Effectiveness Bulletin

Preventing falls and subsequent injury in older people

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This paper is based on *Effective Health Care*, Vol 2, No 4 which is a systematic review of the evidence for the effectiveness of interventions to prevent falls and subsequent injury in older people.[1] The relevant literature was identified by a search of several computerised databases (Social Science Citation Index (BIDS), PSYCHLIT, EMBASE, RCN database, AMED, and UNCOVER), citation in identified papers and previous reviews, and contributions from peer reviewers and other experts in the field. Only randomised controlled trials evaluating the effectiveness of preventive interventions which measured the effect on falls, injuries related to falls, or change in a risk factor for falls were included.

Background

In 1991 in the United Kingdom about one in six people were over 65 years of age, and by 2021 this proportion is expected to be nearly one in five.[2] Accidents are a major health problem among older people[3,4] with falls, traffic accidents, and burns the main causes of accidental death.[5] Of these categories, falls are the leading cause of death from injury among people aged over 75[5] and over 85% of all fatal falls in the home in England and Wales are in people aged over 65.[6] About one third of the population over 65 years of age and more than half of the women over 85 years living at home (and a greater proportion of those in institutional settings) will fall at least once every year.[5,7,8] Reducing the death rate from accidents in people aged 65 and over by at least 33% by the year 2005 is a specific target in the United Kingdom Department of Health's strategy *Health of the Nation*.[4]

Identifying older people at risk

There are many epidemiological studies which have identified several potential risk factors for falls.[5,9–12] At present, however, there is no agreed and reliable set of risk factors for falls and subsequent injury, although it is widely recognised that the causes of falls are often multifactorial.[6] Some of the most often cited potential risk factors are nutritional status such as vitamin D and calcium deficiency; environmental hazards such as loose carpets in the home; prescribed medications; lack of exercise (associated with weak muscles and poor balance) and age related changes such as a deterioration in vision.

Effectiveness of interventions to reduce the risk of falling

EXERCISE

The question of whether short term exercise reduces falls in older people has been specifically considered in the frailties and injuries cooperative studies of intervention techniques (FICSIT) programme of randomised controlled trials in the United States.[13] Two of the trials[14,15] were carried out in nursing homes and five were community based and participants had to be at least 60 years of age.[16–20] Seven of the trials included an exercise component, for a duration of 10-24 weeks, which was sometimes combined with other interventions. Participants were followed up from two to four years after the intervention (table 1).

In a meta-analysis of these trials, participants who were assigned to exercise groups had an estimated 10% lower risk of falling than controls (adjusted fall incidence ratio (IR)=0.90; 95% confidence interval (95% CI) 0.81-0.99; P=0.04).[13] When the results from trials in which balance training was the only intervention, were pooled, a 25% reduction in the risk of falling was found (IR=0.75, P=0.01). In one trial of community dwellers of average age 75 those receiving Tai Chi classes (a balance exercise) had a 37% lower risk of falling than the control group (IR=0.63; 95% CI 0.44-0.89).[13]

Because the study participants were generally healthier and better educated than average it is not clear whether the results could be generalised to a typical older population.[21] One of the trials, for example, which evaluated balancing and resistance exercises in an unrepresentative healthy and well off group of older people found no effect of the intervention.[20]

Table 2 shows the results of other randomised controlled trials which have evaluated exercise only interventions in the prevention of falls.[22–24] In one study, where the aim

*Table 1 Exercise interventions of the FICSIT trials**

	Site 1 (Hornbrook et al 1993)[16]	*Site 2 (Tinetti et al 1994)*[17]	*Site 3 (Buchner et al 1993)*[18]	*Site 4 (Mulrow et al 1994)*[14]	*Site 5 (Wolf et al 1996)*[19]	*Site 6 (Fiatarone et al 1994)*[15]	*Site 8 (Wolfson et al 1993)*[20]
Number and age of participants	1323 participants aged at least 75, or 65 if they had fallen within the previous month	300 participants aged at least 70	100 participants aged 65-85	194 participants aged at least 60	180 participants aged at least 70	100 participants aged at least 70	120 participants aged at least 75
Exercise interventions	4 months of low level endurance followed by flexibility exercises	3 months of resistance, balance, and flexibility exercises	6 months of flexibility training plus resistance and/or endurance exercises	16 weeks of resistance, flexibility, and balance training	15 weeks of static balance training on a balance platform or dynamic exercise training using Tai Chi	10 weeks of resistance training	13 weeks of balance and resistance training

*All participants, except those at site 4 and 6, were living in the community. Some of the interventions were combined with other non-exercise interventions (sites 1, 2, and 6).

