*Age and Ageing* 2010; **39:** 681–687
doi: 10.1093/ageing/afq102
Published electronically 4 September 2010


**SYSTEMATIC REVIEW**

# Does the 'Otago exercise programme' reduce mortality and falls in older adults?: a systematic review and meta-analysis

Susie Thomas[1], Shylie Mackintosh[2], Julie Halbert[3]

[1]Rehabilitation and Aged Care, Flinders University, Repatriation General Hospital, Daws Road, Daw Park, Adelaide, South Australia 5041, Australia
[2]School of Health Sciences and [3]School of Psychology, Social Work and Social Policy, University of South Australia, Adelaide, South Australia, Australia

Address correspondence to: S. Thomas. Tel: (+61) 8 8275 1103; Fax: (+61) 8 8275 1130.
Email: susie.thomas@health.sa.gov.au

## Abstract

**Background:** the 'Otago exercise programme' (OEP) is a strength and balance retraining programme designed to prevent falls in older people living in the community. The aim of this review was to evaluate the effect of the OEP on the risk of death and fall rates and to explore levels of compliance with the OEP in older adults.
**Methods:** a systematic review with meta-analysis. Clinical trials where the OEP was the primary intervention and participants were community-dwelling older adults (65+) were included. Outcomes of interest included risk of death, number of falls, number of injurious falls and compliance to the exercise programme.
**Results:** seven trials, involving 1503 participants were included. The mean age of participants was 81.6 (±3.9) years. The OEP significantly reduced the risk of death over 12 months [risk ratio = 0.45, 95% confidence interval (CI) = 0.25–0.80], and significantly reduced fall rates (incidence rate ratio = 0.68, 95% CI = 0.56–0.79). There was no significant difference in the risk of a serious or moderate injury occurring as the result of a fall (risk ratio = 1.05, 95% CI = 0.91–1.22). Of the 747 participants who remained in the studies at 12 months, 274 (36.7%) were still exercising three or more times per week.
**Conclusion:** the OEP significantly reduces the risk of death and falling in older community-dwelling adults.

**Keywords:** *Otago exercise programme, mortality, falls, aged, elderly, systematic review*

## Introduction

Falls and fall-related injuries are a serious consequence of declining physical function [1–3]. Approximately 35% of people over 65 fall each year [4, 5] with this figure rising to 50% in those aged 80 and over [6]. Falling has a significant impact on the confidence and independence of an individual [7–10] and may lead to hospitalization, institutionalization or death [11, 12]. As the proportion of the population over 65 continues to rise, the prevalence of falls will continue to grow, placing an increasing demand and cost on the public health system [13].

A substantial number of studies have investigated different types of exercise programmes designed to reduce functional decline and prevent falls. However, these programmes have had considerable diversity in the mode of delivery and exercise prescription, including the setting, type of exercise, levels of supervision, duration and intensity of the programme. Recently, it has been determined which components of these exercise programmes are important to reduce falls. A Cochrane review of falls prevention strategies [14] concluded that exercise programmes that target two or more components of strength, balance, flexibility or endurance, reduce rate of falls and number of people falling. This can be achieved via a supervised group, Tai-Chi or an individually prescribed home exercise programme. This was consistent with a systematic review [15] which identified that greater relative effects on fall rates are seen in programmes that include exercises that challenge balance and use a higher dose of exercise.

One programme that encompasses all of these aspects is the 'Otago exercise programme' (OEP). This is a home-exercise programme, combining strength and balance retraining exercises to prevent falls in older, community-dwelling people [16]. It has been shown to be effective in reducing the number of falls and fall-related injuries by 35% in community-dwelling older adults and had the greatest impact in those aged 80 and older [17]. This programme is unique in its clearly defined prescription and ability to be readily implemented across the community. Consequently, this programme is now widely used throughout New Zealand and is used increasingly around the rest of the world.

An individual-level data meta-analysis examining the effect of this programme on falls prevention was conducted by the developers of the programme and analysed four of their own clinical trials [17]. A review including trials by other research groups and analysing the OEP's impact on other important outcomes such as risk of death and compliance to the programme has not been carried out. Therefore, the purpose of this review was to evaluate the effect of the 'OEP' in older adults (65+) on risk of death, fall rates, injurious falls and compliance to the exercise programme.

