What Works in Falls Prevention After Stroke?  
A Systematic Review and Meta-Analysis

Frances Batchelor, MHS; Keith Hill, PhD; Shylie Mackintosh, PhD; Catherine Said, PhD

Background and Purpose—Falls are common after stroke. Despite evidence that single and multifactorial interventions can reduce falls in older people, this issue remains relatively underexplored in stroke survivors. Effective fall prevention in this population has the potential to prevent injury, improve quality of life, and decrease the likelihood of subsequent fear of falling and activity restriction. The aim of this article was to review and integrate the research evidence relating to interventions that reduce falls after stroke.

Methods—Published studies evaluating interventions to reduce falls in stroke survivors were retrieved and screened according to predetermined criteria. Included studies were independently assessed. Quality of trials was assessed using the Physiotherapy Evidence Database score. Pooling of results was undertaken for similar interventions with comparable outcomes using the inverse variance method.

Results—Thirteen studies met the inclusion criteria, with pooling of results possible for only 2 types of intervention. Methodological quality of the included studies was variable with the main bias because of lack of blinding of participants and those administering the intervention. Variability in falls data reporting was seen across the studies. The only intervention shown to be effective in reducing falls was vitamin D for female stroke survivors in an institutional setting. Other interventions were no more effective than usual care.

Conclusions—Fall risk is high in stroke survivors; however, the only intervention shown to be effective in reducing falls in this review was vitamin D supplementation. Consistency in outcome measurement would enable comparisons across studies. Additionally, further research evaluating a range of single and multifactorial interventions for fall prevention in the stroke population is required.  

(Stroke. 2010;41:1715-1722.)

Key Words: accidental falls ■ meta-analysis ■ stroke ■ intervention ■ systematic review

Stroke is one of the leading causes of disability worldwide.\cite{1} Consequences of stroke include physical, cognitive and psychological impairments, and, often, falls. Falls are common after stroke, with between 14% and 65% of stroke survivors experiencing falls while in hospital\cite{2,3,4} and up to 73% of stroke survivors experiencing a fall in the first 6 months after discharge home.\cite{5,6} These rates are higher than for older people in general.\cite{6} Falls in the stroke population may result in serious injury, with fracture rates up to 4-times higher than in the general population.\cite{7,8} Other less obvious consequences include increased fear of falling, which potentially leads to activity restriction, further compounding physical function deficits, and increased caregiver stress.\cite{9,10} Therefore, fall prevention is of vital importance for stroke survivors, their caregivers, and society.

Despite the evidence indicating that single and multifactorial fall prevention strategies are effective in reducing falls in older people across a range of settings,\cite{11,12} there is limited evidence in relation to stroke survivors, a clinical group at high risk for falls. Impairments commonly experienced after stroke, such as leg weakness, sensory loss, foot problems, visual problems, balance problems, and incontinence problems, may increase falls risk.\cite{13} Interventions addressing these issues have been shown to be effective in fall prevention in the older population, but are these interventions as effective in people with stroke? Additionally, people with stroke may have stroke-specific impairments such as neglect or inattention, which also contribute to falls risk. Examination of studies evaluating the effectiveness of a wide range of interventions directed at decreasing falls in the stroke population would provide valuable evidence on which to base practice.

To date there have been no published systematic reviews or meta-analyses evaluating falls prevention programs in the stroke population and, despite the large number of studies examining the effects of stroke-directed interventions (eg, strength training, circuit class training), it is unclear how many of these also include fall-related outcomes. Therefore,
the purpose of this review was to systematically evaluate the effects of any interventions on falls in people with stroke.

