Interventions for the prevention of falls in older adults: systematic review and meta-analysis of randomised clinical trials

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Abstract

Objective To assess the relative effectiveness of interventions to prevent falls in older adults to either a usual care group or control group.
Design Systematic review and meta-analyses.
Data sources Medline, HealthSTAR, Embase, the Cochrane Library, other health related databases, and the reference lists from review articles and systematic reviews.
Data extraction Components of falls intervention: multifactorial falls risk assessment with management programme, exercise, environmental modifications, or education.
Results 40 trials were identified. A random effects analysis combining trials with risk ratio data showed a reduction in the risk of falling (risk ratio 0.88, 95% confidence interval 0.82 to 0.95), whereas combining trials with incidence rate data showed a reduction in the monthly rate of falling (incidence rate ratio 0.80, 0.72 to 0.88). The effect of individual components was assessed by meta-regression. A multifactorial falls risk assessment and management programme was the most effective component on risk of falling (0.82, 0.72 to 0.94, number needed to treat 11) and monthly fall rate (0.63, 0.49 to 0.83; 11.8 fewer falls in treatment group per 100 patients per month). Exercise interventions also had a beneficial effect on the risk of falling (0.86, 0.75 to 0.99, number needed to treat 16) and monthly fall rate (0.86, 0.73 to 1.01; 2.7).
Conclusions Interventions to prevent falls in older adults are effective in reducing both the risk of falling and the monthly rate of falling. The most effective intervention was a multifactorial falls risk assessment and management programme. Exercise programmes were also effective in reducing the risk of falling.

Introduction

In the United States one in three people aged 65 or more living in the community fall at least once a year. This increases to one in two for those over 80 years.[1–3] The reduction in mobility and independence after a fall are often serious enough to result in admission to hospital or a nursing home or even premature death.[4 5] To identify effective interventions and their relative effectiveness in preventing falls in older adults, we conducted a meta-analysis of relevant randomised controlled trials. This approach builds on earlier work, where beneficial interventions are identified by using separate estimates of absolute effectiveness in different study strata.[6] Our strategy provides additional insight by applying a global multivariate model, allowing for assessment of the relative effectiveness of each intervention component while controlling for the effect of other components in multifactorial interventions across all studies.

Methods

We selected four categories of intervention programmes to prevent falls.

Multifactorial falls risk assessment and management programme—This was defined as a focused post-fall assessment or systematic risk factor screening among individuals at risk tied to intervention recommendations and follow up. Review of drugs was an important component of nearly all the programmes.

Exercise programmes—These included both general and specific physical activities. Examples of general activity included walking, cycling, and aerobic movements. Specific activity included training targeted towards balance, gait, and strength.

Environmental modification programmes—These often included a home visit to check for environmental hazards such as poor lighting, recommendations of modifications, and sometimes assistance with their implementation.

Educational interventions—These targeted individuals, groups, or communities, and could vary from pamphlets and posters at senior centres and nursing homes to more intensive interventions such as one to one counselling about risk factors.

To identify relevant literature, we checked the reference lists from 82 reviews and reference lists from

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experts, associations, and societies. We also searched the Cochrane Library, Medline, Ageline, Embase, CINAHL, and PsycINFO databases (see bmj.com for details and search terms).

Data collection

JTC and WAM independently reviewed the articles and extracted general information. Detailed information was extracted only from studies that met the major inclusion criteria: focus on falls prevention, data on participants aged 60 or more, randomised controlled trial, and inclusion of a usual care or control group. Data were collected on study design, and study quality was assessed with the Jadad score.[7 8] Each study could contain one or more intervention groups, and each intervention consisted of one or more components. Disagreements were resolved by consensus.

Each study intervention was classified independently by LZR (for content) and by PGS (for methods) as including up to two of the four intervention components under study. If more than two components were described, each investigator chose the two judged to contribute most to the effectiveness of the intervention.

Statistical analyses

We considered two outcomes: falling at least once during a specified follow up period and the monthly rate of falling. Our first analysis included studies that provided the number of patients in each group (intervention, control, or usual care) who fell at least once during follow up of six to 18 months. A risk ratio was estimated for most of the studies that compared an intervention group with a usual care or control group. For the few studies that contained more than one intervention group, we estimated multiple risk ratios, one for each intervention compared with the common usual care or control group, and performed a sensitivity analysis to assess the impact of correlation among these ratios. We estimated the DerSimonian and Laird random effects pooled log risk ratio of all studies, conducted a χ^2 test of heterogeneity, and calculated the I^2 statistic and its 95% uncertainty interval; this was also done for the second analysis of incidence rate ratios. We also adjusted for the heterogeneity across interventions and performed an exploratory analysis to determine the relative effectiveness of the components of the multifactorial falls risk assessment.

Our second analysis included studies that provided data on the total number of falls and the average follow up period in each group. For each group we calculated the monthly incidence rate of falling and the incidence rate ratio for each comparison between an intervention group and usual care or control group. The same modelling approach was applied as that used for the outcome of falling at least once.

