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Falls

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Summary

Falls and fall-related injury are common and become more prevalent with increasing age. Risk factors for falling are numerous, synergistic and complex, and require multidisciplinary assessment. The evidence base for intervention strategies continues to improve, but is often limited by the methodological difficulties that are inherent in falls research. The most effective intervention is a multifactorial approach that targets identified risk factors. Multicomponent exercise, either in a group or individually, is one of the most effective components of intervention. Other successful components include home hazard modification and psychotropic medication withdrawal. Primary prevention does not appear to be cost effective, but secondary prevention far outweighs the cost of falls and fall-related injury.

Key words: accidental falls, vitamin D.

Introduction

Falls and fall-related injury are a common and far-reaching clinical problem facing many specialists, surgeons, and primary and secondary care physicians. The causes of falls are legion, synergistic and often complex; this, alongside the difficulty in measuring or recording falls, may have led to the relative lack of progress in successfully translating falls prevention and management research strategies into clinical practice. However, some progress has been made and in the context of a rapidly expanding older population the prevalence of falls is expected to increase greatly. With this in mind it is important that clinicians recognize and treat those at risk of falls, and academics perform high-quality clinically relevant research.

Search strategy and selection criteria

The Ovid MEDLINE database was searched for relevant publications from 1946 to December 2012. The Cochrane Library was searched for relevant reviews, and the American Geriatrics Society, the British Geriatrics Society and the Royal College of Physicians websites were searched for current guidelines, audits and documents. Selected articles from reference lists were selected if judged to be relevant.

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The relevance of falls

Falls are highly prevalent and pose problems on a personal, societal and economical level. One in three community-dwelling people aged over 65 years will fall each year and, as the population expands and ages, the relevance of falls will only become more and more important.[1,2] Indeed, a national audit of falls and falls services in the UK found that falls-related hospital admissions increased by 36% between 2003 and 2008. Economically this is a huge cost, with estimates of the annual cost of falls to the UK National Health Service in 2003 being £1.6 billion for older people alone.[3] These figures place falls in the top 20 most costly medical conditions.[4] On a more personal level, falls can result in serious injury; in a prospective study of 1103 community-dwelling people aged over 70 years in the USA, 52% had a fall and 24% of these sustained a serious injury (fracture, joint injury, intracranial injury).[5] Even a single, non-injurious fall resulted in an increased risk of long-term care (relative risk 4.9; 95% CI 3.2–7.5). Furthermore, sequelae of falling include fear of falling, social isolation and loss of independence.[6] Worryingly, over 80% of women aged over 75 years would rather die than lose their independence from a hip fracture.[7] Falls-related mortality is most significant in those with two or more falls per year, with an odds ratio (OR) for death of 2.6 (95% CI 1.4–4.7) at 1 year and 1.9 (95% CI 1.2–3.0) at 3 years.[8]

This problem has been recognized and national strategies now exist to promote a standard of care in the prevention and treatment of falls and related

injury. The UK National Institute of Health and Clinical Excellence (NICE) produced a framework for the assessment and treatment of people at risk of falls in 2004;[9] an update of these guidelines is currently in progress and is due to be published in June 2013. Following this national guidance a national audit was performed by the Royal College of Physicians in 2006; while this demonstrated that 74% of NHS Trusts had a falls service, it revealed a worrying lack of public health strategy for falls prevention. More recently the Royal College published the results of its National Audit of Falls and Bone Health in Older People 2011, its title perhaps reflecting some of the negative outcomes, 'Falling Standards, Broken Promises'. Unfortunately, there is still a wide variation in clinical practice, with some services falling below what is considered good practice.[10]

Academic considerations

Falls definition. Definitions of falls vary greatly between research studies, limiting the comparability of trial methodologies, trial outcomes and meta-analyses. This limited the potential of the 2003 Cochrane review of falls intervention studies due to the heterogeneity of definitions. To address this problem the Prevention of Falls Network Earth (PRoFaNE) developed an international consensus statement for falls prevention trials, with the resultant definition 'an unexpected event in which the participant comes to rest on the ground, floor, or lower level'.[11] In addition, they developed a useful lay definition to standardize the way in which individuals are asked about falls: 'in the past month, have you had any fall including a slip or trip in which you lost your balance and landed on the floor or ground or lower level?'.

Recording falls. The standardized definition allows considerable progress to be made in falls research but the method by which falls are recorded must also considered. Retrospective recall of falls is flawed methodologically; this is based on the findings of a prospective trial in which participants recorded any falls on a weekly basis for 12 months but were interviewed throughout the reporting period to recall falls over the past 3, 6 and 12 months. Up to 32% of individuals did not recall a fall that they had reported within the previous 3 months.[12] The gold standard for recording falls, by consensus, has become prospective daily recording of falls with a falls diary, with regular review and corroborative history/recording if possible.[11] However, even prospective reporting is subject to limitation, with possible over-reporting of falls and a certain degree of retrospective recall. Additionally, with such intensity, combined with the length of time required to detect change, poor adherence and high drop-out rates may arise. Technological advances may have a role to play in enhancing or validating the reporting of falls. Accelerometers that can detect sudden postural change and accurately distinguish falling from other activities are increasingly being used academically but in combination with telecare show great potential for clinical use.[13]

Reporting falls. Falls studies may report falls in many different ways; the most common have included fall rates (e.g. number of falls over time, rate ratios between cohorts (RaR)), number of people falling (as a proportion, or as a relative risk (RR)), rate or number of fractures or injuries and time to first fall. In order to improve comparability of trial data it is recommended that studies report fall outcome data as number of falls, number of fallers, fall rate and time to first fall.[11]

