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# Prevention of falls in old people – a review

**Magnus K. Karlsson, Caroline Karlsson, Maria Cöster, Håkan Magnusson and Björn E. Rosengen**
*Clinical and Molecular Osteoporosis Research Unit, Lund University, Malmö, Sweden*

## Summary

Physical training, if including specific different training modalities, reduces the fall risk in healthy community-dwelling older people, as does a home hazards modification programme. Vitamin D supplementation in older individuals with low levels of vitamin D, adjustment of psychotropic medication, and structured modification of multi-pharmacy are all drug-focused programmes that reduce the number of falls. Anti-slip shoe devices during icy conditions for older people who walk outdoors and multifaceted podiatry in patients with specific foot disability reduce the fall risk. First eye cataract surgery and pacemakers in patients with cardio-inhibitory carotid sinus hypersensitivity are surgical interventions that reduce the fall risk. Multi-factorial preventive programmes that include training, both individually designed and generally prescribed, also reduce the fall frequency. With this in mind, we ought to initiate fall preventive programmes in older people, especially in high- risk groups, to reduce the number of falls and fallers in society.

*Key words:* epidemiology, falls, older people, prevention, randomized controlled trial.

## Introduction

The number of fragility fractures has risen during the last 50 years[1] so that the worldwide prevalence in adults above the age of 50 years is 9.0 million, of which 1.6 million are of the hip, 1.7 million the forearm and 1.4 million clinically diagnosed vertebral fractures.[2] The increase is estimated to continue, so that by the year 2050 there will be 6.3 million hip fractures globally, half of these in Asia[3] (Fig. 1). This will impose a significant health care burden worldwide.[1] Therefore we must introduce measures that reduce the number of falls and fractures.

Falls are commonly found in older people. One-third of community dwellers aged over 65 years and 60% of individuals in nursing and retirement homes fall each year.[4] Furthermore, women fall more often than men.[4] Falls are also often followed by pain syndromes, functional limitations, dislocations, serious soft tissue injuries, fractures, high healthcare costs and high mortality.[5] About 15% of falls in patients living in the community[4] and 20% in institutionalized patients[6] result in a significant injury, and 12% of all falls in older people are followed by a fracture.[7] In addition, 23% of trauma-related deaths in patients above age 65 years and 34% in those above age 85 years follow a fall.[8]

Fractures may provide the largest healthcare burden among fall-related injuries.[9] Fragility fractures, i.e. fractures of the proximal humerus, distal forearm, vertebrae, pelvis, hip and the tibial condyles in older individuals due to low-energy trauma share common features, such as having a higher incidence in women than in men and an exponential increase with age.[10] The incidence of hip fractures has increased during the last 50 years[1,11] even if in many western countries there has been a decline in the incidence since the end of the twentieth century.[1,11] Despite this, the total number of hip fractures is still increasing due to changes in population demographics. As the proportion of older people in the population is due to grow even larger, the total number of fragility fractures will continue to rise,[3] a fact that increases the need of fall- and fracture-reducing interventions. As a fall is one of the most striking risk factors for fractures, and as there exists strong evidence supporting the effectiveness of several fall preventive strategies, this review summarizes the fall prevention programmes that have been shown to have beneficial effects in randomized controlled trials (RCTs).

### *Search methods*

We identified potentially interesting studies through a structured search in PubMed from all years by using the terms: 'accidental falls',

Address for correspondence: Magnus Karlsson, Department of Orthopaedics, Skåne University Hospital, SE-205 02 Malmö, Sweden.
Email: magnus.karlsson@med.lu.se

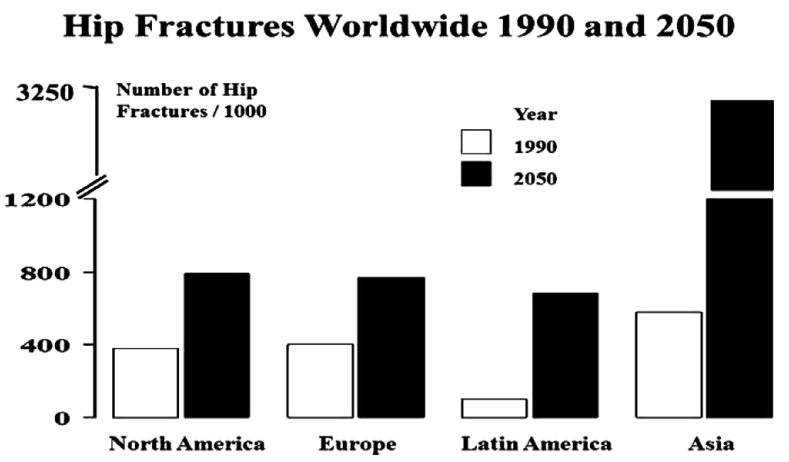


**Figure 1.** Estimated number of hip fractures in four geographic regions in 1990 and 2050[3]

'physical therapy', 'equipment', 'supplies', 'self-help devices', 'protective devices', 'environmental intervention', 'home modification', 'exercise', 'exercise therapy', 'physical education' and 'training'. From the identified studies, we included only those studies which, using RCTs, evaluated the effects of interventions designed to reduce falls in older people (individuals aged 60 years or more or described as elderly, seniors or older). The participants had to be living in the community at home or in places of residence that did not provide residential health-related care. Trials that included younger participants, for example those recruited on the basis of a medical condition such as a stroke or Parkinson's disease were only included if the mean age minus one standard deviation was more than 60 years. Some references found evaluated interventions in nursing care facilities or hospitals, but these data are presented separately. In studies with participants living in different settings, participants were included only if data were provided for subgroups based on setting. Intervention programmes were compared with 'usual care' or 'placebo'. Studies that evaluated two types of fall-prevention interventions were also included. Finally, we went through the included studies and excluded those without end-point variable rate or number of falls or number of participants sustaining at least one fall during follow-up (fallers). Apart from these studies, we also included recently published structured reviews and Cochrane reviews within the field that summarized the outcome in published RCTs.[12–20] We chose to present central studies reported in these Cochrane reviews in the figures; that is, not all of the total of 159 RCTs reported in the latest Cochrane review are included in the figures, while additional reports could be referred to in the text. Finally, we also reviewed the reference lists of each to identify papers fulfilling the above-mentioned criteria to add further relevant RCTs.