## Methods

### Types of studies

All randomised controlled trials (RCTs) or controlled trials with masked assessment of outcome. A date restriction was set to only include trials that were published after 1990, as the intervention of interest was not developed until 1995.

### Types of participants

Participants aged 65 and older.

### Types of interventions

Trials were included if the OEP was an intervention and comparison was made to a control group. Social visits may have occurred in the control group but no other significant intervention was administered.

The OEP was defined as a tailored, home based, strength and balance retraining programme, where resistance to lower limb muscles was provided via ankle cuff weights and the programme was carried out at least three times per week. The programme needed to include the following features:

- individually tailored
- increased in difficulty (increasing resistance, repetitions, the difficulty of balance exercises and/or the duration of the walking component)
- a stable, sustainable programme was established after a series of home visits from an instructor
- a walking programme to complement the strength and balance programme [16].

### Types of outcome measures

Outcomes of interest were risk of death, falls and fall injuries and 12-month compliance to the exercise programme.

### Search strategy and selection criteria

The following were searched: The Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE (1990–week 2 September 2008), CINAHL (1990–week 3 September 2008), TRIP (1990–2008), AARP Ageline (1990–August 2008), INFORMIT (1970–2008) and the search was supplemented with searches of the Australian Digital Theses Program, Physiotherapy Evidence Database (PEDro; www.pedro.fhs.usyd.edu.au/index.html; accessed September 2008) and the Prevention of Falls Network Europe (ProFaNE; http://www.profane.eu.org/) website as well as a citation search of included articles through Web of Science (ISI). Conference proceedings and reference lists of articles were also accessed. No language restrictions were applied. Further trials were identified by contact with key researchers in the field. See Supplementary data available in *Age and Ageing* online for an example of the search strategy used.

Two investigators (S.T., J.H.) independently reviewed titles and abstracts to determine eligibility for inclusion. Full articles were obtained for the identified titles and those which met the selection criteria were included. Differences of opinion of the two investigators about study eligibility were resolved by discussion with the third author (S.M.).

### Data extraction and quality assessment

A data extraction form was designed and piloted prior to use. Information about the method (i.e. design, participants, intervention, outcome measures) and results (i.e. sample size, incidence rates and number of events) were extracted. Where information was not available in the published trials, details were requested from the author listed for correspondence.

Methodological quality was assessed for each study by two reviewers independently (S.T. and S.M.), using the PEDro Scale (reliable for rating quality of RCTs [18]). The two reviewers then met to resolve any discrepancies between the scoring of the papers through open discussion about their justification for each of the scores.

### Analysis of effect of the OEP

Summary-level data of the included studies was entered into Review Manager (RevMan) (Version 5.0, The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, 2008) to calculate pooled estimates of the effect of OEP using a fixed-effects model when appropriate. The overall effect of the intervention for each outcome was reported as a risk (death, injurious falls) or rate (total falls) ratio with a 95% confidence interval (CI). Statistical heterogeneity was quantified with the $I$ and $\chi^2$ statistics.

Where studies reported similar outcome measures but used different forms of analysis, the authors were contacted for total number of falls and total follow-up time (person-years), to allow incidence rates of falls to be determined. Incidence rate ratios were calculated by dividing the incidence rate of the intervention group over the incidence rate of the control group [19].

All included trials used the same fall definition: 'unintentionally coming to rest on the ground, floor, or other lower level', coming to rest against furniture or a wall was not counted as a fall.

## Results

### Trial flow and study characteristics

The searches produced 493 RCTs. Two papers reported on the same trial at two different time points: both 12-month [20] and 2-year follow-up [21]. The 12-month follow-up was selected for inclusion as this is generally considered the gold standard period of time for follow-up in falls studies. A total of seven studies were appropriate for inclusion (Figure 1) [20, 22–27]. No extra studies were identified through contacting experts in the field. Six studies were published in peer-reviewed journals with publication dates ranging from 1997 to 2008 [20, 23–27], whereas one was an unpublished thesis produced in fulfilment of a Masters degree [22]. Of the seven included trials, 1503 community-dwelling participants were involved, with sample sizes in individual studies ranging from 59 to 450 participants. Characteristics of the included trials are described in Table 1.