Screening

The UK National Service Framework for Older People and NICE's clinical guideline states that those who are at risk of falling should be identified in order to co-ordinate the appropriate preventative strategies. Screening for community-dwelling individuals at risk of falls is inherently difficult due to the number and complexity of existing risk factors. There is no good evidence to support large scale population screening to identify those at risk of falls; such a screening programme would rely upon the existence of a simple tool that could accurately and confidently identify those who will fall and those who will not; no such tool exists. A study based in Nottingham, UK offered falls screening to 5289 people aged over 70 years via primary care providers, followed by an invitation to a falls prevention intervention scheme for those identified as high risk. Uptake was low (54% responded to screening, 25% offered intervention accepted), completion rates

Table 1. *Commonly used falls screening tools*

Tool	Accuracy	Comments
Falls Risk Assessment Tool (FRAT)[18]	Sensitivity 0.15–0.59 Specificity 0.8–0.97	Requires multidisciplinary knowledge of patient. Promotes thorough assessment
Tinetti Performance Orientated Mobility Assessment (POMA)[19]	Sensitivity 0.27–0.76 Specificity 0.52–0.83	Thorough gait and balance assessment based on common functional tasks, no equipment. Relatively time consuming
Timed Up and Go (TUG)[20,21]	Sensitivity 0.1–0.54 Specificity 0.73–0.95	Requires 3 m of clear walking space. Very simple and allows for concomitant gait assessment
Berg balance score[22,23]	Sensitivity 0.53 Specificity 0.92 (Bogle *et al.* 1996[23])	Lengthy (15–20 min) High intra- and inter-rater reliability, no equipment
Physiological profile assessment [24,25]	Sensitivity 0.58 Specificity 0.69	Multifactorial and comprehensive. Lengthy, much equipment needed

were even lower (37%) and cost analysis results were unfavourable, with £3000 spent for each fall prevented.[14,15] Many screening tools are available and the most widely used are listed in Table 1.[16]

Despite the aforementioned data, the American and the British Geriatrics Societies joint guideline recommends annual screening in the primary care of older people with falls or self-reported gait and balance problems. The collaboration also produces an algorithm detailing the assessment and appropriate interventions for those identified at risk through screening.[17]

Presentation

Secondary, rather than primary prevention is the most common approach when referring individuals to a falls prevention intervention. The odds of falling in someone who has already fallen are three times greater than in an individual who has not fallen (OR 3.0, 95% CI 1.7–7.0), highlighting the importance of recognition and onward referral for intervention.[26] Potential sources to identify secondary prevention targets are the emergency department (17–39% of attendances), the ambulance service (8–10% of emergency calls) and primary care.[27–31] Alternative approaches include open access to falls services, such as via long-term care facilities, family and self-referral. In fact, identification and onward referral to falls services by the ambulance service can result in significant falls reduction. A randomized controlled trial (RCT) of community-dwelling older people who had fallen and been assessed by an ambulance crew, but not taken to hospital, demonstrated an impressive reduction in falls rates for those referred to falls services compared with those who were not (RaR 0.45; 95% CI 0.35–0.58).[32]

Leading causes

It would not be possible to assess and investigate every identified risk factor for falling in an individual; several hundred have been identified and this number continues to increase, although some of these risks arise from rather dubious quality studies.[33] A comprehensive systematic review and meta-analysis identified 31 factors that significantly increased the risk of falling in older community-dwelling adults, reinforcing the need for comprehensive, multidisciplinary falls assessments.[34] The prevalence of risk factors are variable, depending on the population studied; those that have been consistently identified in older, community-dwelling populations are listed in Table 2.[9,26,35–37]

The interplay of risk factors is complex and many may overlap (e.g. arthritis, gait abnormality and muscle weakness). In one study that classified individuals according to number of risk factors, falls were increasingly common with the accumulation of increasing risk factors: no recurrent fallers in those with between 0 and 3 risk factors, 31% of those with 4–6 risk factors were recurrent fallers, and all those with 7 or more risk factors were recurrent fallers.[38]

Sarcopenia is becoming increasingly relevant both as a concept of ageing and as a risk factor for falls. Muscle weakness is a well-recognized

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Table 2. *Risk factors for falls that have been consistently identified in older, community-dwelling populations*

- Muscle weakness
- History of falls
- Gait abnormality
- Balance abnormality
- Use of walking aids
- Visual impairment
- Arthritis
- Impaired functional activity
- Depression
- Cognitive impairment
- Culprit medication
- Polypharmacy
- Fear of falling
- Incontinence
- Peripheral neuropathy
- Parkinson's disease
- Stroke
- Age over 80 years
- Cardiovascular (orthostatic hypotension, vasovagal syncope, carotid sinus syndrome, arrhythmia)

risk factor for falls and many interventions have focused on this as a therapeutic target. The association between muscle weakness and falls may occur through sarcopenia. Several years ago, results from the Hertfordshire Cohort Study hinted at an increased risk of falls with sarcopenia (using grip strength as proxy measure) (unadjusted risk in men OR 1.36, 95% CI 1.13–1.64; adjusted OR 1.23 (1.0–1.52)).[39] More recently, an Italian group followed 260 community-dwelling individuals aged 80 years or more over a period of 2 years. One quarter of their cohort had evidence of sarcopenia and of these 27% fell over the course of the follow-up, significantly more than those without sarcopenia (9.8%, $P<0.001$). Even after adjusting for several demographic and falls risk factors, the risk of falling remained significantly higher in the group with sarcopenia (adjusted HR 3.23; 95% CI 1.25–8.29).[40] Over the next few years we may learn more about the association between sarcopenia, falls and ageing.