For the statistically significant adjusted risk ratios, we calculated the number needed to treat or number needed to harm. Publication bias was assessed using funnel plots, an adjusted rank correlation test, and a regression asymmetry test. To assess the robustness of our findings, we also undertook several sensitivity analyses. See bmj.com for full statistical and sensitivity analyses.

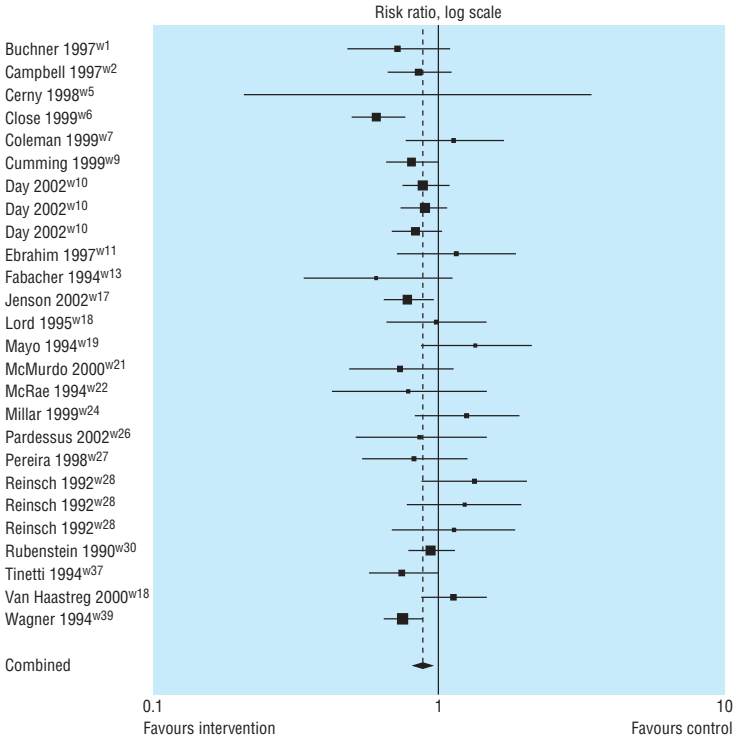

Fig 1 Pooled risk ratio of participants who fell at least once

Results

Ninety nine of 830 articles met the inclusion criteria for detailed data abstraction. After exclusions, 40 trials contributed data to the meta-analyses (see bmj.com).

Data for the meta-analysis of participants who fell at least once came from 26 intervention groups in 22 studies. The combined data found a significant reduction in the risk of falling (risk ratio 0.88, 95% confidence interval 0.82 to 0.95; $P=0.03$; $I^2=31\%$, 95% uncertainty interval, 0% to 61%; fig 1). Data for the meta-analysis on monthly rate of falling came from 30 intervention groups in 27 studies. The combined data showed a significant reduction in the monthly rate of falling (incidence rate ratio 0.80, 0.72 to 0.88; $P<0.001$; $I^2=81\%$, 74% to 86%; fig 2).

None of the studies directly assessed the relative effectiveness of intervention components. We therefore compared the magnitude of the effect of each of the components to a control group that received usual care. We entered all studies in the meta-regression model that assessed the effect of individual components while controlling for other components (table). A multifactorial falls risk assessment and management programme had a statistically significant beneficial effect on both risk of falling and monthly rate of falling. The two models fit relatively well, explaining 29% and 16% of the variance, respectively. The most commonly assessed risks were drugs, vision, environmental hazards, and orthostatic blood pressure. Exercise was an intervention in the largest number of studies. This also had a statistically significant beneficial effect on the risk of falls, but on monthly rate of falling did not reach conventional statistical significance. Environmental modification and education were primary

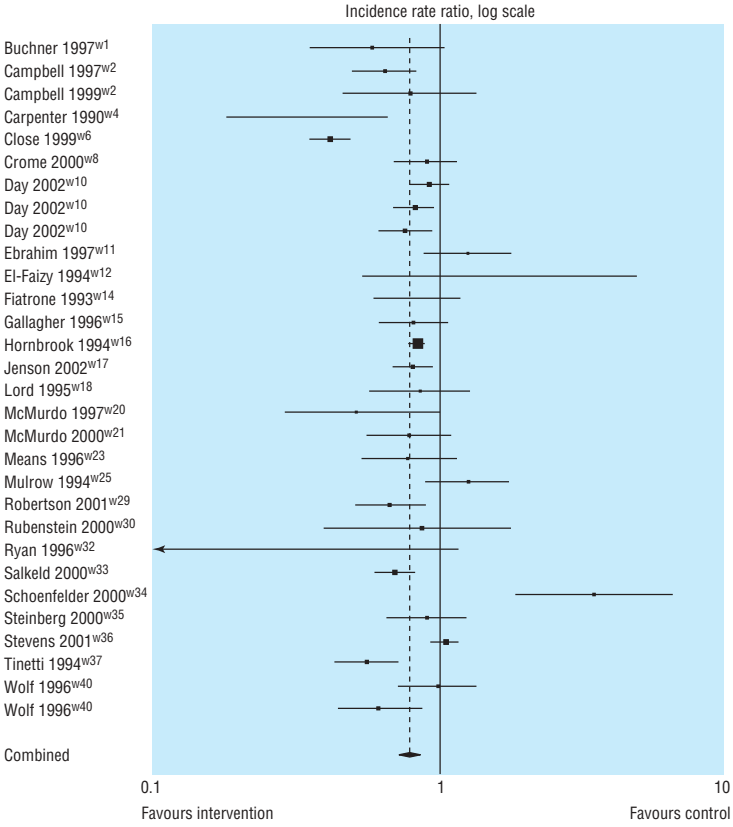

Fig 2 Pooled incidence rate ratio of monthly rate of falling

components of a few studies, and the pooled estimates were not statistically significant.