### Materials and Methods

#### Identification and Selection Criteria: Search Strategies

A systematic search of the literature was conducted in March 2009 of the following databases: Allied and Complementary Medicine, EMBASE, MEDLINE, PsycINFO, Cumulative Index to Nursing, and Allied Health Literature. In addition, Ageline, ProFANE, Physiotherapy Evidence Database (PEDro), NICE, and the Cochrane Library were searched to identify relevant studies. Before commencement, a protocol was developed and agreed on by the authors. Search strategies relevant to the database (using MeSH headings when appropriate) were developed to identify appropriate studies. Search terms were used “stroke, cerebrovascular accident,” and “accidental falls, falls, fallers, complications.” A sample search strategy is included in the Appendix. Reference lists of key studies and systematic reviews were also examined to identify additional studies.

#### Inclusion Criteria

The inclusion criteria for studies were:

1. Study design: randomized controlled trials.
2. Participants: adult stroke survivors (aged 18 years and older) at any stage after stroke and in any setting were included. When the study included participants with conditions other than stroke, the study was included if at least 80% of patients had a diagnosis of stroke or if separate data were available for participants with stroke.
3. Intervention: all interventions that may affect falls outcome were included. This included single interventions, multiple interventions (fixed combination of interventions applied to all participants), and multifactorial interventions (>1 main category of intervention, with the particular combination of interventions based on individual assessment).11 Interventions at the individual level (eg, balance training, exercise therapy, treatment for inattention or neglect, or medication treatments) or at a systems level (eg, models of stroke care) were included.
4. Outcomes: primary or secondary fall-related outcomes were included. Any definition of accidental falls and any form of falls measurement (eg, falls/1000 bed days, time to first fall) were included.

#### Exclusion Criteria

Studies were excluded if written in languages other than English. Studies also were excluded if they used only laboratory-induced falls as an outcome.

#### Selection of Studies/Assessment of Methodological Quality

From the initial search, titles and abstracts were reviewed to determine if each study was suitable for inclusion. Full articles were retrieved for studies that were not clearly excluded from review of the title and abstract, and they were reviewed to determine eligibility for inclusion. Once included, studies were evaluated for methodological quality according to the PEDro criteria and scoring system, which has fair-to-good reliability.14–15 The PEDro scale, designed to rate methodological quality of randomized controlled trials has 11 items, 1 of which assesses external validity and does not receive a score. The remaining 10 assess internal validity and are assigned 1 point each if the criterion for that item is satisfied. One reviewer (F.B.) rated each study and this score (a maximum of 10 points) was compared with the score provided on the PEDro database, when available. If scores differed, then a second rater reviewed the studies (K.H., S.M.) and, when difference still existed, consensus was reached by discussion. For studies not rated on the PEDro database, 2 authors (F.B. and 1 other) independently rated the article quality, with a third rater used to adjudicate when ratings differed. In this way, 2 assessors independently reviewed all articles for quality. Studies achieving a PEDro score of ≥4 were considered to be of higher methodological quality, and studies rating ≤3 were considered as being of lower quality.17

#### Data Extraction

Data were extracted by 2 reviewers (F.B. and 1 other) using a customized form. When difference existed, consensus was reached by discussion.

#### Data Analysis

For the purpose of meta-analysis, results were combined for similar interventions with comparable outcomes (fall rate, fallers), either by using data reported in the study or by using data able to be calculated from published or unpublished data. Meta-analysis was undertaken using RevMan5 software (The Nordic Cochrane Centre, The Cochrane Collaboration).18 The F statistic was used to assess heterogeneity,19 and a random-effects model was used when there was significant statistical heterogeneity.20 The inverse-variance method was used for meta-analysis, with the natural logarithm of the rate ratio (for falls rate) or the risk ratio (for proportion of fallers) entered, as used in a recent Cochrane review of falls interventions for community-dwelling older people.21 Studies were excluded from the meta-analysis if insufficient information was provided to enable faller or fall rate calculation, for example, if the duration of follow-up was not specified. If a study reported the rate ratio and 95% confidence interval (falls per person-time), then this was used in the meta-analysis. When possible, study authors were contacted to obtain or clarify data, and these data were used if the information was available. If the falls rate was not reported, then it was calculated from the raw data and the 95% confidence intervals for the ratios were calculated using a macro, and then the standard error of the rate (or risk) ratio was calculated.