Syncope may mimic falls and as such the assessment for cardiovascular causes of falls is important. The most common causes of syncope in the older population are orthostatic hypotension (30% of cases), carotid sinus syndrome (20%), neurally mediated hypotension (such as vasovagal or situational syncope, 15%) and cardiac arrhythmias (20%).[41] The typical description of a syncopal episode may not be present in older people; for example, compared with younger people with syncope, older people with vasovagal syncope are less likely to describe transient loss of consciousness (OR 0.5 (0.38–0.64)) and more likely to present with unexplained falls (OR 2.33 (1.36–4.32)).[42]

Falls assessments

The components of a falls assessment included in the UK NICE guideline are included in Table 3. These features should be included in an assessment of an individual who presents to health services because of a fall, and an experienced and skilled clinician should perform these assessments, ideally in a specialist setting.

Assessment in a specialist setting achieves greater reduction in falls than in primary care. This is evidenced by The Winchester Falls Project, a large, randomized, controlled trial of older community-dwelling individuals.[43] Individuals aged over 65 years who had had two or more falls were randomized to assessment and intervention in primary care or in secondary care. Compared with usual care, the secondary care intervention reduced falls significantly (OR 0.47; 95% CI 0.33–0.69), reduced hospital admission (OR 0.66; 95% CI 0.66 0.48–0.89) and had fewer deaths (OR 0.45; 95% CI 0.22–0.92). Primary care intervention did not differ significantly from usual care in any of these measures. It is anticipated that more evidence will emerge on this issue from the PreFIT (Prevention of Falls and Injury) trial.[44] Community-dwelling people at risk of falls will be randomized to a multifactorial assessment or usual care, or usual care and education. Comparison of assessments taking place in secondary or primary care will form a secondary outcome in this ongoing trial, in addition to the primary outcome measure of peripheral fractures.[44]

Alongside the recommendation for assessments to take place in a specialist setting, the evidence supports the use of qualified staff to perform these assessments. For example, falls rates are reduced further if intervention is delivered by an occupational therapist rather than an unqualified, trained health care worker,and older fallers are more likely to adhere to exercise intervention if it is delivered by a physiotherapist.[45,46]

Treatment/prevention

Many different falls interventions have been studied, and comparison between them is hindered by significant heterogeneity. Studies may be divided into single intervention, multiple intervention

Table 3. *An overview of the principle multidisciplinary components of a falls assessment and intervention*

Multidisciplinary team member	Assessment	Multifactorial interventions
Physician	Falls history	Medication
	Medication	– Vitamin D if risk of deficiency
	Neurological	– Withdraw 'culprit' medication
	Cardiovascular*	Cardiovascular
	Vision	– Address NMH
	Incontinence	– Pacemaker
	Fracture risk	
Physiotherapy	Falls	Multicomponent exercise
	Gait	– Group exercise
	Balance	– Individualized exercise
	Strength	– Tai chi if low risk of falls
	Fear of falling	
Occupational therapist	Function	Footwear
	Cognition	Home hazards
	Home hazards	
Other		Onward referral if necessary

*Cardiovascular assessment should include examination, ECG and postural blood pressure as a minimum. NMH, neutrally mediated hypotension (orthostatic hypotension, vasovagal syncope, carotid sinus syndrome).

(where the intervention consists of two or more defined interventions) or multifactorial (where the intervention depends on the identified risks in the individual). Given that the majority of older people who fall have more than one falls risk factor, it would seem that multi-component interventions would be superior to single element treatment and prevention strategies. However, the complexity of multifactorial interventions leads to challenges in measuring effectiveness and treatment outcomes.

It may be argued that multifactorial intervention offers little in terms of superiority when compared with single intervention. This argument is supported by a meta-regression that pooled data for community-based falls prevention programmes for older people, comparing single faceted intervention (ten trials) to multi-component intervention (six trials).[47] Pooled RaR for multi-component intervention was 0.78 (CI 0.68–0.89) compared with 0.77 (CI 0.67–0.89) for single interventions; the difference was not significant. Comparison is not straight forward, particularly with the heterogeneity of falls trials, which was a problem in this analysis. However, it does demonstrate a valid argument that the benefit of additional components to prevention strategies may not provide significantly more effective falls reduction for each additional component.

Single intervention

Exercise. Group multicomponent exercise (more than one type of exercise) classes reduce the rate of falls (pooled RaR 0.71; CI 0.63–0.82) and the number of people falling (pooled RR 0.85; CI 0.76–0.96).[48] In 2005 the FaME trial (Falls Management Exercise) demonstrated a 31% reduction in falls in older frequent fallers attending a group exercise class compared with controls who performed sham exercise at home.[49] These findings are in keeping with the largest trial to date of multicomponent exercise; 1107 community-dwelling individuals aged over 70 years were randomized to a weekly strength and balance exercise class with supplementary daily home-based exercises for 15 weeks, or to home hazard intervention, vision screening with referral onwards if necessary or delayed intervention.[50] Results were first published in 2002 based on time to first fall, and following publication of new consensus guidelines on the reporting and analysis of falls outcome data, were re-published

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in 2010 based on falls incidence over 18 months.[51] The rate of falls in the exercise intervention group was significantly reduced compared with those in non-exercise groups (RaR 0.79; CI 0.67–0.94). Interestingly, when the exercise intervention was combined with a vision and home hazard intervention there was no further reduction in falls rates, supporting the results of Campbell's meta-regression described above.