was to improve lower extremity muscle strength, the rate of falls was found to be higher (although not significantly) in groups receiving low intensity exercise.[22] In another study no significant effect on falls was detected overall, although there was a significant drop in falls due to loss of balance.[24] In a third study balance training was found to reduce the rate of falls in platform sensory tests.[23]

Thirteen randomised controlled trials were identified which evaluated the modifying effect of exercise interventions on potential risk

Table 2 Summary of (non-FICSIT) randomised controlled trials of exercise interventions where falls or injuries related to falls are measured

Author, country, and objectives	*Population, setting, and intervention*	*Design*	*Key result*	*Commentary*
Hu and Woollacot (1994)[23]	Older healthy people age 65-90 living in the community	Method of randomisation: not stated	The I group showed significant improvement in stability in 5 of the 8 conditions (P<0.006) and fell less often during platform sensory tests and stood longer on one leg than the C group (P<0.001)	The I group experienced a greater number of falls in the platform sensory tests at baseline which was adjusted for in the analysis
USA To determine the effects of 10 hour standing balance training on balance ability in a group of healthy older people	Setting: research centre I: a 10 hour training programme over a 15 day period delivered by a physical trainer (n = 12) C: no intervention (n = 12)	Follow up: 4 weeks	Dropouts: I = 17%, C = 17%	Dropouts were not included in any of the analyses
Lord *et al* (1995)[24]	Women aged 60 to 85 years, living independently in one community	Method of randomisation: not stated	The I group showed improved performance in all 5 strength measures, reaction time, neuro-muscular control, and body sway (P<0.05, P<0.01))	Slight differences in reported medical conditions, falls, instability, drug use, and inactivity between C and I groups at baseline
Australia To determine whether a 12 month programme of regular exercise can improve balance, reaction time, neuro-muscular control, and muscle strength and reduce the rate of falling in older women	I: a 1 hour exercise session, twice weekly for 10 to 12 week terms, run by exercise trainers (n = 100) C: no intervention (n = 97)	Follow up: 12 months	There were no significant differences between the I and C groups in the percentage of falls. However, the groups differed in types of falls (balance fall 5% *v* 17% for I and C groups, respectively). Average attendance was 73% Dropouts: I = 25% C = 22%	Dropouts not included in any of the analyses
Reinsch *et al* (1992)[22]	Adults aged 60 years and over in senior centres	Method of randomisation: not stated	The rate of at least one fall was 25% in the E group, 19% in the CB group, 37% in the EC group, and 19% in the C group	The 2 groups (E) (EC) involved in exercise had the highest rates of falling
North America To assess the effectiveness of exercise and cognitive behavioural programmes in reducing falls and injuries and improving balance and strength in older people	Exercise (E): low intensity programme to prevent falls (n = 4 centres, 57 people) Cognitive behavioural (CB): health and safety education to prevent falls and relaxation training (n = 4 centres, 51 people) Exercise and cognitive behavioural (EC): combined programme of exercise, relaxation, and discussion (n = 4 centres, 72 people) C: discussion of health related topics (n = 4 centres, 50 people)	Randomised by senior centre Follow up: 1 year	There were no significant differences in the levels of injuries or on measures of balance and strength Dropouts: E = 23%, CB = 27%, EC = 15%, C = 16%	Intention to treat analysis used

factors for falling. Seven studies showed a decrease in risk factors for falls with exercise,[25-31] four showed no significant effect other than improvements in strength,[32-35] one showed an improvement in flexibility,[36] and one reported a deterioration in postural sway with exercise.[37]

Overall, despite the variable quality of these studies, their results together with the results from the FICSIT trials provide reasonable evidence to suggest that exercise may help reduce the risk of falls and some risk factors for falls. Those interventions which use balancing exercise, strength training, and low impact aerobic exercise may be the most effective.

COST AND BENEFITS OF EXERCISE

An increase in physical activity is likely to have other benefits for older people. A meta-analysis has shown that exercise can reduce the risk of coronary heart disease.[38] A recent review of the healthcare costs and benefits of exercise reported that in people over 45 years of age, exercise results in savings in the cost of health care by reducing in morbidity from coronary heart disease, falls, etc.[39] However, the type of exercise must be appropriate to the level of health and fitness of the person. A recent review of trials evaluating the effectiveness of methods to promote exercise in community based adults (of which some studies were in people over 55 years of age) concluded that it is possible to both increase and maintain levels of activity. This is best achieved when exercise is of moderate intensity, can be performed either alone or with others, is enjoyable and convenient, and can be completed in three sessions a week. Professional support or interaction with a healthcare professional seems to be important in promoting exercise and adherence.[40]