The meta-analyses calculations referred to in this paper are published in detail in cited Cochrane reviews.[12–14] In summary, in the meta-analyses, data from different RCTs with comparable interventions and participant characteristics were pooled by use of a generic inverse variance method. Calculated pooled rate ratios for total number of falls or risk ratios for being a faller with 95% confidence intervals were estimated through the fixed-effect model. Where there was substantial statistical heterogeneity, data were pooled using a random effect model.[21]

## Exercise

Physical training in community-living old individuals reduces the risk of falling[12,13,19,22–49] (Fig. 2) and is generally accepted as the most effective fall-prevention strategy in the community-living population.[50,51] Exercise has also been reported as the most cost-effective fall-preventive strategy.[13,14] Among the different training strategies, multi-component exercise programmes that include balance training and muscle-strength training have been the most effective interventions, followed by flexibility and endurance training.[13,14] The

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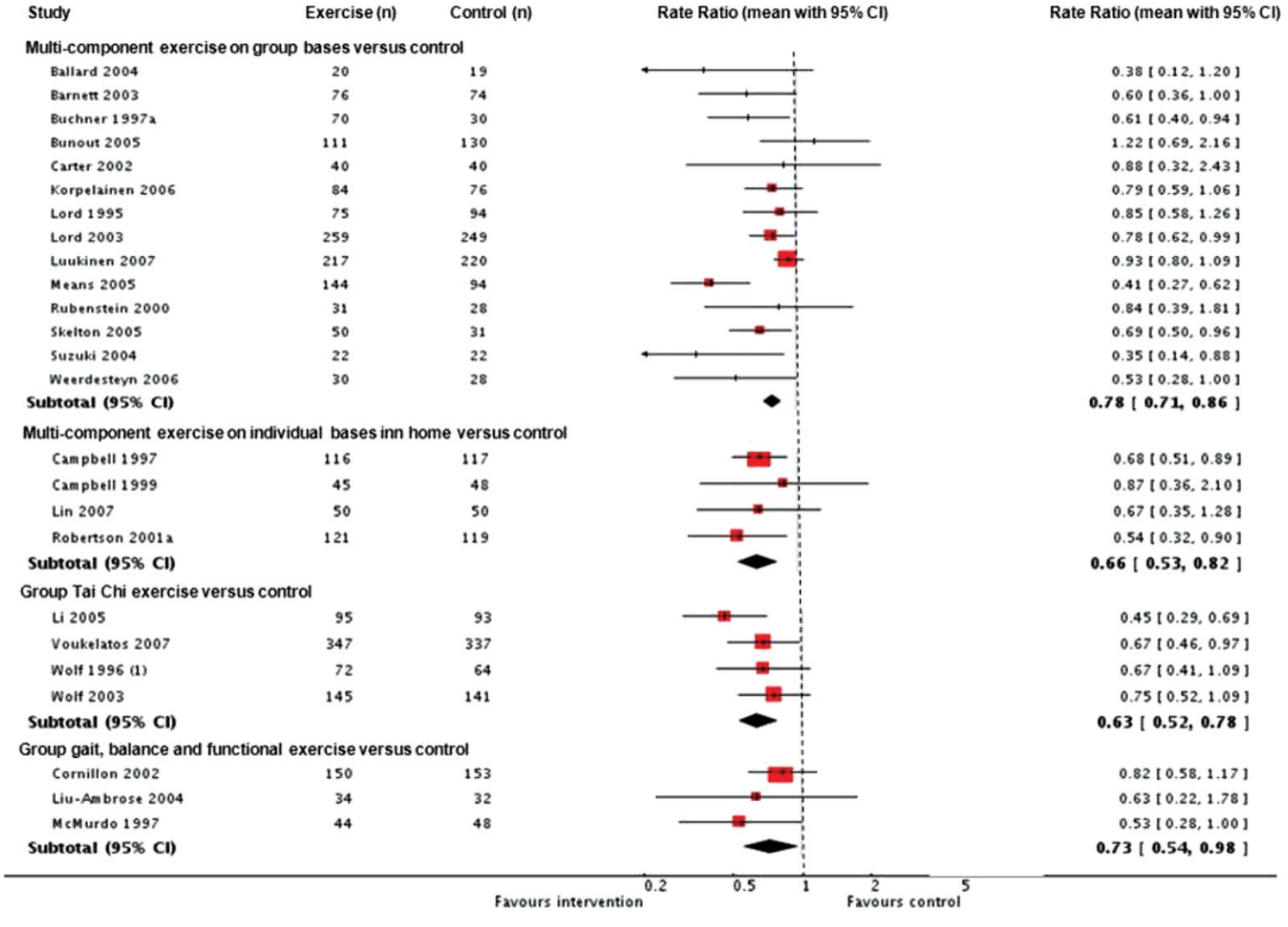


**Figure 2.** Comparison of number of falls in community-living older people exposed to intervention with different types of exercise *versus* controls reported in several randomized controlled trials (RCTs)

training should be performed often and with high frequency.[25,44] Group training, where at least two different training components are included, has, in community-living old people above age 60 years decreased the fall rate by 22% (relative risk (RR) 0.78, 95% confidence interval (CI) 0.71–0.86) and the risk of falling by 17% (RR 0.83, 95% CI 0.72–0.97) (Fig. 2). Training classes that included gait balance alternating with functional training significantly reduced rate of falls by 27% (RR 0.73, 95% CI 0.54–0.98) (Fig. 2). RCTs comparing different types of exercise or methods of delivery have not found any differences.[13]