Similarly, individual home-based multicomponent exercise reduces both rate of falls (pooled RaR 0.68; 95% CI 0.58–0.8, 7 trials) and the number of people falling (pooled RR 0.78; 95% CI 0.64–0.94).[48] In 2010, Bischoff-Ferrari *et al.* recruited 173 older people who had been admitted to hospital for a fractured hip in Switzerland. They were randomized to either standard physiotherapy during hospital stay or extended physiotherapy, which included a programme to educate the participants on how to continue their exercises at home with additional written information. Participants were also randomized to either 800 or 2000 units of vitamin D per day. Using factorial analysis the authors were able to estimate the effect of extended home-based physical activity *versus* no home-based activity, regardless of the vitamin D. The result demonstrated a reduction in falls rate of 25% (95% CI –44 to –1) with extended home activity compared with the hospital only group. Twenty-six per cent of the study's participants had dropped out by 4 months, and 69% in the extended physiotherapy group performed their excise at least once per week.[52]

The Otago Exercise Programme. A well-recognized and well-studied exercise intervention is The Otago Exercise Programme.[53] This is a home-based, individually tailored, strength and balance retraining programme for older people in the prevention of falls. It involves four to five home visits, usually from a physiotherapist who will prescribe a set of strength, balance and flexibility exercises from a set list, depending on the individual's ability. Subsequent visits aim to increase the exercises based on progress. In addition to the three prescribed 30-min exercise sessions, the individual is advised to walk for 30 min, twice per week. The aforementioned FaME trial based its intervention on these exercises.

Although The Otago Exercise Programme has been relatively well studied in community-dwelling older adults, the majority of these studies have been conducted and reported by the same group. Nevertheless, a meta-analysis of seven non-blinded RCTs ($n = 1503$) revealed significant reductions in falls rates (incidence RR 0.68; 95% CI 0.56–0.79) and mortality (RR 0.45; 95% CI 0.25–0.8) despite low levels of adherence at 1-year follow-up ($36.7 \pm 15.8\%$).[53] The authors of the programme stipulate that the exercise should be performed three times per week, but with low levels of adherence and significant, positive outcomes, perhaps there is benefit from a reduced frequency of exercise.

Adherence to exercise programmes or physical therapy is generally expected to be low and to decrease over time. A meta-analysis of 23 randomized, controlled, exercise intervention programmes for the prevention of falls revealed that pooled adherence rate was as low as 21% (95% CI 15–29%). Those interventions that demonstrated the greatest adherence rates involved balance training, walking, home visit support, the intervention being led by a physiotherapist and the absence of flexibility training. The same meta-analysis addressed whether the level of adherence was associated with effectiveness of the intervention. In short, there was insufficient evidence to support greater adherence being associated with a more effective programme. One possible explanation for this is that interventions over-prescribe the minimal effective dose.[45] More recently, the LiFE (Lifestyle integrated Functional Exercise) study demonstrated significantly greater adherence to exercise in older people at high risk of falls, if the exercises are embedded into daily activity. The exercises focused on strength and balance and were performed when the opportunity arose, rather than at set points. An example includes squatting down to reach something on the ground, rather than bending forward at the hip. Falls were significantly reduced (RaR 0.69; 95% CI 0.48–0.99) compared with controls and 64% of participants were still performing 'embedded exercises' at 1-year follow-up.[54]

Despite good evidence in support of multicomponent exercise (graded A by the joint AGS and BGS guideline) the UK RCP national audit reports limited access to evidence-based programmes with only 19% of (non-hip) fracture patients participating in falls prevention exercise.[10]

Tai chi. The 2012 Cochrane update found that Tai chi reduced the risk of falling (RR 0.71; 95%

CI 0.57–0.87; 6 trials) and marginally reduced the rate of falls (RaR 0.72; 95% CI 0.52–1.0, 5 trials). However, a subgroup analysis, based on the falls risk of the participants, found that those who have lower risk of falls benefited the most from Tai chi, whereas those with the higher falls risk had no statistically significant benefit.[48]

Vision. Changes in visual acuity, depth perception and contrast sensitivity are known to increase the risk of falling.[55] However, correcting problems with vision in order to reduce falls and injury does not appear to be as straightforward as expected. In Day's 2002 factorial trial (described earlier), the vision intervention consisted of screening visual acuity, depth perception and visual fields. An abnormality triggered referral onward to primary care or an optometrist. Of 547 participants in this arm, 26 received some form of treatment for their vision. Those participants in the vision intervention arm had no significant reduction in number of falls (RaR 0.89; 95% CI 0.75–1.04), although the number of participants who received visual intervention was low.[50] In contrast, the impact of visual assessment and onward referral was assessed further in 2007 in a cohort of 616 older people who were recruited from secondary care. They were randomized to either visual assessment by an optometrist or to usual care. Visual assessment resulted in new spectacles, glaucoma treatment, cataract surgery or a home assessment. Rather surprisingly the rate of falls increased significantly in the intervention arm (RaR 1.57; 95% CI 1.2–2.05). However, there were some significant differences between the control and intervention group. The controls were taking significantly more medication, in particular psychotropic medication, were more dependent, and more of them used walking aids. This suggests that the control group was frailer and as such may have been less mobile and less likely to recall and report falls.[56]