HOME ASSESSMENTS AND SURVEILLANCE

Table 3 shows the results of randomised controlled trials which have evaluated home assessment and surveillance interventions.[17 41-48] All studies involved visiting older people at home, assessment of the safety of the home environment, followed by a range of interventions such as safety checks and necessary modifications, referral to care, and recommendations for exercise. All these studies took place in North America except for one in the United Kingdom.[43]

In one study, which included over 2000 people, it was found that participants who were offered a home intervention to remove and repair safety hazards showed a reduction in falls compared with controls.[47] Similarly, in a study in which the intervention involved trained volunteers visiting older people at home, one third of the number of falls were reported compared with controls.[42] A multifactorial intervention with home visits from nurses was also associated with a reduced number of falls in the first year of follow up.[48] However, this effect was not sustained at two years, suggesting that the effects may be lost if the intervention is discontinued. In another multifactorial intervention in which nurses and physiotherapists were responsible for implementation, interventions were tailored to individual risk factors such as multiple drug use, use of sedatives or hypnotics, postural hypotension, etc. The rate of reported falls was reduced by 21%.[17] The two other large trials did not find any effect of home assessment on the rate of falls.[41 43]

Effectiveness of interventions to reduce injury from falls

DIETARY INTERVENTIONS

Reduced concentrations of vitamin D are associated with increased bone loss, an important risk factor for bone fractures, especially in older women. Vitamin D is one of several agents which can reduce bone loss in healthy postmenopausal women, particularly in the winter[49] and may therefore reduce the risk of fractures in those who fall.

A recent Cochrane Collaboration systematic review[50] found two large randomised controlled trials which assessed the effect of oral vitamin D and calcium supplements on frail women in nursing homes[51] and oral vitamin D alone.[52] Vitamin D given with calcium in doses between a quarter to a third higher than the current United Kingdom recommended daily allowances seemed to reduce the number of people who had one or more fractures by 20% over a three year period ($P<0.02$).[51] However, when given in lower doses, vitamin D by itself did not show a protective effect.[52] The only trial to evaluate vitamin D given as an annual injection reported a significant drop in the fracture rate.[53] However, this study was not properly randomised, but points to the need for replication in a better trial. The review also showed that dietary calcium supplement alone may be effective in reducing symptomatic fractures (OR = 0.37; 95%CI 0.4 -0.97).[50]

This review shows that there is potential to prevent fractures in older people with vitamin D, or calcium, or both. One possible way to implement this intervention would be to promote exposure to sunlight and increased consumption of dairy products. However, dietary supplements in older people at high risk of fractures may be a more effective option.[54]

HIP PROTECTORS

A Danish randomised controlled trial evaluated the use of external hip protector pads to prevent injury from falls in people in residential nursing homes aged 69 years and over (table 4). The risk of a hip fracture in those wearing hip pads was more than halved (age adjusted risk ratio (RR) = 0.4; 95% CI 0.18 - 0.82).[55] No fractures occurred in anyone wearing the pads at the time of a fall. Although, this seems a promising intervention in those at high risk of a fall the extent to which protection pads are generally acceptable and would be worn by older people living in the community is unclear. One of the FICSIT trials is designed to explore the acceptability of hip protectors in community and residential settings.[56]

Table 3 Summary of randomised controlled trials of home assessment and surveillance interventions measuring falls, injuries related to falls or potential risk factors for falls

