Rethinking individual and community fall prevention strategies: a meta-regression comparing single and multifactorial interventions

A. John Campbell, M. Clare Robertson

部artment of Medical and Surgical Sciences, University of Otago Medical School, Dunedin, New Zealand

Address correspondence to: A. John Campbell. Email: john.campbell@stonebow.otago.ac.nz

Abstract

Background guidelines recommend that fall prevention programmes for older people include multifactorial interventions.

Objective we aimed to determine if randomised controlled trial evidence supports interventions with multiple components over single strategies in community based fall prevention.

Methods we searched the literature for trials of interventions aimed at preventing falls. We included trials if they met the following criteria: (i) participants were randomly allocated to intervention and control groups, (ii) all participants were aged 65 years or older, (iii) the majority lived independently in the community, (iv) fall events were recorded prospectively using a diary or calendar during the entire trial and monitored at least monthly, (v) follow up was for 12 months or longer, (vi) at least 70% of participants completed the trial, (vii) all falls during the trial for at least 50 participants were included in the analysis, and (viii) a relative rate ratio with 95% CI comparing the number of falls in the intervention and control groups was reported. We calculated a pooled rate ratio separately for trials testing multifactorial and single interventions and compared their overall efficacy using meta-regression.

Results meta-regression showed that single interventions were as effective in reducing falls as interventions with multiple components (pooled rate ratios 0.77, 95% CI 0.67–0.89 and 0.78, 0.68–0.89 respectively).

Conclusion multifactorial fall prevention interventions are effective for individual patients. However, for community programmes for populations at risk, targeted single interventions are as effective as multifactorial interventions, may be more acceptable and cost effective.

Keywords: accidental falls, elderly, meta-analysis, randomised controlled trials, public health

Introduction

Half of those 80 years and over, will fall sometime in any 1 year [1, 2] and 27% of all hospital costs for this population will result from these falls [3]. The falls put older people at risk of injury, loss of independence, rest home admission and death. Over the last 10 years a number of successful fall prevention trials using a variety of interventions have been published and, as a consequence, there has been international interest and investment in fall prevention programmes. To have any noticeable effect on such a common problem as falls, community programmes need to be proven to be effective, acceptable to participants and affordable within limited public health budgets. Most importantly, they need to be available to a high proportion of the population at risk.

Current guidelines support multi-component fall prevention programmes [4, 5]. On the surface, such an approach seems entirely logical. Most falls result from multiple risk factors and the early multifactorial intervention trials were successful [6]. However, it has not yet been demonstrated that multiple or multifactorial interventions prevent more falls than single, targeted interventions. The assumption that
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more components are necessarily better may have arisen from a failure to distinguish between fall prevention for an individual patient and community fall prevention for populations at risk.

Fall prevention requires two approaches: (i) services for individual patients referred for specialist management, and (ii) community programmes directed at populations of elderly people living in the community and at risk of falling. The services for individual patients are based on comprehensive patient assessment and diagnosis and are staff and resource intensive. A multi-disciplinary team provides treatment. On the other hand, community or public health programmes need to be less individually expensive and staff intensive in order to reach more people at risk. They are commonly based on a simple assessment, delivered by a single health professional working according to a protocol and suitable for widespread dissemination.

Although there is trial evidence to support a full assessment, and multifactorial interventions for individual patients [7] there is no direct trial evidence that multiple or multifactorial interventions are more effective than targeted single interventions for community populations at risk. However, there is trial evidence that two interventions used concurrently are less effective in reducing falls than the interventions used singly. In a recently completed trial of two interventions we showed that the effective intervention prevented more falls when delivered singly than in combination [8].

Multifactorial intervention community programmes, especially if delivered by a multi-disciplinary team, are likely to be more costly than single interventions [9, 10]. The additional cost of multifactorial interventions could only be justified if they prevented more falls than single intervention programmes.

To determine if multi-component interventions are more effective than single interventions we have reviewed all community based fall prevention randomised controlled trials and conducted a meta-regression of those trials where the analysis and reporting of data made the comparison of all falls possible [11].

Methods

This study was part of an ongoing research programme, so that literature searches were made at multiple time points until December 2006. We searched the Cochrane Bone, Joint and Muscle Trauma Group register, Cochrane Controlled Trials Register, MEDLINE, EMBASE, CINAHL, and reference lists of identified articles (including systematic reviews and meta-analyses) for trials of interventions aimed at preventing falls. The search strategy was developed and used during a systematic review of interventions to prevent falls in elderly people for the Cochrane Library [12]. Resources allowed review of articles in English only.

Trials were included in our meta-analyses if they met the following criteria: (i) participants were randomly allocated to intervention and control groups, (ii) all participants were aged 65 years or older, (iii) the majority lived independently in the community, (iv) fall events were recorded prospectively using a diary or calendar during the entire trial and monitored at least monthly, (v) follow up was for 12 months or longer, (vi) at least 70% of participants completed the trial, (vii) all falls during the trial for at least 50 participants were included in the analysis, and (viii) a relative rate ratio with 95% CI comparing the number of falls in the intervention and control groups was reported [13–16].