The VISIBLE study (Visual Intervention Strategy Incorporating Bifocal and Long distance Eyewear) suggests that changing from multifocal spectacles to single-lens glasses may reduce falls in people who are more active. In a study of 597 older, community-dwelling people who were at risk of falling, a cohort of multifocal lens wearers were compared with a group who usually wore multifocal lenses but were switched to single-lens glasses. Overall, the intervention did not reduce the rate of falls (RaR 0.92; 95% CI 0.73–1.17), but those who were more active outside did gain significant reduction in falls rate (RaR 0.6; 95% CI 0.42–0.87).[57]

Surgical removal of cataracts is known to increase activity levels in the elderly and to improve self-efficacy.[58] However, the effect of cataract surgery on falling is not entirely clear. Harwood demonstrated a 34% reduction in falls in 360 women aged over 70 who had their first cataract removed (RaR 0.66; 95% CI 0.45–0.96).[58] The same group continued to study the impact of surgical removal of a second cataract on falls. The results were less encouraging, with a non-significant increase in falls (hazard ratio 1.06; CI 0.69–1.61) in those whom had expedited cataract surgery (median wait 30 days) compared with routine surgery (median wait 316 days).[59] Although there was no improvement in falls rates there was a significant improvement in quality of life measures in the expedited surgery group.

On a population level, one large observational study of 15,295 first cataract operations noted that fall-related hospital admission rates were significantly higher in the 1 year after surgery compared with the year before surgery (RaR 1.27; CI 1.04–1.56). While this study does not allow for detailed analysis or discussion, it adds to the current pool of conflicting evidence regarding the impact of cataract surgery on falls.[58,60,61] Indeed, the uncertainty of the benefits of visual intervention is reflected by the joint AGS and BGS falls guideline, which states that evidence is insufficient to recommend for or against inclusion in a multifactorial programme.

Vitamin D. Another area of controversy in the prevention of falls is the use of vitamin D. Activity levels, chronic pain and cognition may all respond to vitamin D supplementation, which in theory could lead to a reduction in falls.[62–64] Table 4 summarizes the results of several large RCTs and meta-analyses. Overall, it would appear that vitamin D does not have a role to play in falls prevention on a population level. However, a subgroup analysis performed within the Cochrane review based on the participants' baseline vitamin D level would suggest that there is a significant reduction in falls if vitamin D is taken by those who have low baseline serum levels (RaR 0.57; CI 0.37–0.89).[48]

Table 4. *Summary of several large trials assessing the effectiveness of vitamin D in falls prevention*

Study	Cohort	Intervention	Outcome
The RECORD trial, 2005[65]	Age ≥70, British, mobile with recent fall and fracture, $n = 5292$	800 IU vitamin D alone *vs* 800 IU vitamin D with calcium *vs* calcium alone *vs* placebo for 1–5 years	No difference in reported falls (HR 0.97 (0.84–1.12))
The OSTRE-FPS trial, 2010[66]	Age ≥65, ambulatory, Finnish females, $n = 3432$	800 IU vitamin D *vs* no vitamin D for 3 years	No difference in number of fallers (RR 0.98 (0.92–1.05))
Porthouse, 2005[67]	Age ≥70, community-dwelling British females, $n = 3314$	Education and leaflet on lifestyle and diet *vs* education and leaflet with 800 IU vitamin D; follow-up 1 year	No reduction in risk of falls (OR 0.98 (0.79–1.2))
Sanders, 2010[68]	Age >70 community-dwelling female Australians, $n = 2258$	Annual dose of 500,000 IU oral vitamin D *vs* annual placebo for 3–5 years	Falls rate increased following vitamin D (RaR 1.15 (1.02–1.3)); largest increase occurred in the 3 months after dose
Smith, 2007[69]	Age >75, community-dwelling, British, $n = 9440$	Yearly IM 300,000 *vs* placebo	No reduction in falls rate (HR 0.98 (0.93–1.04)) in treatment arm
Trivedi, 2003[70]	Age 65–85, British, $n = 2686$	100,000 IU vitamin D every 4 months *vs* placebo for 5 years	Age-adjusted RR 0.93 (0.76–1.14)
Murad, 2011[71]	26 trials, $n = 45,782$	Meta-analysis	OR (risk) 0.86 (0.77–0.96), OR (rate) 0.79 (0.7–0.88)
Cochrane review, 2012[48]	14 trials, $n = 28,135$	Meta-analysis	RaR 1.0 (0.9–1.11), RR 0.96 (0.89–1.03)

RCT, randomized controlled trial; OSTRE-FPS, Osteoporosis Risk Factor and Prevention Study-Fracture Prevention Study; OR, odds ratio with 95% CI; IU, international units; RECORD, Randomised Evaluation Of Calcium Or vitamin D; IM, intramuscular; RR, relative risk with 95% CI; RaR, rate ratio with 95% CI; HR, hazard ratio with 95% CI.