Individually designed exercise programmes with more than one exercise modality, conducted at home, is another approach that reduces the number of falls in community-living old individuals by 34% (RR 0.66, 95% CI 0.53–0.82) and the risk of falling by 23% (RR 0.77, 95% CI 0.61–0.97)[13] (Fig. 2). However, training can be beneficial even if using only one exercise modality. Such an example is Tai Chi training where the beneficial effects include both strength and balance training. In the general old population this type of training reduced the number of fallers by close to 50% in one RCT published by the FICSIT group (Frailty and Injuries: Co-operative Studies of Intervention Techniques)[52] and a meta-analysis that included unselected community-living older people supported this notion when reporting that Tai Chi reduced the number of falls by 37% (RR 0.63, 95% CI 0.52–0.78) and the number of fallers by 35% (RR 0.65, 95% CI 0.51–0.82) (Fig. 2). The beneficial effect is usually referred to the fact that Tai Chi includes both strength and balance training.[53] Another recent published RCT showed that home-based balance and strength training in older community-living individuals aged 70 years or older, who had two or more falls or one injurious fall in the past 12 months, was followed by a 31% reduction in the number of falls (RR 0.69, 95% CI 0.48–0.99).[54] A music-based multi-task exercise programme in community-dwelling individuals older than 65 years who were at increased risk of falling was also effective, and the programme resulted in 54% fewer falls in the exercise group (RR 0.46; 95% CI 0.27–0.79).[55] The authors concluded that functional-based exercise should be a focus for interventions to protect older, high-risk individuals from falling and that the effect of physical training as a fall reductive strategy is less effective in institutionalized individuals.[12,56–62] (Fig. 3). Supervised training in institutionalized individuals above age 65 years reduced the risk of falling by 56% (RR 0.44, 95% CI 0.20–0.97)[12] in one meta-analysis, but further subgroup analyses showed that the positive effect was only found in older people in sub-acute care hospitals, and not in those staying in general nursing care facilities[12] (Fig. 3). However, it should be noted that gait, balance and co-ordination exercises utilizing a mechanical apparatus in individuals in nursing homes did reduce the rate of falls by 55% (RR 0.45, 95% CI 0.24–0.85). Therefore, we cannot exclude that specific types of training in specific groups actually can reduce the fall frequency also in older individuals staying in nursing homes or other type of institutions (Fig. 3).

## Vitamin D

Vitamin D supplements provided to unselected community-living older people did not reduce the number of falls (RR 0.95, 95% CI 0.80–1.14) (Fig. 4).[13,14,63–69] Slightly more positive conclusions could be drawn when the supplement was given to institutionalized old individuals, where the total number of falls was reduced by 28% (RR 0.72, 95% CI 0.55–0.95) (Fig. 4).[12] In old people with low vitamin D levels, the subgroup analyses revealed that the number of falls was reduced by 43% (RR 0.57, 95% CI 0.37–0.89) (Fig. 4), as was the number of fallers by 35% (RR 0.65, 95% CI 0.46–0.91).[66,68] No fall reduction was seen in old people with normal vitamin D levels. However, the type of supplement also seems to be of importance, as calcitriol reduced the number of falls by 36% (RR 0.64, 95% CI 0.49–0.82)[67] while alfacalcidol did not (RR 1.08, 95% CI 0.75–1.57)[70] (Fig. 4). Vitamin D supplements may reduce the number of falls but probably only in those with low vitamin D levels and maybe only with specific types of vitamin D drugs.

## Medication

Multi-pharmacy and combinations of specific drugs may be associated with increased fall risk in the older population. A structured prescription modification programme could therefore hypothetically reduce the fall risk. One RCT demonstrated this in the intervention group, where a gradual

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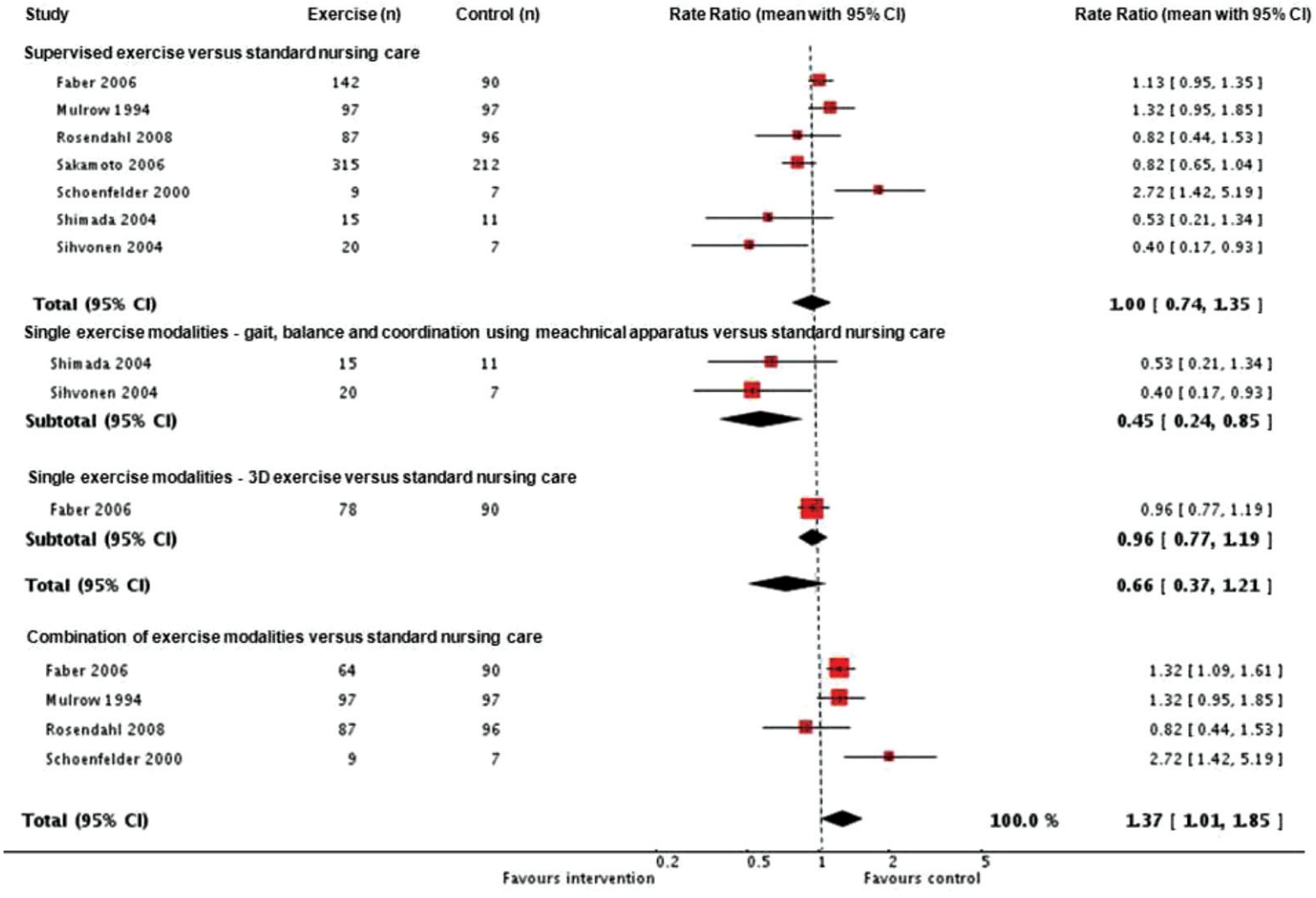