#### Results

#### Search

The initial search strategy yielded 677 potentially relevant studies. Of these, 619 were rejected on title, abstract, or keywords. Fifty-eight full articles were retrieved and, of these, 45 did not meet the inclusion criteria (reasons detailed in Figure 1). Therefore, a total of 13 randomized controlled studies were included in the review.

The Table summarizes the general characteristics and outcomes of the included studies. Four studies used the same study population, with follow-up of participants at different
### Table 1. Summary of Included Studies

<table>
<thead>
<tr>
<th>Study (Year of Publication)</th>
<th>Participants</th>
<th>Setting</th>
<th>Intervention N at Follow-Up</th>
<th>Control N at Follow-Up</th>
<th>Duration of Intervention</th>
<th>Falls Outcome Measure</th>
<th>Result</th>
<th>Agreed PEDro Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barreca et al (2004)</td>
<td>N=48; 30 days after stroke, age 18–90</td>
<td>Inpatient rehabilitation units, Canada</td>
<td>N=25 Group STS practice 3 × per week, 45 min usual care</td>
<td>N=23 Recreational therapy 3 × (control for STS practice) usual care</td>
<td>I: median 37 days C: median 57 days</td>
<td>Falls during time of the study</td>
<td>N (%): fallers No explicit falls definition</td>
<td>Falls: I=6 C=6 Fallers: I=3 (12.0%), C=4 (17.4%), P=0.70</td>
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<tr>
<td>(2008)</td>
<td>Inclusion: unable to perform sit-to-stand independently</td>
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<td>5</td>
</tr>
<tr>
<td>Bernhardt et al(2008)</td>
<td>N=71; Acute stroke &lt;24 hours after stroke, age 74.7 (mean), 46% female</td>
<td>Acute hospital stroke units, Australia</td>
<td>N=38 Very early mobilization emphasizing upright and out of bed at least 2 × per day, 6 days per week usual care</td>
<td>N=33 Usual care: PT/nursing/OT</td>
<td>First 14 days after stroke or until discharge (whichever sooner)</td>
<td>Falls during stroke unit stay (maximum 14 days) and at 3 months</td>
<td>No explicit falls definition</td>
<td>Falls: I=67 C=28 P=0.51 Fall rate during stroke unit stay: I=19.7 falls/1000 bed-days, C=22.9 falls/1000 bed-days, P=0.81</td>
</tr>
<tr>
<td>(2001)</td>
<td>Inclusion: ambulant exclusion: other neurological conditions</td>
<td>Inpatient rehabilitation units, Taiwan</td>
<td>N=30 30 min standing symmetry training, 15 min rest, 20 min STS training daily (with biofeedback) usual care</td>
<td>N=24 Usual care: conventional stroke rehabilitation including neuromuscular facilitation, FES, mat exercises, other exercises</td>
<td>5 × per week for 3 weeks</td>
<td>N (%): fallers Fallers: ≤2 falls in 6 months Falls caused by environmental factors (slipping on slippery ground, tripping) excluded</td>
<td>Fallers: I=5 (16.7%), C=10 (41.7%), P=0.05</td>
<td></td>
</tr>
<tr>
<td>Cheng et al (2003)</td>
<td>N=54; 2–4 months after stroke</td>
<td>Inpatient rehabilitation units, Canada</td>
<td>N=30 30 min standing symmetry training, 15 min rest, 20 min STS training daily (with biofeedback) usual care</td>
<td>N=24 Usual care: conventional stroke rehabilitation including neuromuscular facilitation, FES, mat exercises, other exercises</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Green et al (2002)</td>
<td>N=170; &gt;1 year after stroke, age &gt;50 years</td>
<td>Community, UK</td>
<td>N=80 (at 3 months) N=77 (at 6 months) N=74 (at 9 months) Community PT sessions, main interventions: gait re-education, exercises, functional exercises, balance exercises</td>
<td>N=81 (at 3 months) N=74 (at 6 months) N=72 (at 9 months) No additional treatment</td>
<td>Median N of treatments=3 (IQR 2–7); range=0–22 Mean duration of treatment=44 min</td>
<td>N (%): fallers at 3 monthly intervals over 9 months</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Rossi et al (1990)</td>
<td>N=39; Stroke patients with unilateral visual neglect or homonymous hemianopia</td>
<td>Inpatient rehabilitation, USA</td>