Medication review. Despite recognizing that particular medications increase the risk of falling, there is little evidence that withdrawing 'culprit' medication reduces falls. Those medications that are particularly associated with falls in older people have been established in a recently updated meta-analysis; the odds ratios for nine medication classes are summarized in Fig. 1.[72]

Those medications with the greatest odds ratio for falling are within the psychotropic class. A 1999 study aimed to determine if withdrawal of psychotropic medication would result in a reduction in falls. In this two by two factorial RCT, 93 community-dwelling older people were randomized to withdrawing psychotropic medication, using placebo in its place, *versus* not withdrawing it, and an exercise programme *versus* no exercise. Over 44 weeks of follow-up, the rate of falls reduced with withdrawal of medication (RaR 0.34; 95% CI 0.16–0.74), although the risk of falling did not improve (RR 0.61; 95% CI 0.32–1.17).[73] Moreover, another trial consisting of comprehensive medication review and appropriate modification by a pharmacist or geriatrician, remotely and electronically, failed to produce a significant reduction in falls rates and risk of falling. However, when an educational approach was used, alongside financial incentives, in a study educating primary care physicians there was a reported reduction in falls risk (RR 0.61; 95% CI 0.41–0.91) in community-dwelling people aged over 65.[74]

Cardiac pacing. In 2001 Kenny published the first trial looking at the prevention of falls following pacemaker implantation for cardioinhibitory

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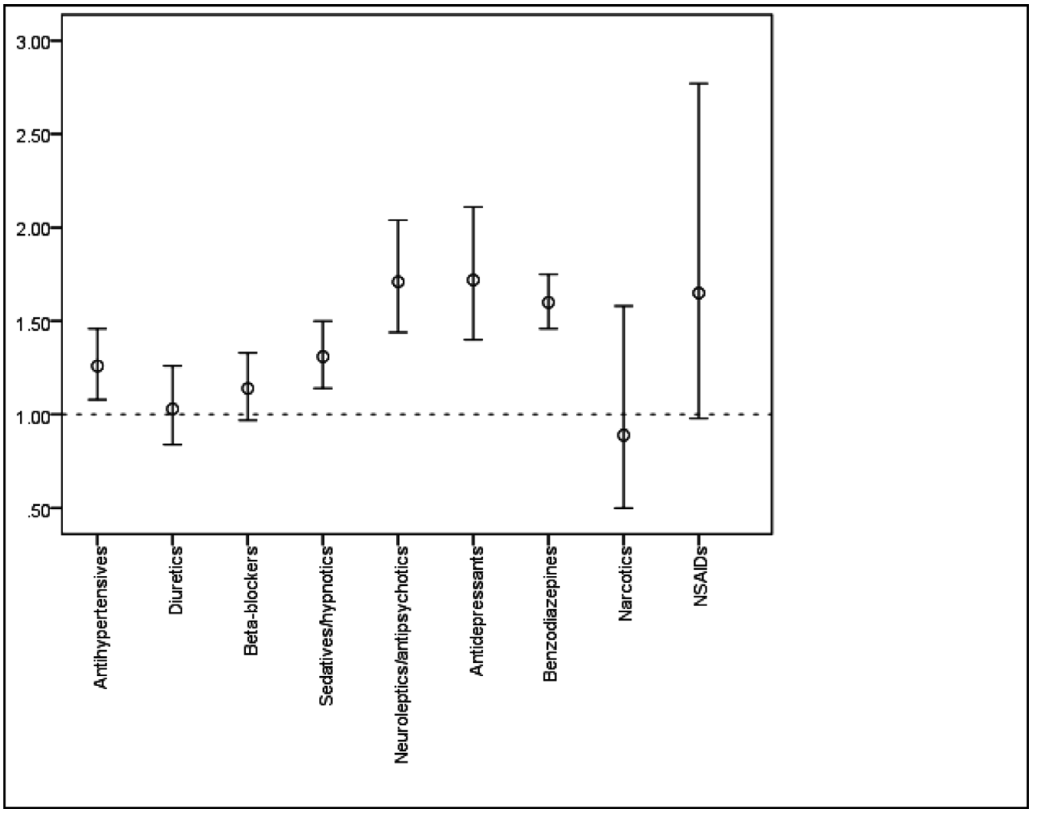

Fig. 1. The nine major classes of drugs that are associated with falls, presented with their odds ratio for falling and 95% confidence intervals[72]

carotid sinus hypersensitivity (CICSH), the SAFE PACE study (Syncope and Falls in the Elderly Pacing And Carotid sinus Evaluation). The results were encouraging with a significant reduction in rate of falls (RaR 0.42; 95% CI 0.23–0.75). Participants ($n = 175$) were aged over 50 years, had a history of falls and confirmed CICSH on testing. Those in the intervention arm received cardiac pacing whereas the controls did not, and as such it was not possible for blinding to occur.[75] Two further studies have been published since 2001. Parry did not demonstrate a reduction in fall rates (RaR 0.82; 95% CI 0.61–1.1) or falls risk (RR 1.14; 95% CI 0.83–1.56). This was a relatively small trial ($n = 34$), however, and was double blinded with participants randomized to having their pacemaker turned on or off.[76] The most recent study (SAFE PACE2) was a multicentre double-blinded RCT across Europe and the US ($n = 141$) with participants receiving either a pacemaker or implantable loop recorder.[77] It failed to detect a significant reduction in rate of falls (RaR 0.79; 95% CI 0.41–1.5) or a risk of falls (RR 1.34; 95% CI 0.83–2.14). Unfortunately this study failed to recruit an adequate sample size and was heavily underpowered. Nevertheless, pooled analysis of these studies did produce a significant reduction in rate of falls (pooled RaR 0.73; 95% CI 0.57–0.93) but not risk of falling (pooled RR (excludes SAFEPACE) 1.2; 95% CI 0.18–3.39).[48]

Cognitive behavioural therapy. One of the earliest trials of psychological intervention to prevent falls was in 1992, in a RCT set in Los Angeles. As fear of falling is a risk factor for falling in itself, it could in theory be a potential preventative target by using cognitive behavioural therapy (CBT). Participants were randomized to CBT, an exercise programme, both or a control (discussion group). Falls rates were not reported but falls risk did not respond to therapy (RR 1.13; 95% CI 0.79–1.6).[78] More recently, Huang performed an RCT based