**Figure 3.** Comparison of number of falls in older people living in nursing home or hospitals exposed to intervention with different types of exercise *versus* controls reported in several RCTs

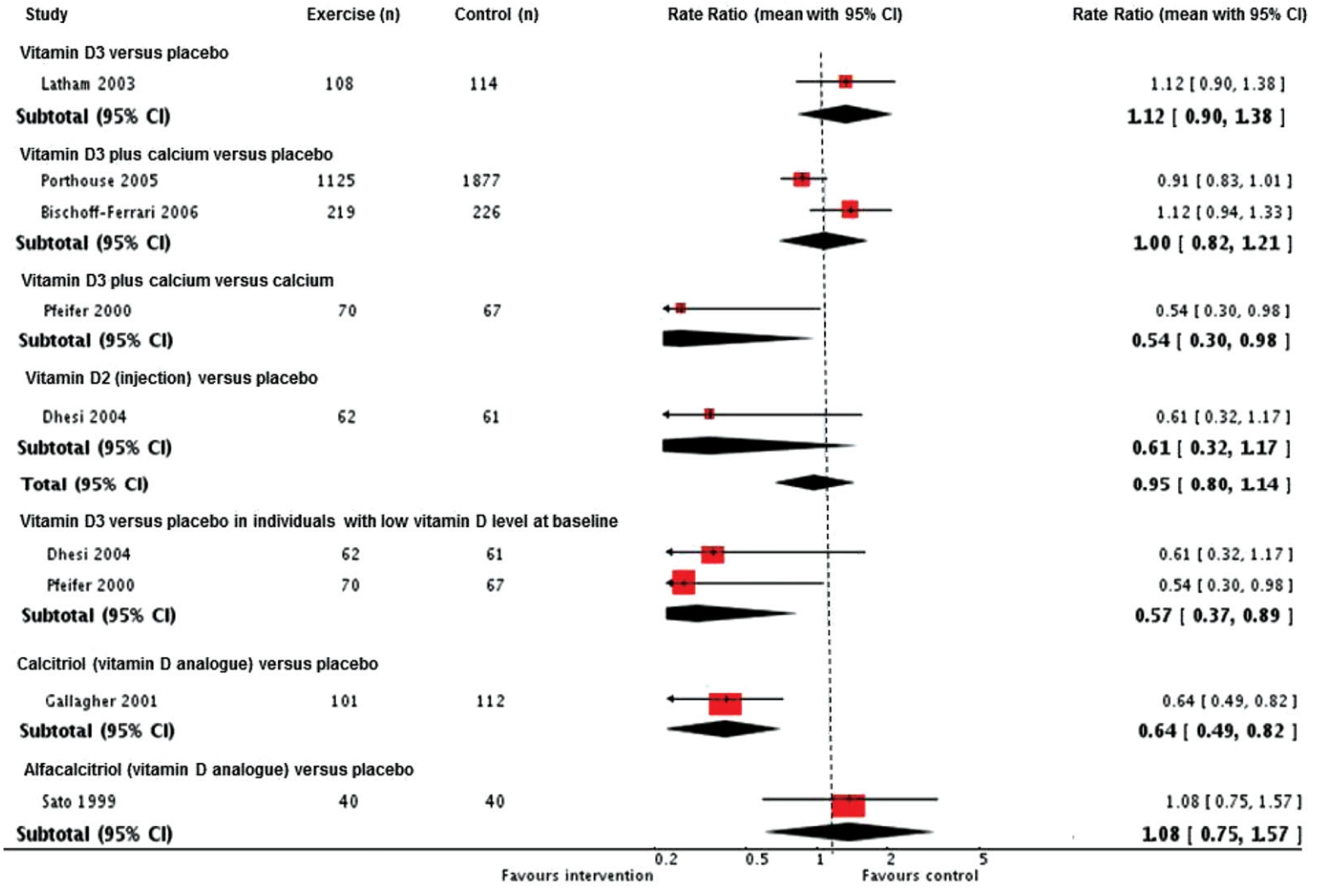


**Figure 4.** Comparison of number of falls in community-living older people exposed to vitamin D supplement with or without calcium *versus* controls reported in several RCTs

withdrawal of psychotropic medication resulted in a 66% reduction in the number of falls (RR 0.34, 95% CI 0.16–0.73) (Fig. 5).[22] Fall preventive education for family physicians that included academic teaching, feedback on prescribing practices and financial rewards combined with self-assessment of medication followed by a medication review with modification of prescriptions in community-dwelling older people was found to reduce the risk of falling by 39% (RR 0.61, 95% CI 0.41–0.91)[71] (Fig. 5). Modification of prescriptions could also have an effect on individuals staying in institutions, since beneficial effects were found in one RCT that evaluated a prescribing modification programme by pharmacists in nursing care facilities or hospitals, an intervention that reduced the fall frequency by 38% (RR 0.62, 95% CI 0.53–0.72).[22]