<td>N=18 Fresnel prisms applied to affected hemi-field worn for daytime activities usual rehabilitation including visual retraining</td>
<td>N=21 Usual rehabilitation including visual retraining</td>
<td>Not stated</td>
<td>N of falls in 4 weeks</td>
<td>Falls definition: patient’s knees, buttocks, or trunk unintentionally contacting the floor Falls recorded on standardized forms</td>
<td>Falls: I=4 C=4 P not reported</td>
</tr>
<tr>
<td>(2003)</td>
<td>Inclusion: dementia, total disability, medications interfering with vitamin D metabolism, time spent outside hospital in previous 6 months</td>
<td>Convalescent hospital, Japan</td>
<td>N=109 Sunlight exposure outdoors for 15 min/day</td>
<td>N=108 No additional sunlight exposure</td>
<td>12 months</td>
<td>N of falls in 12 months No explicit fall definition</td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>Study (Year of Publication)*</th>
<th>Participants</th>
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<th>Falls Outcome Measure</th>
<th>Result</th>
<th>Agreed PEDro Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Von Koch et al11 (2000)</td>
<td>N=40</td>
<td>As for Widén Holmquist 1998 study</td>
<td>N=40</td>
<td>As for Widén Holmquist study</td>
<td>Self-reported N of falls in 6 months</td>
<td>Falls: 0–6 months: no difference in N of falls between I and C (numbers not reported, P not reported)</td>
<td>Frequent fallers 0–6 months (&lt;1 fall): I=10 (25.0%), C=7 (18.4%), P&lt;0.001</td>
<td>6</td>
</tr>
<tr>
<td>Widén Holmquist et al11 (1998)</td>
<td>N=83; patients eligible for rehabilitation</td>
<td>Community, Sweden</td>
<td>N=41 Home rehabilitation Multidisciplinary outreach service with PT, OT, speech therapy, and SW and assignment of case manager</td>
<td>N=40 Routine rehabilitation</td>
<td>3–4 months of program duration</td>
<td>Self-reported N of falls in 3 months</td>
<td>Falls (unpublished data): I=20: C=19+ Fallers (≥1 fall): I=14/41 (34%), C=11/40 (27.5%), P=0.684 Recurrent fallers (&gt;1 fall): I=4/41 (9.8%), C=5/40 (12.5%)</td>
<td>7</td>
</tr>
<tr>
<td>Sato et al21 (2005c)</td>
<td>N=280; Men &gt;65 years &gt;3 months after stroke, ambulant, &quot;convalescent&quot; setting for follow-up not reported</td>
<td>Japan</td>
<td>N=134 2.5 mg oral risedronate sodium daily</td>
<td>N=133 Placebo daily</td>
<td>18 months</td>
<td>N of falls over 18 months Falls definition: fall caused by unexpected loss of balance Fallers: patients who fell at least once in 3 months during study period</td>
<td>Falls: I=269, C=278 Fall rate (for fallers only): I=4.2 falls/person/year, C=4.2 falls/person/year, P not reported</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>N=374; Women &gt;65 years with hemiplegia/paresis of upper and lower limbs</td>
<td>Acute hospital, Japan</td>
<td>N=173 2.5 mg oral risedronate (pyridinyl bisphosphonate) daily</td>
<td>N=172 Placebo</td>
<td>12 months</td>
<td>N of falls over 12 months Falls definition: fall caused by unexpected loss of balance Fallers: at least 1 fall in 3 months during study period</td>
<td>Falls: I=1, C=0, no difference in N, P=0.90, numbers not reported</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>N=96; Hospitalized elderly women with poststroke hemiplegia</td>
<td>Convalescent hospital, Japan</td>
<td>N=43 Ergocalciferol, daily dose of 1000 IU ergocalciferol Adherence assessed through pill count of returned tablets</td>
<td>N=42 Placebo</td>
<td>2 years</td>
<td>N of falls per person over 2 years Falls defined as fall caused by loss of balance, recorded by nursing staff if they observed or received information about a fall</td>
<td>Falls: I=22, C=136, 71% reduction in falls accounted for by vitamin D (estimate 0.95; 95% CI, 0.9%–95%, P=0.0002) after adjustment for covariates Fallers: I=11 (25.6%), C=33 (78.6%), RR=0.33 (85% CI, 0.19–0.56; calculated from raw data) Excess falls (N of falls in intervention period–N of falls in pretreatment period): lower in vitamin D group (P&lt;0.0042), P only reported</td>
<td>9</td>
</tr>
</tbody>
</table>