#### *Quality*

PEDro scores of the included trials ranged from four through to eight (Table 1). Although the maximum PEDro score is 10, realistically the maximum achievable score on PEDro for this type of trial is 8 as it is almost impossible to blind both participants and therapists to an exercise intervention. Consequently, a common area of bias was that participants or therapists were not blinded. Also, three of the seven papers were unable to obtain measures of falls from more than 85% of the participants initially allocated to groups [22, 24, 26]; however, five studies did manage to

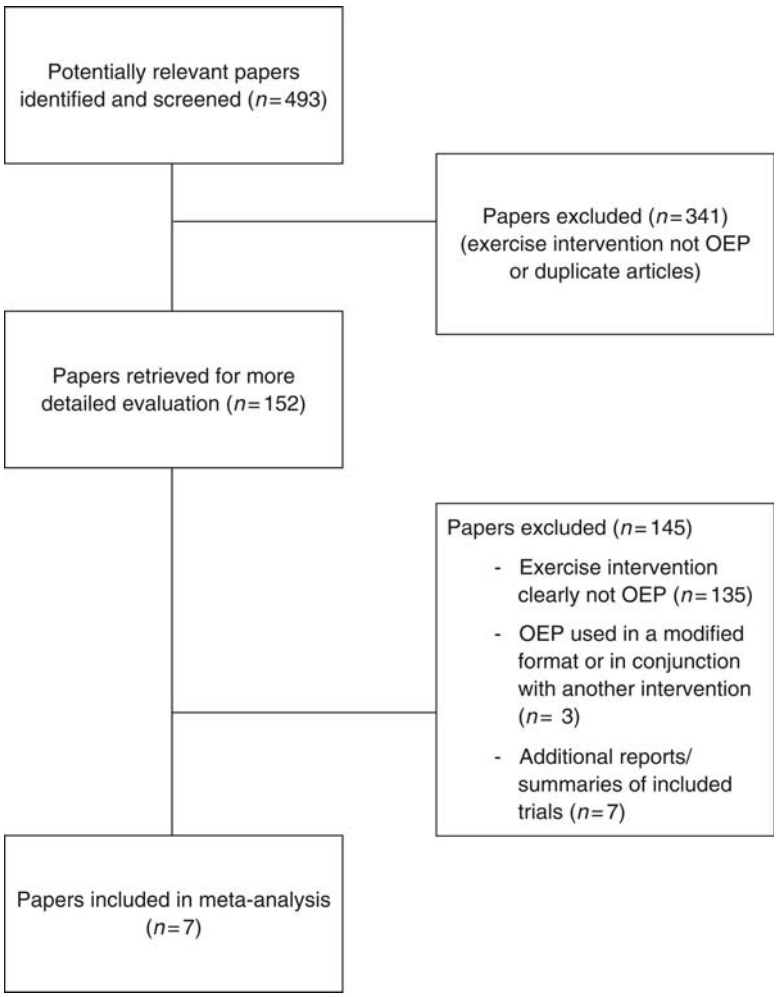


**Figure 1.** QUOROM statement flow diagram.

Table 1. Characteristics of included trials

| Author, reference | Quality (PEDro score) | Trial design | Sample size (intervention:control) | Follow-up (months) | Outcome measures | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mortality | Falls | Fall injuries | Compliance |
| Campbell *et al.* [20] | 8 | RCT (Year 1) | 233 (116:117) | 12 | ✓ | ✓ | ✓ | ✓ |
| Campbell *et al.* [24][a] | 5 | ✓RCT 2 × 2 factorial design | 93 (45:48) | 10 | ✓ | ✓ | ✓ | ✓ |
| Robertson *et al.* [25] | 8 | RCT | 240 (121:119) | 12 | ✓ | ✓ | ✓ | ✓ |
| Robertson *et al.* [26] | 4 | Controlled trial (3× exercise centres, 4× control centres) | 450 (330:120) | 12 | ✓ | ✓ | ✓ | ✓ |
| Campbell *et al.* [27] | 8 | RCT 2 × 2 factorial design | 391 (97:96) | 12 | ✓ | ✓ | ✓ | ✓ |
| Binns [22] | 5 | Controlled trial | 37 (19:18) | 6 | ✓ | ✗ | ✗ | ✗ |
| Liu-Ambrose *et al.* [23] | 8 | RCT | 59 (31:28) | 12 | ✓ | ✓ | ✗ | ✓ |

[a]Number of injurious falls, total number of falls, total follow-up time and total number of deaths sourced from the author [30].

obtain measures from more than 80% of the participants initially allocated to groups [20, 23, 25–27]. There is also some potential for bias in the reporting of falls outcomes; it relies on the participant's themselves accurately reporting on this and they are not 'blind' to the result.