### Surgery

Surgical interventions may be effective in reducing falls in specific risk groups. Cardiac pacemakers, in patients with cardioinhibitory carotid sinus hypersensitivity, were in one published RCT reported to reduce the rate of falls by 58% (RR 0.42, 95% CI 0.23–0.75) (Fig. 5).[72] Cataract surgery for the first eye was, in another RCT, found to reduce the rate of falls by 34% (RR 0.66, 95% CI 0.45–0.95) (Fig. 5).[73] Cataract surgery for the second eye was, however, not associated with a reduced fall rate (RR 0.68, 95% CI 0.39–1.17)[74] (Fig. 5).

### Home hazards

Modification of home hazards in the general older population reduce the number of falls (RR 0.81, 95% CI 0.68–0.97) (Fig. 6) and the number of fallers (RR 0.88, 95% CI 0.80–0.96).[14,41,75–80] Modifications of home hazards in individuals above age 75 years with visual impairment that removed or changed loose floor mats, painted the edges of steps, reduced glare, installed grab bars and stair rails, removed clutter and improved lighting where needed, was followed by a 41% fall reduction (RR 0.59, 95% CI 0.42–0.83) (Fig. 6) and 24% reduction in number of fallers (RR 0.76, 95% CI 0.62–0.95).[13,14,78] A pooled sub-group analysis revealed that a home safety programme reduced the fall risk by 44% (RR 0.56, 95% CI 0.42–0.76) (Fig. 6) and the number of fallers by 22% (RR 0.78, 95% CI 0.64–0.95) in high-risk individuals, such as individuals with a history of a fall or multiple risk factors. Home hazard assessment and modification of risk factors should therefore be provided to all older people, but particularly focused on high-risk individuals as the interventions seem more effective in people at higher risk of falling.[14]

### Footwear

The type of footwear may influence the risk of falling.[81] Anti-slip shoe devices have, in one study, been shown to reduce the rate of falls by 58% (RR 0.42, 95% CI 0.22–0.78) (Fig. 5), but only in old individuals who walked outdoors during icy conditions[82] (Fig. 5). Anti-slip shoe devices should therefore be recommended to ambulatory old people who walk outdoors under icy conditions and multifaceted podiatry to patients with specific foot disability. Another RCT that evaluated the effect of multifaceted podiatry including foot and ankle exercise found that this intervention reduced the fall risk by 36% (RR 0.64, 95% CI 0.45–0.91) (Fig. 5) compared with standard podiatry in patients with disabling foot pain.[83]

### Generalized multifaceted intervention

Hypothetically, it ought to be beneficial to modify as many risk factors as possible. One approach would be to prescribe generally designed intervention programmes that include a fixed combination of different components of interventions that are delivered to all participants independently of individual demands. Examples of such programmes are those including exercise, care planning, medical and/or diagnostic approaches, changes in physical environment, education programmes, calcium and vitamin D supplementation, medication review and removal of physical restraints.[12–14,18,78,84–87] (Fig. 7). Generalized programmes have, in RCTs, been found to reduce the fall rate by 31% when including exercise, education and a home safety intervention (RR 0.69, 95% CI 0.50–0.96),[85] by 81% when including exercise plus nutritional supplementation in vitamin D and calcium replete women (RR 0.19, 95% CI 0.05–0.68),[87] by 24% when including exercise and home safety assessment (RR 0.76, 95% CI 0.60–0.97),[80] by 27% when including exercise plus vision assessment (RR 0.73, 95% CI 0.59–0.91),[80] by