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in a Chinese community-dwelling population (n = 120). Participants were assigned to CBT once per week for 8 weeks or CBT with Tai chi or neither. They failed to produce a significant reduction in rate of falling (RaR 1.0; 95% CI 0.37–2.72) and risk of falling (RR 1.0; 95% CI 0.4–2.51).[79] Pooled analysis of both of these studies confirms the lack of effectiveness of CBT in falls prevention (pooled RR 1.11; 95% CI 0.8–1.54). Results from the STRIDE study (strategies to increase confidence, independence and energy), which is currently in progress, should provide further evidence on this matter.[80]

Home environment intervention. Assessment of the environment in the home of individuals at risk of falling with appropriate modification is an effective falls prevention strategy, depending on how it is delivered. Two large Australian RCTs at the turn of the century both failed to demonstrate a reduction in falls rates with their environmental intervention. Day's 2002 trial, which is described earlier, used factorial analysis and found that an intervention which consisted of a trained home assessor who identified home hazards and offered appropriate intervention resulted in a non-significant reduction in falls rates (RaR 0.97; 95% CI 0.81–1.16).[50] Similarly, Stevens' RCT compared a home-based nurse falls education with home hazard identification and modification with the education alone; there was no significant reduction in falls rate (RaR 1.02; 95% CI 0.82–1.27).[81] Both of these trials are large but neither employed the skills of an occupational therapist (OT) to deliver the intervention, which may explain, in part, why these studies failed to demonstrate a reduction in falls. Recently, a UK-based RCT (n = 238) compared a home intervention delivered by OT compared with trained, but non-qualified assessors (healthcare support workers). Falls were reduced significantly in the OT intervention (RaR 0.54; 95% CI 0.36–0.83) but not in the non-OT intervention (RaR 0.78; 95% CI 0.51–1.21).[46] Furthermore, home hazard intervention appears to have benefits that extend beyond the home. In Cumming's 1999 study, falls decreased away from the home as well as in the home, the theory being that a certain degree of behaviour modification occurs with regards to falls risk avoidance.[82]

Feet and footwear. Very little research has been performed in the use of podiatry services to reduce falls. Emerging evidence suggests that podiatry is effective at reducing rate of falling, but not risk of falls, in older people with foot pain. A recent study randomized older (≥65 years), community-dwelling individuals with disabling foot pain who were already using podiatry services to receive either a continuation of the care they were already receiving or a multifaceted podiatry intervention that consisted of foot orthoses, appropriate outdoor footwear, foot/ankle exercises (30 min three times per week for 6 months) and falls education (n = 305). Falls rate in the enhanced intervention was significantly lower than in the usual care cohort (RaR 0.64; 95% CI 0.45–0.91), whereas the proportion of those falling did not (RR 0.85; 95% CI 0.66–1.08).[83] It would be premature to allocate success to podiatry alone as the exercise component may be the greatest reason for the outcome, particularly as the control group received standard podiatry care.

Multiple interventions

A large proportion of the single interventions described so far have been extracted from multi-faceted intervention using factorial analysis. The majority of multiple intervention trials employ exercise as one of the interventions and the majority of multiple intervention trials do not achieve significant reductions in falls, in contrast to multifactorial approaches.

Multifactorial interventions. A multifactorial falls prevention approach is considered the most effective. Although this approach seems common sense, the evidence for it has not always been consistent. One of the problems has been insufficient numbers of adequately powered, high-quality studies. A further limiting factor has been the randomization of individuals to multifactorial intervention or to usual care. Over the last 10 years, falls services for older, community-dwelling individuals have improved dramatically and as such, the differences seen in fall reductions are less pronounced as usual care has advanced.

One of the earlier landmark studies in multifactorial intervention was that of Tinetti in 1994.[84] In this American study, 301 community-dwelling individuals aged over 70 years who

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were at risk of falling were randomized to either a multifactorial intervention, which targeted identified falls risk factors, or to home visits from a social worker. Those in the multifactorial arm had an impressive reduction in the rate of falls over 3 months of follow-up (RaR 0.56; 95% CI 0.42–0.75). The largest reductions in falls were seen in those who were on greater than three medications, had difficulty with transfers and had poor balance, which suggests that a multidisciplinary approach is required.

The recent Cochrane review on falls intervention identified 19 RCTs ($n = 9503$) reporting the rate of falls. As ever, heterogeneity was a significant problem when performing the meta-analysis but the result demonstrated a significant reduction in falls (pooled RaR 0.76; 95% CI 0.67–0.86) but not in risk (pooled RR 0.93; 95% CI 0.86–1.02). The UK NICE guideline, the AGS and BGS Clinical Practice Guideline and the European Falls Prevention Network (Profane) all recommend a multifactorial intervention for fallers.

Specific circumstances

A full review of the following circumstances is beyond the scope of this article; however, given their clinical importance, results from several select studies are presented.

Parkinson's disease

In one of the first prospective falls studies in Parkinson's disease, the annual prevalence of falls was as high as 68%, with just over half of the cohort falling recurrently.[85] Fallers had significantly more severe symptoms and a poorer quality of life. Independent predictors of falling were previous falls (OR 4.0; 95% CI 1.3–12.1), loss of arm swing (4.3 (1.3–13.7)), longer disease duration (1.3 for each additional year (1.1–1.6)) and dementia (6.7 (1.1–42.5)). Perhaps surprisingly there were no significant differences noted in autonomic testing; in particular orthostatic hypotension was not significantly more prevalent in fallers.