### *Participants*

The mean age of participants was 81.6 (±3.9) years. Two trials included females only [20, 22], whereas the remaining five included both men and women. All trials included community-dwelling ambulant participants, who were not receiving any other form of physiotherapy.

### *Interventions*

All trials used the OEP in its original form, as described by Gardner *et al.* [16] as the sole intervention, except for one trial, which used a 2 × 2 factorial design where the OEP was combined with a reduction in psychotropic medications in one of the four groups [24]. The authors for this particular trial confirmed that the two interventions had no interaction effects and therefore considered it was appropriate to disseminate their results as exercise intervention versus no exercise intervention ignoring the psychotropic medication intervention. The other trial that used a 2 × 2 factorial design [27] had a definite interaction effect between the two interventions, OEP and a home safety assessment and modification programme, and therefore, the data extracted were those of the OEP group only versus the control group. It should also be noted that the OEP was not provided as a stand-alone treatment in this trial as it was coupled with vitamin D supplementation and should therefore be considered a 'multiple' as opposed to a 'single' intervention. However, a Cochrane review of falls prevention strategies indicated that overall vitamin D supplementation does not reduce falls [14] and it was not thought that vitamin D would have an impact on the other outcomes of interest, compliance to the exercise programme and mortality for the combined meta-analysis. The control intervention was usual care or social visits only in each of the seven studies analysed.

### *Outcomes*

All studies monitored risk of death, fall rates, injurious falls and compliance over a period of 12 months, except for Campbell *et al.* [21] who had a follow-up period of 10 months and Binns [22] who had a follow-up period of 6 months and who did not monitor compliance to the exercise programme. Binns [22] also had a relatively large loss to follow-up for falls data, however did account for all deaths within the participants over a 6-month period, so was therefore still included in the analysis for risk of death but excluded for falls data. Injurious falls were defined by all studies in the same manner. A 'serious' injury from a fall was that which resulted in a fracture, admission to hospital with an injury or where stitches were required. A 'moderate' injury involved bruising, sprains, cuts, abrasions or reduction in physical function for at least 3 days or if the participant sought medical help and the third classification was that of 'no injury'. Six studies reported compliance with the OEP over 12 months (Table 2).

## Mortality

The OEP significantly reduced the risk of death over 12 months (Risk Ratio = 0.45, 95% CI = 0.25–0.80, $P = 0.007$; fixed-effects model; Figure 2). If the Binns [22] study was removed from analysis due to shorter duration of follow up of only 6 months, the overall risk of death was still significantly reduced (risk ratio = 0.43, 95% CI = 0.24–0.78, $P = 0.006$). Risk of death was not significantly altered if 'random-effect' as opposed to 'fixed-effect' meta-analysis was conducted (risk ratio = 0.48, 95% CI = 0.27–0.86, $P = 0.01$).

## Fall rates

The pooled estimate of the incidence rate ratio (the effect of OEP on fall rates) was 0.68 (95% CI = 0.56–0.79, $P < 0.00001$; fixed-effects model; Supplementary data available in *Age and Ageing* online), indicating a positive effect of OEP on reducing fall rates over 12 months.