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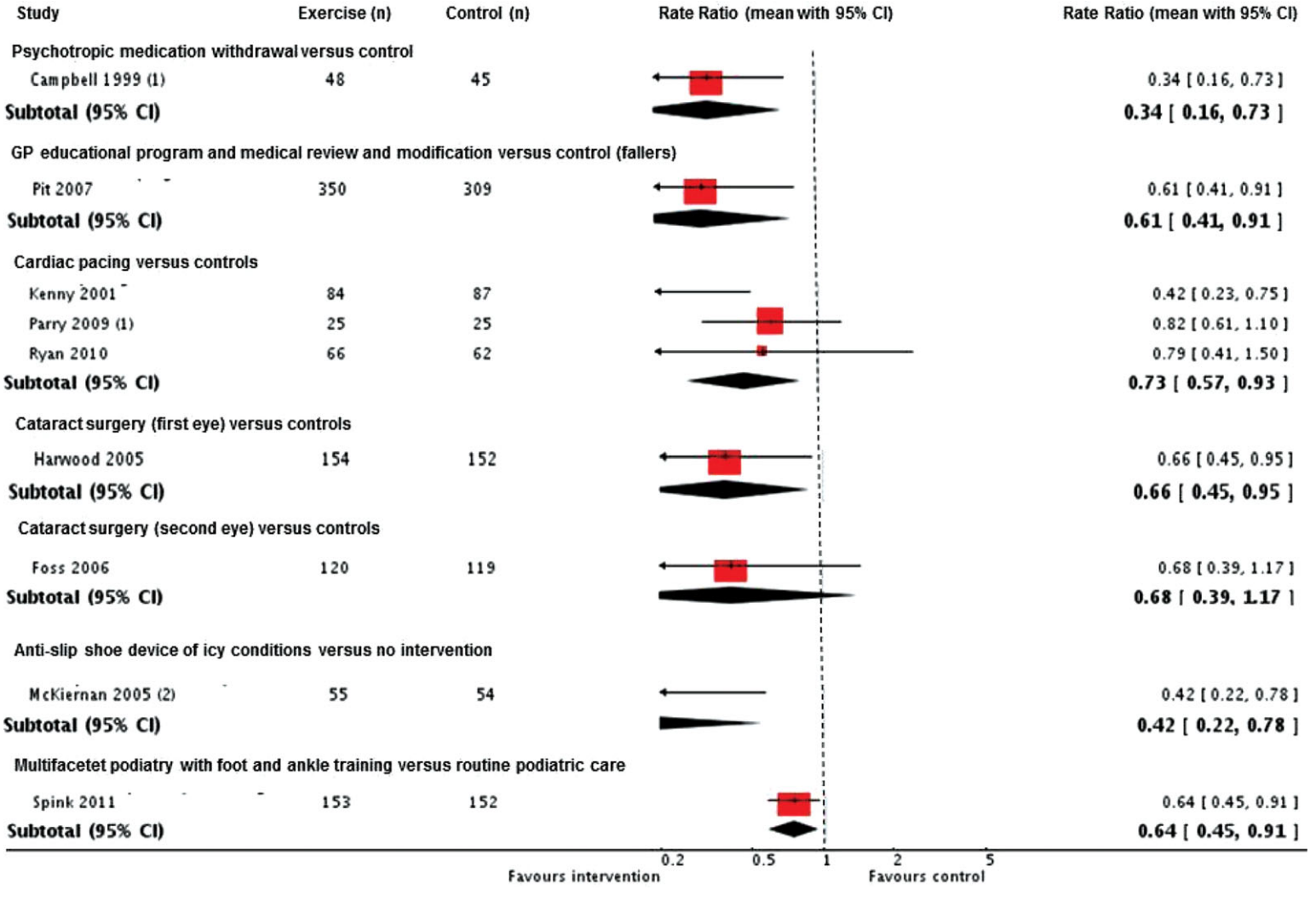


**Figure 5.** Comparison of number of falls in community-living older people exposed to drug withdrawal, surgery and foot assessment *versus* controls reported in several RCTs

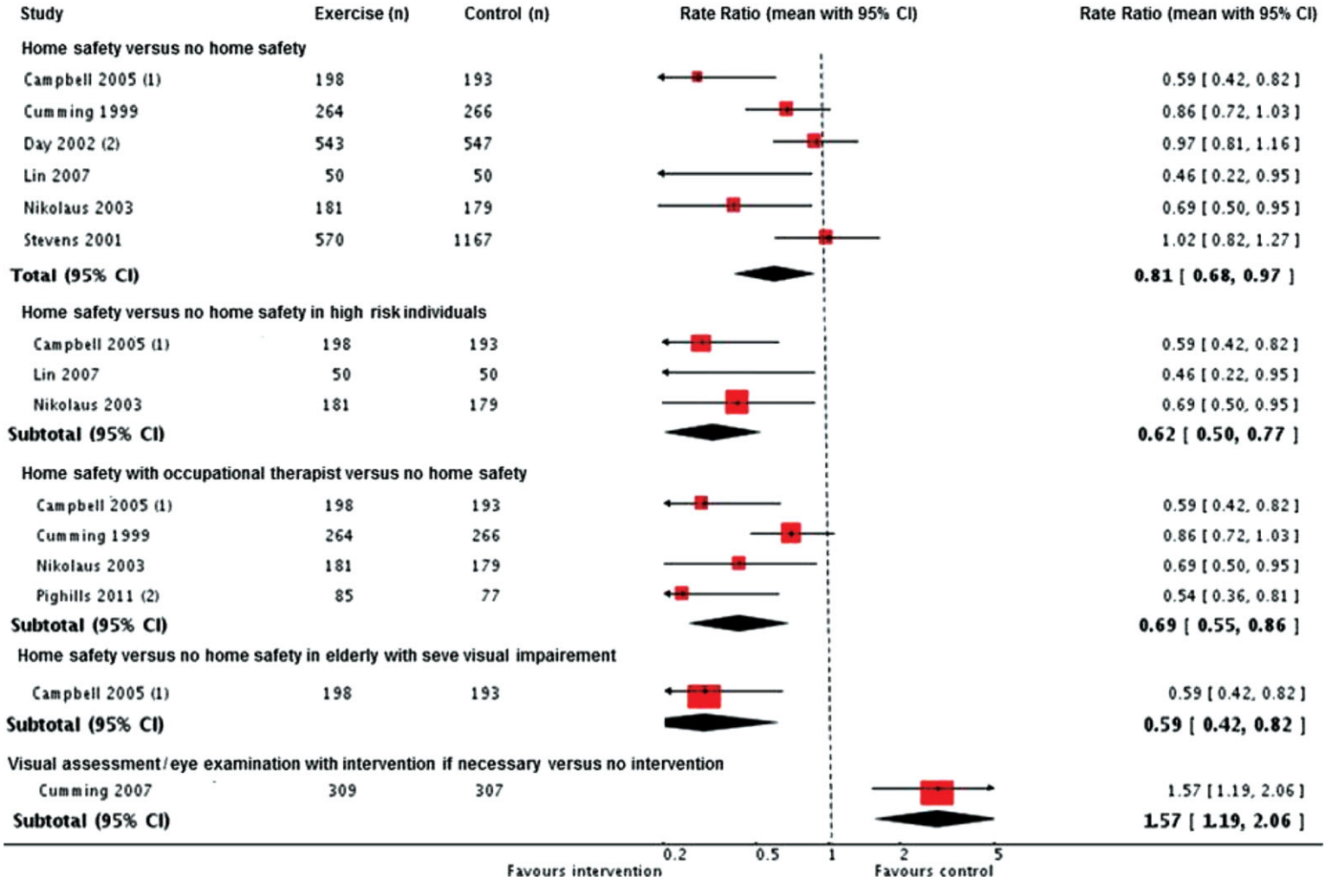


**Figure 6.** Comparison of number of falls in community-living older people exposed to intervention with home hazard assessment followed by risk factor reduction versus controls reported in several RCTs