The quality of the methodology used in each trial was assessed by two reviewers independently using a predetermined scoring system [12]. Reviewers were not blinded to author and source institutions and authors did not review their own studies. Disagreement was resolved by consensus or third party adjudication.

We grouped the studies into two categories according to the intervention being tested — (i) multi-component interventions and (ii) interventions addressing one category of fall risk factor only (for example, exercise programme, home safety programme). We used Stata 8.0 to calculate a pooled rate ratio separately for the multi-component and single factor interventions. We tested for heterogeneity between the studies using the chi-squared test and the I² statistic (which was greater than 50% in all cases for fixed effect models). Consequently, we used random effect models. We compared the two pooled rate ratios by introducing a variable indicating whether the intervention was single factor or had multiple components into a meta-regression model of all the trials [17].

We carried out a sensitivity analysis by widening the three following selection criteria items and repeating the analyses: (i) all participants were aged 60 years or older or mean age ≥70 years, (ii) fall events were recorded prospectively using a diary or calendar during the entire trial (frequency of monitoring not restricted), and (iii) follow up was for 6 months or longer.

Results

We identified 90 trials in community living older people and 32 in institutions and hospitals. From the community trials, 14 trials (5,968 participants, with 3,991 (67%) being women) met our initial criteria (Appendix Table 1 on the journal website http://www.ageing.oxfordjournals.org/). In five trials, each participant in the intervention groups received an individual combination of interventions addressing more than one major risk factor [6, 18–21], and in nine trials, each intervention addressed only one particular category of risk [8, 10, 22–28]. In one trial with a two-by-two factorial design, two single interventions were tested [8], and in one trial, two multifactorial interventions were each compared with the control [21]. The quality assessment scores are available in Appendix Table 2 on the journal website (http://www.ageing.oxfordjournals.org/).

Meta-analyses showed that the six interventions with multiple components reduced falls by 22% (pooled rate ratio 0.78, 95% CI 0.68–0.89) and the 10 single interventions
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reduced falls by 23% (pooled rate ratio 0.77, 95% CI 0.67–0.89) (Figure 1). The indicator variable for single and multifactorial intervention trials was not significant in a meta-regression model containing all 16 comparisons ($P = 0.902$), confirming no difference in the two pooled rate ratios.

The sensitivity analyses included nine more trials (one multifactorial comparison and 10 single intervention comparisons [29–37], see Appendix Table 1 on the journal website [http://www.ageing.oxfordjournals.org/], but showed similar results (total 8,380 participants, 5,903 (70%) women). The seven multifactorial interventions reduced falls by 23% (pooled rate ratio 0.77, 95% CI 0.68–0.87) and the 20 single interventions reduced falls by 29% (pooled rate ratio 0.71, 95% CI 0.62–0.80) (Figure 2). There was no difference in these two pooled rate ratios ($P = 0.273$).

For both the initial and sensitivity meta-analyses there was evidence for heterogeneity in the single intervention models ($Q = 19.56, P = 0.021, I^2 = 54%$; $Q = 42.54, P = 0.001, I^2 = 55%$ respectively) but none for the multifactorial models ($Q = 8.06, P = 0.153, I^2 = 38%; Q = 8.52, P = 0.203, I^2 = 30%$).

Discussion

The meta-analyses demonstrate that the delivery of single factor interventions to selected populations is as effective in reducing falls as delivering multifactorial interventions to at-risk community populations. This runs contrary to currently accepted guidelines, and both the validity of and explanation for this finding require close examination.

There may be, as yet, insufficient good quality trials to demonstrate significant additional benefits from multifactorial interventions. Using very rigorous inclusion criteria, we were able to include 16 interventions involving 5,968 individuals in the first analysis. We performed a sensitivity analysis using broader criteria and included 27 interventions involving 8,380 individuals. In neither analysis was there any trend towards multifactorial interventions being more effective.

Effective fall prevention interventions, single or multi-component, decreased the number of falls by almost a third. The interventions used in the trials were based on the increased fall rate associated with known falls risk factors. The contribution of known, remediable risk factors for falls [38], and the extent to which these risk factors are improved on intervention [39], suggest that fall reduction in the order of 30–40% is likely to be the maximum effect to be expected in multifactorial fall prevention trials. It is, therefore, unlikely that future interventions, based on decreasing known fall risk factors, will increase the trial success rate sufficiently to alter the meta-regression null result.

There was significant heterogeneity in the single intervention meta-analyses, which is consistent with the hypothesis that single interventions need to be carefully directed to the appropriate population. Such interventions are highly successful when used in populations where the risk factor addressed accounts for a large proportion of the falls risk. Such a specific intervention is ineffective if it does not alter the risk factor, or the risk factor accounts for a small proportion of the risk. If there is a single risk factor, such as dementia, which accounts for a high proportion of the falls risk, then even multifactorial interventions which do not address the root cause of the falling, will be ineffective [40].