There was no significant difference in the risk of a serious or moderate injury occurring as a result of a fall in the OEP versus the control group (risk ratio = 1.05, 95%

Table 2. 12-Month compliance to OEP

| Author, reference | Exercising three times per week + (those still exercising/ those remaining in the ex group at 12 months) (%) | Exercising two times per week (those still exercising/ those remaining in the ex group at 12 months) (%) |
|---|---|---|
| Campbell *et al.* [20] | 48/114 (42) | Nil report |
| Campbell *et al.* [24] | 20/32 (63) | 23/32 (72) walking at least two times a week |
| Robertson *et al.* [25] | 49/113 (43) | 81/113 (72) |
| Robertson *et al.* [26] | 114/265 (43) | 164/265 (62) |
| Campbell *et al.* [27] | 36/195 (18) | 70/195 (36) |
| Binns [22] | Nil report | Nil report |
| Liu-Ambrose *et al.* [23] | 7/28 (25) | 16/28 (57) |
| Total | 274/747 (36.7) | 354/633 (55.9) |

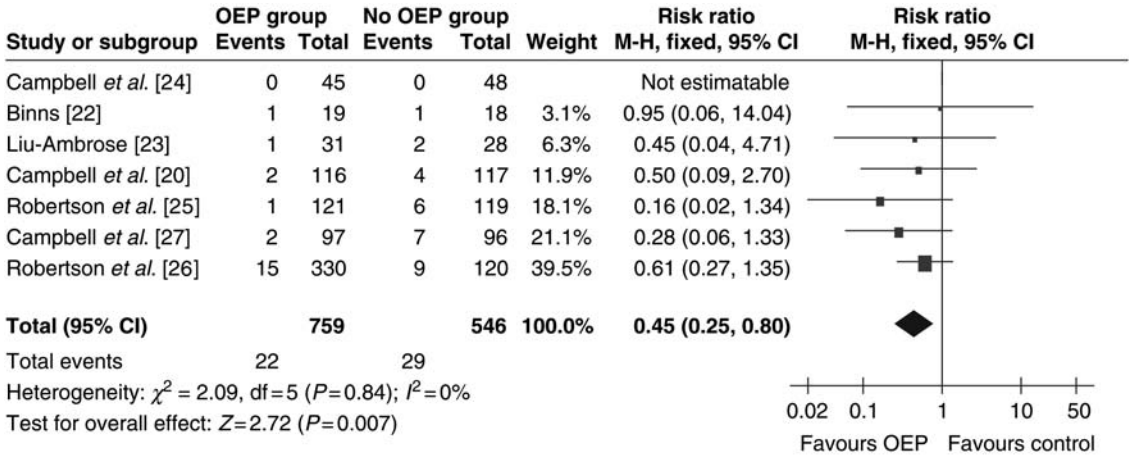


**Figure 2.** Forest plot of comparison: 'OEP' versus 'no exercise'; outcome: mortality.

CI = 0.91–1.22; Supplementary data available in *Age and Ageing* online), where events was the total number of injurious falls and 'total' was the total number of falls seen in the OEP versus the control group.

### Compliance

A total of 843 participants were randomised into a group receiving the OEP as an intervention (in the six studies who monitored compliance over 12 months). Of this, 747 participants remained in the studies until 12 months and 274 (36.7 ± 15.8%) of them were still exercising three or more times per week (ranging from 18 to 63%). This increased to 55.9% (±14.8%) ($n = 354$, ranging from 36% to 72%) in those studies who reported on compliance two times per week at 12 months (Table 2).

### Adverse events

Four of the included studies also reported on adverse events; with a total of six adverse events while participants were exercising according to instruction. These events included three falls [25, 26], one episode of pain due to the exercises, which was reported to the participants GP and she ceased exercising [26], one moderate injury but no fall [27] and two participants reported low back pain while exercising, with one participant resuming exercising following this complaint and the other ceasing any further exercise intervention [23]. The remaining three studies did not report on adverse events [20, 22, 24].

## Discussion

This meta-analysis provides evidence that the OEP significantly reduces the risk of death in the 12 months after it has first been initiated in older community-dwelling individuals. The quality of the included trials was of a high standard. All studies reassessed outcomes at 12 months, except for one which was only 10 months [24], and another which was only 6 months [22]. In most cases, dropout rates were low where measures of at least one key outcome were obtained for more than 80% of the study population, allocation was concealed, participants were randomly allocated to groups and groups were similar at baseline within trials and also across all trials included in the meta-analysis.