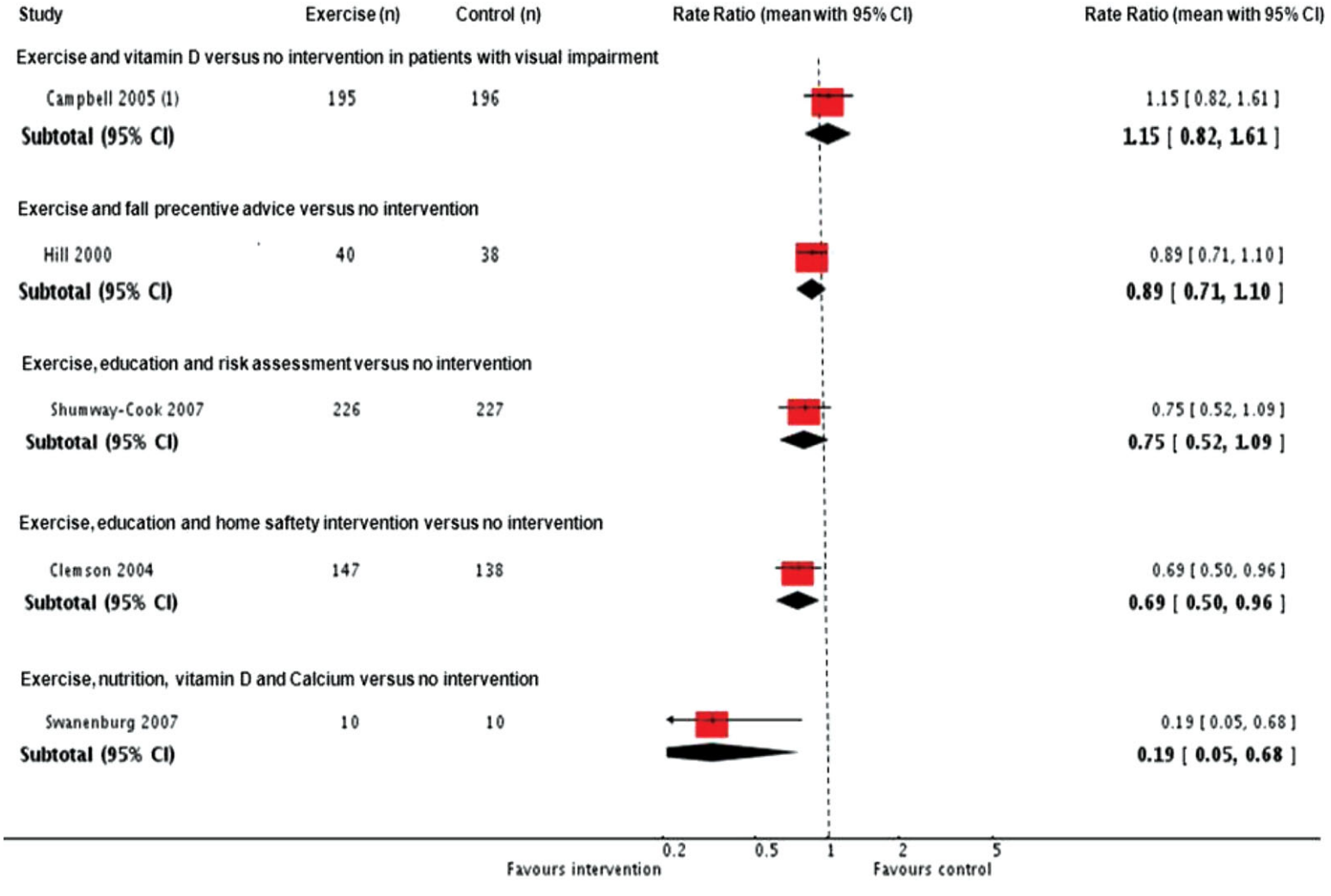


**Figure 7.** Comparison of number of falls in community-living older people exposed to generalized multifaceted interventions *versus* controls reported in several RCTs