We were not able to detect statistically significant differences or consistent trends in the efficacy between different types of exercises. Colinearity between balance and both flexibility and strength was problematic. We observed some trends in the relative effectiveness of the major components of a multifactorial falls risk assessment and management programme, but there was little difference between the most or least effective.

We attempted to see if the greater effectiveness of the multifactorial falls risk assessment and management programme was due to the preferential enrolment of people at higher risk. However we found no significant differences in effectiveness of the interventions by population studied.

The funnel plots showed no evidence of publication bias. Although the adjusted rank correlation test also showed no evidence of publication bias, the regression asymmetry test did indicate some evidence for the falling at least once outcome. None of the sensitivity analyses significantly changed the estimates of the meta-regression models, nor did the additional meta-regression models yield contrary conclusions.

Discussion

Interventions to prevent falls significantly reduce the proportion of older people who fall at least once and the monthly rate of falling. Our review found a multifactorial falls risk assessment and management programme to be the most effective at reducing falls. Exercise was also effective, but we found no clear evidence for the effectiveness of environmental modification or education programmes.

Our results for exercise need to be put into the context with those from the FICSIT trials (Frailty and Injuries: Cooperative Studies of Intervention Techniques) a preplanned meta-analysis of randomised controlled trials.[9] Our results on exercise agree with those of the central FICSIT meta-analysis, that exercise programmes help prevent falls, with no differences between types of exercise.

Study limitations

Our efforts to locate original studies and advances in analytic capabilities allowed us to include more studies in our meta-analyses than in recent attempts.[6 10] We were thus able to explore the relative effectiveness of intervention components. As none of the studies compared interventions directly, we used indirect methods to assess the relative effectiveness of the individual components. Although this is not as powerful as direct comparisons, the validity of our findings are strengthened by the convergence of results from two clinically important outcomes. Better measures are needed to assess the quality of trials of complex interventions. There remains little consensus about what quality assessment criteria matter most.[11] We examined post hoc the impact of study quality, and our findings were not changed by stratifying studies based on quality. We also acknowledge that the outcome of monthly rate of falling is susceptible to correlation within patients, with one individual potentially contributing a larger number of falls than another. Falls within an individual are correlated and should not be treated as independent. Unfortunately the studies did not provide adequate infor-

Meta-regression estimates of effect of individual intervention components controlling for other intervention components

	Participants who fell at least once*			Monthly rate of falling†		
Treatment component	No of studies (comparison pairs)	Adjusted risk ratio (95% CI)	Number needed to treat	No of studies (comparison pairs)	Adjusted incidence rate ratio (95% CI)	Fewer falls in treatment group‡
Multifactorial falls risk assessment and management programme	10 (10)	0.82 (0.72 to 0.94)	11	7 (7)	0.63 (0.49 to 0.83)	11.8
Exercise	13 (15)	0.86 (0.75 to 0.99)	16	19 (21)	0.86 (0.73 to 1.01)	2.7
Environmental modifications	5 (4)	0.90 (0.77 to 1.05)	NA	5 (6)	0.85 (0.65 to 1.11)	NA
Education	2 (3)	1.28 (0.95 to 1.72)	NA	1 (1)	0.33 (0.09 to 1.30)	NA

NA=not applicable.
*R^2=0.29.
†R^2=0.16.
‡Per 100 patients a month.

What is already known on this topic

Many interventions have been developed to prevent falls

Systematic reviews have reached conclusions on the absolute effectiveness of individual components of these interventions

The relative effectiveness of different approaches to prevent falls is not known

What this study adds

Among current randomised clinical trials, a multifactorial falls risk assessment and management programme was the most effective component of a falls prevention programme

The next most effective component was exercise

mation to allow us to adjust for this correlation. The rate of falling, however, remains important, and by examining both the risk and the rate of falling we were able to conduct a more thorough analysis.

Since the completion of our analysis, there have been six additional randomised controlled trials of falls intervention programmes with falls outcomes. Two included a multifactorial falls risk assessment and management programme but focused on participants with cognitive impairment. Both found that the intervention was not effective in older adults with significant cognitive impairment.[12 13] Three studies included exercise as an intervention; two were effective.[14–16] One study focused on an environmental modification component and reported a significant reduction in the rate of falls, particularly in a subgroup of frequent fallers.[17]

Our results indicate a two pronged approach to falls prevention. Implementing a multifactorial falls risk assessment and management programme would be most feasible by targeting selected people, such as those with a history of falls. Exercise programmes, however, could feasibly be implemented to a general population of older adults.

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