The homogeneity of the groups across all seven trials was supported by the low measures of statistical heterogeneity and the effect of OEP described in all trials was consistent and pronounced for fall rates, as has been previously described in the literature [17], and for death. This finding of the OEP reducing the risk of death in the first 12 months following the initiation of the programme

is new and adds to the findings of a recent longitudinal study that reported an association between a higher frequency of falls and an increased risk of death in older adults [28]. It is possible that this meta-analysis failed to support the previous finding of the OEP significantly reducing the risk of an injurious fall [17] because the authors of this review did not have access to individual-level data. The findings of this review provide further evidence to support the use of the OEP, especially in light of a recent systematic review of economic evaluations that determined that cost savings are delivered by the OEP in people aged ≥80 [29].

It is also possible that more impressive outcomes could be achieved if compliance to the exercise programme was maximised. Only 37% of participants originally allocated to the exercise groups and still participating in the trial at 12 months continued to comply with the programme at the recommended level of three or more times per week. One of the included trials ran subgroup analysis looking at the effect of the OEP in those who adhered to the programme appropriately and found that the rate of falls was 77% lower in those who exercised at least three times per week compared with those exercising less than once a week [27].

It should also be considered that 56% of participants complied with the programme a minimum of two times per week in the five trials that reported this data. Perhaps lower levels of compliance to OEP, at two times per week, can still result in favourable effects on health outcomes in this older population. This finding is supported by a recent systematic review looking to establish whether specific components of exercise programmes are associated with a larger reduction in falls [15]. It was concluded that a higher total dose of exercise equivalent to greater than 50 h over the trial period showed the greatest effects. Participation in the OEP at two times per week over 12 months would meet this guideline. Also, the study that reported the lowest levels of compliance [27], involved older community-dwelling adults who were also visually impaired, which may suggest that the standard delivery of the OEP is not appropriate for this population.

A limitation of this meta-analysis is that while the included studies were of a high quality, they involved trials that were predominantly conducted by the same group of researchers [20, 21, 24–27]. This allowed for a very homogeneous population to analyse; however, the results would be more robust if several different research groups had been able to replicate similar results. The homogeneity of the sample also means that the results should be interpreted with caution when considering using the programme in groups of participants who are not community-dwelling or normally independently ambulatory.

In conclusion, the findings of this meta-analysis suggest that the OEP appears to reduce death and fall rates over 12 months in older community-dwelling people; however, the numbers analysed were relatively low and the CI wide, to truly allow for the magnitude of benefit of the OEP on mortality over 12 months to be clear. Future falls studies should include mortality as an outcome to allow for this question to be further investigated. Issues around compliance were also prevalent; it is possible that greater effects on health outcomes could be achieved if compliance was maximised.

## Key points

- Otago exercise programme significantly reduces risk of death in older adults.
- Otago exercise programme significantly reduces falls in older adults.
- Significant results achieved with compliance to the programme two times per week.

## Acknowledgements

The authors wish to acknowledge Clare Robertson for her assistance in sourcing articles, for the provision of additional data for inclusion and for review of the final manuscript.

## Conflicts of interest

None declared.

## Funding

This work was supported by a grant from the National Health and Medical Research Council (426758) and a National Health and Medical Research Council Priority Public Health Research Scholarship (grant ID 480484) to S.T.

## Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

## References

1. Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G. Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. J Gerontol A Biol Sci Med Sci 2004; 59A: 255–63.
2. Fried LP, Tangen CM, Walston J *et al.* Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001; 56A: M146–56.
3. Ensrud KE, Ewing SK, Taylor BC *et al.* Frailty and risk of falls, fracture, and mortality in older women: the study of osteoporotic fractures. J Gerontol A Biol Sci Med Sci 2007; 62A: 744–51.
4. Campbell AJ, Spears GR, Borrie MJ. Examination by logistic regression modelling of the variables which increase the relative risk of elderly women falling compared to elderly men. J Clin Epidemiol 1990; 43: 1415–20.