Author, country, and objectives	*Population, setting, and intervention*	*Design*	*Key result*	*Commentary*
Carpenter and Demopoulos (1990)[42]	Adults aged 75 and over from 2 general practices	Method of randomisation: women allocated by random number tables, husbands allocated to same group, remaining men allocated by random number tables	94 people received interventions initiated as a result of the project	There were differences in baseline disability scores between groups. Initial disability was not adjusted for in the analysis
UK	I: volunteers visited participants, completed activity of daily living questionnaires and revisited at regular intervals. Those with an increase >5 in their activity of daily living score were referred to their GP (n = 272)	Follow up: 3 years	36 falls in C group *v* 12 falls in I group (P<0.05)	No information provided about the sorts of interventions that were initiated by GPs
To test the benefits of regular surveillance of older people at home over a 3 year period	C: subjects were visited at the beginning and end of the study (n = 267)		90% (of those completing a questionnaire) wished to continue with the scheme Dropouts: I = 34% C = 31%	Intention to treat analysis used
El-Faizey and Reinsch (1994)[46]	Adults over 60 years of age living in the community who were members of a senior centre	Method of randomisation: not stated	No significant differences in the implementation of home safety changes between the I and the C groups	This was a very small study in which the groups were self selected from a much larger randomised controlled trial of exercise and a cognitive behavioural intervention
North America	Setting: home	Randomised by senior centre and participants were volunteers	In the I group 8 participants fell (38% of falls due to home hazards) and in the C group 4 participants fell (20% of falls due to home hazards)	
A preliminary study to evaluate compliance with recommended safety changes in the home and its effect on falls in older adults	I: home safety assessments and education about safety and home modifications carried out by researchers (n = 2 centres, 14 people) C: home visits, no safety information (n = 1 centre, 14 people)	Follow up: 6 months	No dropouts	
Fabacher *et al* (1994)[45]	Community living adults aged 70 years and over	Method of randomisation: randomly generated assignement cards in sealed envelopes	Gait and balance were the most common disorders identified from screening (22%)	The I group differed significantly in age (P<0.05) and level of education (P<0.05) from the C group at baseline
North America	I: a home visit by a physician's assistant or nurse to screen for medical, functional, and psychosocial problems and follow up visits every 4 months for 1 year (n = 131)	Follow up: 1 year	20 out of 28 recommendations made to modify the home to reduce the risk of falls were followed up	Dropouts were not included in the analyses
To evaluate the effectiveness of assessments of geriatric patients in a home as a means of providing preventive health care and improving health and functional status in older adults	C: telephone interviews every 4 months to collect outcome data (n = 123)		No significant difference in self reported fall rates between groups, although there was a trend for the I group to have fewer falls during the follow up year (14% *v* 23%) Dropouts: I = 24% C = 23%	
Hornbrook *et al* (1994)[47]	Adults living in the community aged 65 years and over	Method of randomisation: not stated	There were 1730 falls in the I group and 2084 in the C group	The effect was strongest for men aged 75 years and above
North America	Both groups had home assessment, and falls safety hazards were recorded	Randomised by household	Participating in the intervention reduced the odds (OR 0.85) of being a faller relative to the C group (P<0.05)	Dropouts were not included in the analyses
To evaluate the impact of a programme to prevent moderate intensity falls in older adults	I: participants encouraged to remove or repair safety hazards. Didactic approach (4 weekly, 90 minute group meetings) to dealing with falls and falls prevention and a group exercise component (n = 1271 households, 1611 people)	Follow up: 2 years	No statistically significant effect on the probability of medical care falls	
	C: minimal treatment; no repair advice or group sessions (n = 1238 households, 1571 people)		61% attended 3 or more group meetings Dropouts: I = 10% C = no information given	
Ploeg *et al* (1994)[44]	Adults aged 65 years and over living in the community (mean = 77 years)	Method of randomisation: not stated	Both groups made safety changes (69% of which were to prevent falls) with a slightly higher proportion of people making changes in the safety promotion group (22% *v* 18%)	Groups were not compared at baseline — measure only after intervention
Canada	Setting: home	Follow up: 3 months	Changes included installing grab bars and use of a cane	Blinded assessment was carried out; with research assistants obtaining data over the telephone, blinded to the intervention groups