In multifactorial intervention studies there may be an interaction amongst the interventions, which means that each is less effective when used in combination. In a factorial design of fall prevention trial in elderly people with severe visual impairment, we found that a successful home modification intervention used alone prevented more falls than when used in conjunction with a previously successful strength and balance re-training programme [8]. The interaction was significant and there are plausible explanations for such an interaction, which may explain the lack of additional benefit seen in the multifactorial intervention trials.

Two or more interventions may cause confusion, or lead to more change than the older person is willing to accept. She may then opt for the intervention which is most acceptable. This is particularly so if the advice appears conflicting. For example, a home and behaviour modification programme emphasises safety and possible decrease of some activities, whereas a strength and balance programme requires increased and new activity. Too many changes may lead to rejection of all interventions, decreased adherence or limited programme uptake.

Not all interventions in multi-component intervention studies result in change. In the multifactorial intervention study of Tinetti et al., the reduction in psychotropic drug use was no different in the intervention and control groups at reassessment [6]. In multifactorial intervention studies there may be insufficient time and resource to implement effectively the more demanding interventions.

Single interventions were effective when they were directed at the major remedial risk factor for the particular trial population.

Strength and balance re-training, home based, as a group programme or as tai chi, was the most widely investigated intervention. Impairment of strength and balance may be the final common pathway to a fall for a number of risk factors, such as knee arthritis, inactivity, medications (for example, psychotropic medications) and vitamin D deficiency.

The population chosen for strength and balance as a single intervention needs not to be too fit or too frail. Our studies have shown benefit in those of 80 years and over, but not in those younger [41]. In the VIP study, in which the population was severely visually impaired and trailer than in our earlier studies, there was a lower adherence to the Otago Exercise Programme, and no fall reduction in those who did not exercise regularly [8].

We suggest that strength and balance re-training is most effective when the participants are just at that critical threshold where daily home tasks are at the limits of the person’s stability. Small gains have a disproportionate benefit by enabling the person to cope more safely with the activities of daily living.
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![Diagram showing relative rate ratios for multifactorial and single interventions]

Figure 1. (a) Meta-analysis for multifactorial interventions (initial pooling)*; (b) Meta-analysis for single interventions (initial pooling)†.

*Pooled rate ratio 0.78 (95% CI 0.68–0.89). Tests for homogeneity: $Q = 8.06, P = 0.153; I^2 = 38%$. †Pooled rate ratio 0.77 (95% CI 0.67–0.89). Tests for homogeneity: $Q = 19.56, P = 0.021; I^2 = 54%$.

Selection need not be complex and can be made on the basis of age, previous falls, or determination by the general practitioner. Community programmes based on more sophisticated analysis of risk have not been more effective [21]. Those with dementia have been shown not to benefit from a fall prevention programme [40]. Inability to participate in a programme because of cognitive impairment is currently a justifiable reason for exclusion.

A home safety programme delivered by an occupational therapist was successful in those with a previous fall, discharged from hospital [24] and in a population with severe visual impairment [8]. A safe environment may be particularly important for those with severe sensory impairments. Other than in these groups, success has been limited. Environmental hazards may be too ubiquitous for total removal and elderly people too resistant to interference in their homes for this intervention to be more universally successful. In two successful home modification trials, falls have been reduced as much away from home as at home [8, 24]. The advice of the occupational therapist may be the critical element in the intervention rather than the home modifications.

Programmes that have included a detailed assessment for syncope showed a subsequent reduction in falls [32]. The number needed to assess in order to identify those likely to benefit from subsequent interventions means that this is not an intervention suitable for primary community prevention. Instead, such patients need to be identified by their general practitioners or emergency department staff and referred for specialist assessment.

The blinded withdrawal of psychotropic drugs was successful in preventing falls in a community based study [31]. However, recruitment and adherence were so difficult that this intervention was likely to be successful in individualised programmes and not in community primary prevention.

Concluding comment
Those who have fallen and are at increased risk of further falls may benefit from individualised assessment and treatment.
Figure 2. (a) Meta-analysis for multifactorial interventions (sensitivity analysis)*; (b) Meta-analysis for single interventions (sensitivity analysis)†.

*Pooled rate ratio 0.77 (95% CI 0.68–0.87). Tests for homogeneity: \( Q = 8.52, P = 0.203; I^2 = 30\% \).

†Pooled rate ratio 0.71 (95% CI 0.62–0.80). Tests for homogeneity: \( Q = 42.54, P = 0.001; I^2 = 55\% \).

Such intensive assessment will not be available for the large number of elderly people at risk of falling. We suggest that lean and targeted single interventions are the most acceptable and easily instituted method of achieving fall reduction in the community.

**Key points**

- Most falls result from multiple risk factors. Therefore, it is assumed that multifactorial fall prevention strategies will be most effective
- Meta-regression showed that interventions addressing a single risk factor are as effective in reducing falls as interventions with multiple components
- Multifactorial fall prevention interventions are effective for individual patients
- For a community based approach, targeted single interventions are as effective as multifactorial interventions, may be more acceptable and cost effective

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**Conflict of interest statement**

There are no conflicts of interest.
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Supplementary data
Supplementary data for this article is available online at http://ageing.oxfordjournals.org.

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