5. Rubenstein LZ, Josephson KR. The epidemiology of falls and syncope. In: Kenny RA, O'Shea D, eds. Falls and Syncope in Elderly Patients Clinics in Geriatric Medicine. Philadelphia: W. B. Saunders Co., 2002.
6. Campbell AJ, Robertson MC, Gardner MM. Elderly people who fall: Identifying and managing the causes. Br J Hosp Med 1995; 54: 520–3.
7. Tinetti ME, Mendes de Leon CF, Doucette J, Baker D. Fear of falling and fall-related efficacy in relationship to functioning among community living elders. J Gerontol A Biol Sci Med Sci 1994; 49: M140–47.
8. Tinetti ME, Williams CS. The effect of falls and fall injuries on functioning in community-dwelling older persons. J Gerontol A Biol Sci Med Sci 1998; 52A: M112–9.
9. Kosorok MR, Omenn GS, Diehr P, Koepsell TD, Patrick DL. Restricted activity days among older adults. Am J Public Health 1992; 82: 1263–7.
10. Wood B, Bennie A, Armstrong M, Michael S, Cameron I. Falls: a coordinated strategy. Aust Health Rev 1999; 22: 144–54.
11. Rockwood K, Stadnyk K, MacKnight C, McDowell I, Hebert R, Hogan DB. A brief clinical instrument to classify frailty in elderly people. Lancet 1999; 353: 205–6.
12. Speechley M, Tinetti M. Falls and injuries in frail and vigorous community elderly persons. J Am Geriatr Soc 1991; 39: 46–52.
13. Moller J. Projected costs of fall related injury to older persons due to demographic change in Australia (revised). Report for Commonwealth Department of Health and Ageing, 2003.
14. Gillespie LD, Robertson MC, Gillespie WJ *et al*. Interventions for preventing falls in older people living in the community. Cochrane Database of Systematic Reviews 2009, Art. No. CD007146.
15. Sherrington C, Whitney JC, Lord SR, Herbert RD, Cumming RG, Close JCT. Effective exercise for the prevention of falls: a systematic review and meta-analysis. J Am Geriatr Soc 2008; 56: 2234–43.
16. Gardner MM, Buchner DM, Robertson MC, Campbell AJ. Practical implementation of an exercise-based falls prevention programme. Age Ageing 2001; 30: 77–83.
17. Robertson MC, Campbell AJ, Gardner MM, Devlin N. Preventing injuries in older people by preventing falls: a meta-analysis of individual-level data. J Am Geriatr Soc 2002; 50: 905–11.
18. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro Scale for rating quality of randomized controlled trials. Phys Ther 2003; 83: 713–21.
19. Portney LG, Watkins MP. Foundations of Clinical Research: Applications to Practice, 3rd edition. USA: Pearson Prentice Hall, 2009.
20. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Tilyard MW, Buchner DM. Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. Br Med J 1997; 315: 1065–9.
21. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Falls prevention over 2 years: a randomized controlled trial in women 80 years and older. Age Ageing 1999; 28: 513–8.
22. Binns E. The Otago exercise programme: do strength and balance improve? Masters, Auckland University of Technology, Auckland, 2005.
23. Liu-Ambrose T, Donaldson MG, Ahamed Y *et al*. Otago home-based strength and balance retraining improves executive functioning in older fallers: a randomized controlled trial. J Am Geriatr Soc 2008; 56: 1821–30.
24. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Psychotropic medication withdrawal and a home-based exercise program to prevent falls: a randomized, controlled trial. J Am Geriatr Soc 1999; 47: 850–3.
25. Robertson MC, Devlin N, Gardner MM, Campbell AJ. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 1: randomised controlled trial. Br Med J 2001; 322: 697–701.
26. Robertson MC, Gardner MM, Devlin N, McGee R, Campbell AJ. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 2: controlled trial in multiple centres. Br Med J 2001; 322: 701–4.
27. Campbell AJ, Robertson MC, La Grow SJ *et al*. Randomised controlled trial of prevention of falls in people aged ≥75 with severe visual impairment: the VIP trial. Br Med J 2005; 331: 817–20.
28. Sylliaas H, Idland G, Sandvik L, Forsen L, Bergland A. Does mortality of the aged increase with the number of falls? Results from a nine-year follow-up study. Eur J Epidemiol 2009; 24: 351–5.
29. Davis JC, Robertson MC, Ashe MC, Liu-Ambrose T, Khan K, Marra CA. Does a home-based programme in people aged ≥80 years provide the best value for money to prevent falls? A systematic review of economic evaluations of falls prevention interventions. Br J Sports Med 2010; 44: 80–9.
30. Robertson MC. Development of a falls prevention programme for elderly people: evaluation of efficacy, effectiveness, and efficiency. PhD, University of Otago, Dunedin, New Zealand, 2001.


**Received 15 December 2009; accepted in revised form 26 May 2010**