(Continued)
time points.21–24 In total, 1473 participants were involved in the included studies, with 742 (50.4%) receiving intervention. Most studies had relatively small sample sizes, with 4 studies having intervention/control groups of 40 participants or less. The settings for the trials varied and included acute care,25 rehabilitation,26–28 community,21–24,29 and residential or institutional care30–32 settings. One study specified the setting for recruitment but not the setting for follow-up.33

### Intervention Types

Included studies were grouped under the following themes: physical activity interventions, including balance training, exercise, strength training (4 studies);25–27,29 modifying the environment or improving knowledge (1 study);28 models of stroke care, for example, comparing home rehabilitation with standard rehabilitation (amount of therapy comparable; 4 studies using the same population);21–24 and medication or treatment aimed at influencing bone mineral density (4 studies).30–33 No studies evaluating the effectiveness of a multifactorial falls prevention intervention in the stroke population were found.

### Outcomes

Outcome measures differed between the trials in terms of fall definition, measurement, and reporting of falls.

#### Fall Definition

Of the 13 studies, 4 provided an explicit definition of a fall,28,30,31,33 whereas 8 provided no explicit definition.21–26,29,32 One study27 did not define falls specifically but excluded falls that were the result of environmental factors, such as tripping or slipping. Of the 4 studies with an explicit falls definition, 3 used the same or a similar definition30,31,33 (falling caused by unexpected loss of balance), and 1 defined a fall as the unintentional contact of body parts with the floor.28

#### Fall Measurement

Only 1 study used falls calendars over a period of 12 months to prospectively collect falls data.31 Of the community-based studies, retrospective recall (self-report) over varying time periods ranging from 3 to 12 months was used. For studies based in institutions, falls data were collected by observation and report or from incident reports or hospital files in 2 studies.26,28 For 4 studies, the method of falls measurement was not reported.25,27,29,32

### Fall Data

There were differences in reporting falls data between the studies. The units of analysis included number of falls, fall rate (for example, falls per person-year or falls per bed-day), number (or percentage) of fallers, and number (or percentage) of recurrent fallers. Most studies reported raw data for number of falls and number of fallers.

#### Methodological Quality

The PEDro scores ranged from ten to 4 out of a maximum of 10 (Table). The main biases were lack of blinding of therapists and participants to the intervention, lack of allocation concealment, and lack of intention-to-treat analysis.