A recent meta-analysis of physiotherapy intervention in Parkinson's disease failed to provide convincing evidence in support of physiotherapy in the prevention of falls.[86] Given the nature of Parkinson's disease it would seem likely that multifactoial intervention would be of benefit and include strength and balance training; the results of the REFINE-PD trial (Reduction of Falls IN the Elderly) are eagerly awaited.[87]

Stroke

Similar to Parkinson's disease, falls are very common in stroke survivors but prevention remains mostly un-investigated. In the first 6 months following discharge from hospital, 73% of patients fell in one UK-based cohort.[88] A meta-analysis of interventions to prevent falls following stroke was limited due to the low number of randomized trials. Analysis of two trials failed to support exercise as a preventive strategy (pooled RaR 1.22; 95% CI 0.76–1.98; pooled RR 0.77 (0.24–2.43)).[89] A RCT of early supportive discharge lasting an average of 14 weeks failed to demonstrate a reduction in falls compared with conventional rehabilitation on discharge at 6 months, 1 year and 5 years follow-up, at which time the proportion of fallers remained high in both groups (63 and 61% respectively, $P = 0.86$). Unfortunately, the methods of falls data collection is not well described and methodology may have tempered any possible promising results.[90–92]

Dementia

In a well-conducted prospective trial of falls in people with dementia, rates of falls were huge compared with controls (RaR 7.58; 95% CI 3.11–18.5).[93] The same trial, which recruited patients from an out-patient clinic, performed multifactorial falls assessments and identified the following as independent risk factors for falling: symptomatic orthostatic hypotension (HR 2.13; 95% CI 1.19–3.8), autonomic symptom score (HR per point 1.055; 95% CI 1.012–1.099) and Cornell depression score (HR per point; 1.053, 95% CI 1.01–1.099).

The first RCT of falls in people with dementia compared multifactorial assessment and intervention with conventional care for older people presenting to the Emergency Department because of a fall.[94] The multifactorial intervention was no more effective at reducing the rate of falls (relative risk ratio –0.02; 95% CI –0.32 to 0.09) or the risk of falls (RR 0.92; 95% CI 0.81–1.05). The joint AGS and BGS Clinical Practice Guideline states that there is insufficient evidence to recommend for or against the use of single or

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multifactorial intervention in the prevention of falls in older people with cognitive impairment.

In-patient hospital falls

Falls are very common in the in-patient setting; rates vary between 2 and 10% per patient per hospital stay, increasing to 46% on some rehabilitation wards.[88,95] Risk factors for falling in hospital include gait instability, cognitive impairment, urinary incontinence, a history of falls and being on 'culprit' medication.[96]

The effectiveness of intervention is contentious with conflicting outcomes. Meta-analyses are limited either by including poor quality studies to maximize numbers or by low numbers to uphold quality. As such, results of meta-analyses are equally as conflicting.

Vitamin D may be used to prevent falls if targeted to older females who have an extended hospital stay and are at risk.[97] Although there is little evidence to support falls prevention in the acute setting, use of 'volunteer companions' to sit with at risk individuals has been shown to reduce falls, but only while the volunteer is present.[98] In December 2012, The Cochrane Library published an updated review on falls prevention in hospitals and long-term care.[99] This highlighted the need for more conclusive evidence but suggests that multifactorial intervention reduces the rate of falls in hospitals (pooled RaR 0.69; 95% CI 0.49–0.96, 4 trials) but the results for long-term care were not as convincing. The Royal College of Physicians FallSafe project was a 2-year programme supporting nurses to deliver multifactorial assessments and interventions to older in-patients, using a defined care bundle. The programme resulted in greater numbers of assessments taking place and greater numbers of falls being reported. However, the effect on falls reduction is less clear due to methodological flaws but is estimated to be a 25% reduction.[100]

Cost-effectiveness

A mathematical model designed to extrapolate cost-effectiveness from existing falls literature identified psychotropic medication withdrawal and Tai chi as the cheapest effective interventions at reducing hip fracture. However, by incorporating the quality of evidence into the model, vitamin D supplementation and occupational therapy home modification were most cost-effective.[101] Even the cost benefits of a more expensive, effective intervention such as a community-based exercise programme far outweigh the costs of treating fall-related physical injury, including non-facture injury.[102]

Despite the evidence being in favour of the cost-effectiveness of falls prevention, they are likely to underplay their true effectiveness by focusing on hard outcome measures such as fracture-related costs, excluding the longer term costs of fear of falling and social isolation, for example.

Conclusions

Falls are extremely common and falls-related hospital admissions have increased dramatically in the past decade. Physical and psychological consequences are prevalent and may be disabling. Mortality is increased in people who fall but may be reduced in intervention programmes containing exercise strategies. Risk factors are numerous, complex and synergistic; they are ideally assessed in secondary care by a skilled multidisciplinary team.

Multifactorial intervention is more effective than single or multiple interventions, where risk factors are identified and targeted. The most effective multifactorial interventions usually include strength and balance exercise training, with adherence greatest if exercises are embedded into daily activity. Other effective components of a multidisciplinary intervention include home hazard assessment and intervention, specifically by an occupational therapist, and medication withdrawal.

High-quality evidence is still lacking in several areas due to methodological difficulties inherent in falls research, but with the development of gold standard definitions and data collection methods, the evidence base can be expected to improve in quality. Given the expected rise in the incidence of falls in the context of our changing population, it will be essential that this evidence is translated into clinical practice.

Conflicts of interest

J.D. is an investigator on the ongoing PreFIT study, described in this review.

J.F. has no conflicts to declare.

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