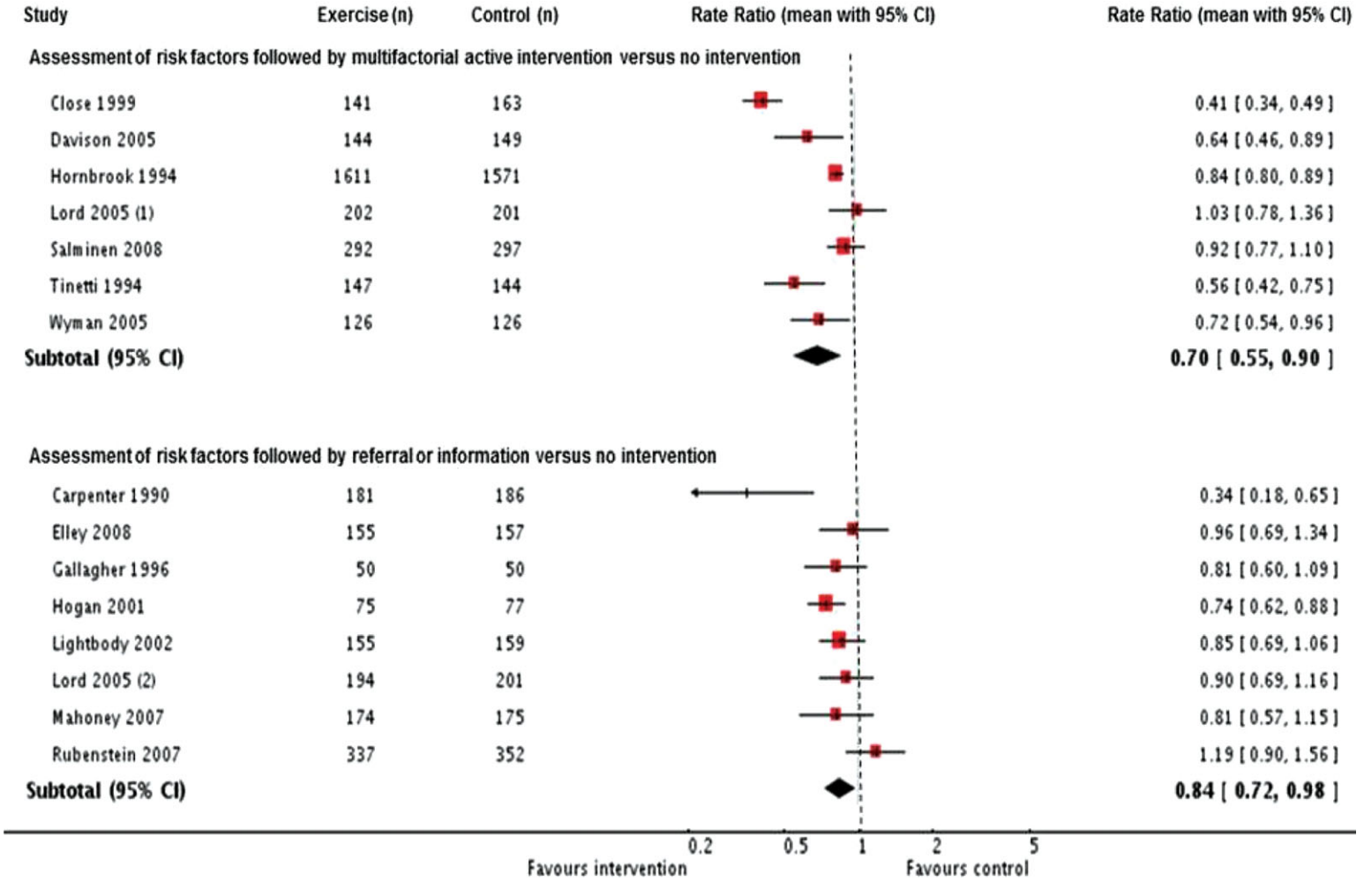


**Figure 8.** Comparison of number of falls in community-living older people exposed to individualized multifactorial interventions *versus* controls reported in several RCTs

23% when including exercise plus vision and home safety assessment (RR 0.67, 95% CI 0.51–0.88)[80] and by 23% when including educational intervention combined with free access to an assessment at a geriatric clinic (RR 0.77, 95% CI 0.63–0.94)[88] (Fig. 7).

### Individualized multifactorial intervention

In individualized multifaceted intervention programmes, each individual would be evaluated for risk factors and then be assigned to an individually designed prevention programme[13,14,21,89–101] (Fig. 8). Similar programmes have been shown to reduce the rate of falls in community-dwelling old adults by 25% (RR 0.75, 95% CI 0.65–0.86) (Fig. 8).[13,14] In hospital settings, these multifactorial interventions reduced the rate of falls by 31% (RR 0.69, 95% CI 0.49–0.96) (Fig. 8) and the risk of falling by 27% (RR 0.73, 95% CI 0.56–0.96). The number of falls was not reduced in individuals living in nursing home facilities (RR 0.82, 95% CI 0.68–1.08), even if further sub-analysis revealed that specific types of interventions with multidisciplinary team approaches together with physical training reduced the rate of falling also in nursing home residents by 40% (RR 0.60, 95% CI 0.5–0.72).[12] It should also be noted that all multiple intervention trials that have been shown to reduce the fall risk include some type of physical training in the intervention[12–14] (Fig. 8) and that multi-factorial risk assessment in conjunction with comprehensive management of identified risk factors are usually recommended to focus on high-risk populations. In the recently updated American Geriatric Society (AGS) clinical practice guidelines, this especially accounts for older adults who have sustained two falls or more in the recent year, have gait or balance problems or have presented with an acute fall.

### Interventions with harmful effects

An intervention programme can also increase the fall rate. Two RCTs have reported that intervention with vision assessment, eye examination, new spectacles and/or ophthalmology treatment in conjunction with mobility training and canes increased the fall rate by 57% (RR 1.57, 95% CI 1.19–2.06)[77,80] (Fig. 6). Exercise in hospitalized individuals that included several different training modalities was in one RCT found to increase the fall rate by 172% (RR 2.72, 95% CI 1.42–5.19)[59] (Fig. 3) and when using pooled data from several RCTs that included different types of training modalities, by 37% in people in hospital settings (RR 1.37, 95% CI 1.01–1.85)[12] (Fig. 3). This highlights the importance of drawing inferences for fall preventive effect only in cohorts similar to the one evaluated in RCTs and not directly transfer the conclusion of beneficial effects in one cohort to other populations.

### Cost benefits

In one review there were eight RCTs that included economic evaluation as an outcome.[13,14] These studies infer that there is weak evidence that prevention strategies for fall reduction can be cost saving during the trial period, but also during the rest of the lifespan of the participants. All reports also infer that the prevention strategies with fall-reducing effects ought to be targeted at high-risk sub-groups of old people to achieve greatest cost-beneficial effects.[13]

## Conclusions

Fall risk in community-living old individuals is reduced by:

- Regular exercise that includes multicomponent training modalities
- Reduction of home hazards
- Vitamin D supplements in individuals with low levels of vitamin D
- Adjustment of psychotropic medication
- Structured modification of multi-pharmacy
- Anti-slip shoe devices in older individuals walking outdoors during icy conditions
- Multifaceted podiatry to patients with specific foot disability
- First eye cataract surgery in patients with visual impairment
- Pacemakers in patients with cardioinhibitory carotid sinus hypersensitivity
- Generalized multifactorial fall prevention programmes
- Individually designed multifactorial fall prevention programmes.

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## Conflict of interest

There are no competing interests for any of the authors.

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