	Safety promotion: during home visits a public health nurse used a checklist to discuss personal, home, and community safety; and suggest strategies to improve safety (n = 148)			
To evaluate the effectiveness of 2 health promotion programmes (safety promotion or influenza vaccination) with older people	Influenza vaccination: home visit by a public health nurse to discuss influenza vaccination (n = 211)		Drop outs: safety promotion = 3% influenza vaccination = 7%	Dropouts were not included in the analyses
Rubenstein *et al* (1990)[41]	Ambulatory patients (mean = 87) in long term residential care	Method of randomisation: computer generated, randomly sequenced cards in sealed envelopes	41% of I group received all recommended interventions (treatment of active problems, minimising potential risks, correcting hazardous environments)	The I group had significantly more medical problems (P<0.05) and was taking more antibiotic medication (P<0.01) than the C group at baseline
North America	I: assessment after a fall included a physical examination and environmental assessment by a nurse practitioner, coupled with referrals for specific treatment and preventive interventions (n = 79)	Follow up: 2 years	No significant differences in falls	
To measure the effects of a specialised assessment after a fall to detect causes and underlying risk factors for falls and to recommend preventive and therapeutic interventions in older adults in residential care	C: usual care (n = 81)		No dropouts	
Tinetti *et al* (1994)[17]	Adults aged 70 and above living in the community with at least 1 risk factor for falling	Method of randomisation: not stated	35% of the I group had fallen at 1 year of follow up compared with 47% of the C group (P=0.04)	The cost of the intervention was $891 per person, the cost per fall prevented was $1947 and the cost for preventing 1 fall requiring medical care was $12392
North America	Setting: subject's homes	Physicians were randomised and participants were assigned to the same group as their physician	A significant reduction in risk factors at reassessment in the I group: medications (63 *v* 86%), balance impairment (21% *v* 46%), gait impairment (45% *v* 62%) and impairment in toilet transfer skills (49% *v* 65%)	Blinded assessment was carried out
To assess the effectiveness of a multifactorial targeted risk-abatement strategy in reducing the risk of falls in older people	I: a nurse practitioner assessed participants' risk factors and targeted interventions accordingly; a physical therapist gave home exercise routines (balance and strengthening programmes) (n =153) C: usual health care plus social visits (n = 148)	Follow up: 1 year	Dropouts: I = 4% C = 3%	I group had more impairement of leg strength than C group at baseline
Vetter *et al* (1992)[43]	Adults living in the community aged 70 years and over	Method of randomisation: random number tables using participants' study numbers and without direct contact with participants	The rate of falls (with fractures) was 5% in the I group and 4% in the C group	There was more disability in the C group than in the I group at baseline
UK	I: assessment and correction of nutritional deficiencies and environmental hazards in the home, assessment and referral of medical conditions, assessment and improvement of fitness carried out by health visitors (n = 350)	Randomised by household	The rate of falls was 23% in the I group and 16% in the C group	Increase in falls in I group compared with C group is most significant in those with no initial disability
To assess whether a targeted intervention including assessment and correction of hazards in the home and assessment and improvement in fitness could reduce the incidence of fractures in older people	C: visited at the beginning and the end of the study (n = 324)	Follow up: 4 years	Dropouts: 33% (over both groups)	Intention to treat analysis used
Wagner *et al* (1994)[48]	Enrollees of a health mainteanace organisation aged 65 years and over (mean = 73 years)	Method of randomisation: not stated	Significant differences were found between I1 and C in percentage falls at 1 year (28% *v* 37%) but not at 2 years (31% *v* 29%) respectively	Dropouts were not included in the analyses
North America	Setting: health centre	Follow up: 2 years	Significant differences found between I1 and C in percentage of injurious falls (10% *v* 15%) at year 1 but not at year 2 (13% *v* 10%) respectively	
To test whether a multicomponent intervention programme could prevent falls and disability in older adults	I1: nurse assessment visit, and follow up targeted interventions (no active interventions during year 2) (n = 635) I2: general health promotion, nurse visit (n = 317) C: usual care (n = 607)		Dropouts: 3% overall	

Table 4 Summary of randomised controlled trials of hip protector pads to reduce injury from falls

Author, country, and objectives	*Population, setting, and intervention*	*Design*	*Key result*	*Commentary*
Lauritzen *et al* (1993)[55]	Residents of a nursing home aged 69 years and over	Method of randomisation: a ward was selected when its number was drawn by an independent doctor	In the I group there were 8 hip and 15 non-hip fractures. In the C group there were 31 hip and 27 non-hip fractures	The risk of hip fracture in the I group was reduced by 53% and 9 hip fractures were estimated to have been avoided
Denmark	I: an external hip protector was worn to divert a direct impact away from the greater trochanter during falls. The protector was fixed in special underwear (n = 10 wards, 247 people)	Randomised by ward	People in the I group with fractures were not wearing hip protectors at the time of fracture	
To investigate the effect of external hip protectors on the prevention of fractures in older residents of nursing homes	C: usual care (n = 18 wards, 418 people)	Follow up: 11 months	The relative risk of hip fracture in the I group (adjusted for skewness in age) was 0.41 (95%CI 0.18 to 0.82) Dropouts: not stated	

Conclusions

Balancing, low impact aerobics, and muscle strengthening exercise may reduce the rate of falls in older people with reasonable levels of fitness. Research is needed to identify the most cost effective exercise programmes which could, for example, explore ways of promoting uptake and long term adherence, and evaluate the relative advantage of different types of exercise.

Home visiting to identify and remedy environmental and personal risks of falling may also reduce the risk of falling. The changes could include removal of throw rugs and objects in pathways, and the installation of improved night lights and bath non-skid mats. These changes could be carried out by health visitors, nurses, occupational therapists, or trained volunteers. Further research on applying this in the United Kingdom is needed.

High dose vitamin D supplements with or without calcium seem to be effective in reducing risk of fracture, although major trials to assess the cost effectiveness of vitamin D and calcium supplements are needed. In particular, the potential value of an annual vitamin D injection should be explored.

The use of hip pad protectors for people in institutional care who are at high risk of falling may significantly reduce the rate of injury due to falls. Their acceptability in other settings needs to be evaluated.

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