful.

QUESTIONS FOR FUTURE RESEARCH

- How can falls screening be implemented as a routine practice during yearly physical examinations in older people?
- What is the best combination of screening tests to assess the risk of falls among older people living in the community?
- What are the specific contributions of the different components included in multifactorial interventions to reduce falls among older people in the community?
- How can we most effectively bridge the gap between clinical care and community programs for falls prevention?

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