#### Effectiveness

Effectiveness of interventions was considered in terms of fall rate and proportion of fallers and presented as rate ratios and

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### Table 1. Continued

<table>
<thead>
<tr>
<th>Study (Year of Publication)*</th>
<th>Participants</th>
<th>Setting</th>
<th>Intervention N at Follow-up</th>
<th>Control N at Follow-up</th>
<th>Duration of Intervention</th>
<th>Falls Outcome</th>
<th>Measure</th>
<th>Result</th>
<th>Agreement</th>
<th>PEDro Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Von Koch et al23 (2001)</td>
<td>12-month follow-up</td>
<td>As for Widén Holmqvist study</td>
<td>N=39</td>
<td>N=38</td>
<td>As for Widén Holmqvist study</td>
<td>Self reported falls in 12 months</td>
<td>Falls: I=64 (IOR, 1–10), C=68 (IOR, 1–10), P=0.74</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thorsen et al24 (2005)</td>
<td>5-year follow-up</td>
<td>As for Widén Holmqvist study</td>
<td>N=30</td>
<td>N=23</td>
<td>As for Widén Holmqvist study</td>
<td>Self reported falls over 6 months before follow-up</td>
<td>Falls: I=19 (63%), C=14 (61%), P=0.86</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Listed in alphabetical order, except for last 3 studies (same sample as Widén Holmqvist 1998).

AMTS indicates Abbreviated Mental Test Score; C, Control; CI, confidence interval; FES, functional electrical stimulation; HR, hazard ratio; I, Intervention; IQR, interquartile range; MMSE, Mini Mental State Examination; NS, nonsignificant; OT, occupational therapy; PEDro, Physiotherapy Evidence Database; PT/physio, physiotherapy/physical therapy; RR, risk ratio; STS, sit to stand; SW, social work.
risk ratios, respectively. The unpooled effect estimates and 95% CI are summarized in Figure 2 and Figure 3. The only significant difference in effect of an intervention compared with a control was seen in the study comparing vitamin D with placebo in female stroke survivors, which found a significant reduction in fall rate and proportion of fallers in those using vitamin D. For the remaining studies, no significant effect of the intervention on fall rate or proportion of fallers was found, although the results from 1 study were close to being significant. Although the group difference for this study was reported as statistically significant by the authors (using χ² analysis), the result was borderline significant when data from the article were used to calculate risk ratios (95% CI, 0.16–1.00).

Meta-Analysis

Pooling of results was possible for 3 comparisons in 2 intervention types: exercise vs usual care (fall rate, fallers) and bisphosphonate medication vs placebo (fallers). Three studies examined the effects of exercise compared with usual care; however, for the outcome of fall rate, only 2 studies could be pooled because 1 study reported only the proportion of fallers and not the number of falls. Similarly, only 2 studies could be included in the meta-analysis when analyzing the effect of exercise on the proportion of fallers because of lack of available data. When pooled, there was no significant effect of exercise on fall rate (rate ratio, 1.22; 95% CI, 0.76–1.98) or proportion of fallers (risk ratio, 0.77; 95% CI, 0.42–2.43). When comparing bisphosphonate with placebo, results from 2 studies were combined, with no significant effect found for proportion of fallers (risk ratio, 0.95; 95% CI, 0.73–1.22). Pooling was not possible for the studies comparing home rehabilitation with conventional rehabilitation because these studies used the same study population assessed at different time points.

Discussion

This review found few studies meeting the inclusion criteria, and pooling of results was possible for a limited number only. Limitations in the meta-analysis occurred because interventions were not comparable and reported falls outcomes were not consistent across studies.

Significant effects were found in only 1 study: vitamin D supplementation in female stroke survivors in an institutional setting, with a significant decrease found in fall rate and percentage of fallers. No significant effects were found in the remaining included studies, either individually or for pooled results.

Potential reasons for the lack of significant results may relate to the type of intervention and measurement of outcome. Most studies used single interventions, which may be effective in the nonstroke population but may not be effective in people with stroke. For most included studies, falls were measured as a secondary outcome, so studies were not powered to detect differences in fall outcomes. In addition, interventions may not have been specifically designed to reduce falls, so an effect would not be expected.

For studies with exercise as the intervention, the exercise may not have been of sufficient intensity, duration, and type to produce a significant effect. A recent meta-analysis of almost 50 falls prevention, exercise-based, randomized, controlled trials with older people identified that the exercise program needed to incorporate balance training (alone or in combination with other exercise types) and needed to have a dosage of sufficient duration and frequency (for example, at least twice per week for 25 weeks) to reduce falls.

Additionally, some studies met the inclusion criteria but implemented interventions that were unlikely to reduce falls. For example, bisphosphonates have an effect on bone mineral density, which is likely to decrease fracture risk but is less likely to decrease falls risk.

The likely mechanism for the effectiveness of vitamin D in this at-risk population relates to the role of vitamin D in muscle function. Supplementation with vitamin D with or without calcium may contribute to increased muscle strength and also to a decreased risk of falls, either directly or indirectly. The study reporting a significant decrease in falls after vitamin D supplementation also found a significant increase in muscle strength and positive correlations between muscle fiber diameter (type II) and serum 25-hydroxyvitamin D levels. Although low-dose vitamin D supplementation was shown to be effective, no significant effect on falls was found in the study comparing sunlight exposure with a control, despite a significant increase in serum 25-hydroxyvitamin D in the exposed group, potentially because the increase was not sufficient to have influenced muscle strength or falls risk.

As mentioned, there was considerable disparity in outcome measures, including differences in fall definition, measurement, and reporting of falls. Duration of follow-up also differed between the studies, making comparison difficult. To enable comparisons to be made, outcomes should be standardized, utilizing recommended internationally endorsed outcomes. Measuring falls prospectively over a period of 12 months using monthly calendars or diaries with follow-up telephone calls is considered the gold standard when collecting falls data for community-based trials. Most community-
based studies included in this review used retrospective recall, which is likely to under-report falls.\textsuperscript{37-38} For studies based in institutions, collecting falls information from incident reports or hospital files also may have led to an underestimation of falls because of under-reporting.\textsuperscript{39}

The methodological quality of the included studies varied, with 8 studies scoring $\leq$6 points, indicating a reasonably high level of bias. However, it is difficult to achieve the maximum PEDro score for trials involving exercise because blinding of participants and those providing the exercise intervention is difficult. Because of this, absolute blinding of outcome assessors is of paramount importance. Of the 13 studies, 10 reported using outcome assessors who were blind to group allocation.

## Conclusion

Although falls are common after stroke, there is very little high-quality evidence on successful approaches to reducing falls in this group and no published, randomized, controlled trials of multifactorial interventions specifically in this population. Current evidence suggests that low-dose vitamin D may reduce falls in female stroke survivors in an institutional setting; however, the applicability of this intervention to all stroke survivors or at earlier poststroke stages has not yet been determined.

This study highlights the need for randomized controlled trials specifically aimed at reducing falls in stroke. There is a need for commonality in the ways falls are defined, measured, reported, and analyzed. The knowledge gained from appropriately designed studies evaluating multifactorial interventions that include strength and balance training, vitamin D supplementation, and strategies targeting falls risk factors, and that report comparable outcomes, will contribute to improved falls prevention and, ultimately, a reduction in falls for this high-risk population.

## Appendix

### Example of Search Strategy

**Medline via OVID**

1. exp Stroke/
2. cerebrovascular accident.mp
3. 1 or 2
4. exp Accidental Falls/
5. falls.tw
6. faller$.tw
7. complications.tw
8. 4 or 5 or 6 or 7
9. 3 and 8
10. randomized controlled trial.pt
11. clinical trial.pt
12. randomly allocated.tw
13. Random Allocation/
14. Randomized Controlled Trial/
15. 10 or 11 or 12 or 13 or 14
16. 9 and 15

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## References

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http://stroke.ahajournals.org/content/41/8/1715

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