Do exercise interventions designed to prevent falls affect participation in life roles? A systematic review and meta-analysis

Nicola Fairhall1,2, Catherine Sherrington1, Lindy Clemson3, Ian D. Cameron2

1Musculoskeletal Division, The George Institute for Global Health, The University of Sydney, Sydney, NSW, Australia
2Rehabilitation Studies Unit, The University of Sydney, Sydney, NSW, Australia
3Faculty of Health Sciences, The University of Sydney, Sydney, NSW, Australia

Address correspondence to: N. Fairhall. Tel: (+61) 400303626; Fax: (+61) 2 9657 0301. Email: nfairhall@georgeinstitute.org.au

Abstract

Background: the World Health Organization describes individuals’ functioning at a societal level as ‘participation’. Despite being a key component of functioning and an important goal of rehabilitation, participation is not measured consistently in ageing research. The aim was to evaluate the extent to which measurement of participation has been reported in trials of fall prevention interventions and to determine the effect of exercise interventions on participation in life roles.

Methods: systematic review with meta-analysis. Randomised controlled trials of exercise interventions that aimed to reduce falls in older people (60+) in community, aged care facilities or hospital settings were included. The outcome of interest was participation in life roles. Trials that measured participation at two time-points were included in the meta-analysis.

Results: ninety-six trials met the review inclusion criteria. Participation was measured in 19 of these trials (20%). Nine instruments were used to measure participation. Fifteen trials, involving 3,616 participants, were included in the meta-analysis. The pooled estimate of the effect of interventions including exercise indicated a small improvement in participation ($Hedges' g = 0.16$, 95% confidence interval = $0.04 - 0.27$, $P = 0.006$). Meta-regression showed multifactorial intervention with an exercise component had a larger effect than exercise intervention alone, but the difference was not statistically significant (effect on $Hedges' g = 0.22$, 95% CI = $-0.05$ to $0.50$, $P = 0.10$).

Conclusion: interventions including exercise may improve participation in life roles in older people. The International Classification of Functioning, Disability and Health may be a useful framework for understanding the broader impact of falls prevention interventions.

Systematic review registration: ACTRN12610000862044.

Keywords: falls, exercise, participation, meta-analysis, elderly

Introduction

Falls are common and create a burden both on the individual and the community. Falls are often injurious and reduce functional ability, confidence, independence and autonomy. The large costs associated with older people falling will increase in the future and present a major problem for health systems and society. Evaluation of falls prevention interventions has focused on rate of falls, impairment of body function (e.g. strength, reaction time) and performance of tasks or activities. However, falls also affect the more complex aspects of functioning such as social participation [1], which will impact profoundly on the older individual, their caregivers and society.

Participation is the term endorsed by the World Health Organization to describe individuals’ functioning at a societal level. Defined as ‘involvement in life situations’ [2], participation is one of three components of function in the International Classification of Functioning, Disability and Health (ICF). Participation restriction includes problems experienced in social interaction, employment, using transportation and community, social and civic life. Participation restriction has been identified in older adults [3], and the incidence of restriction is increased in individuals at risk of...
falling [4], those with a history of falls [1, 5], or a fear of falling [6]. This has implications for older adults, as participation outcomes are associated with health-related quality of life [7] and survival [8]. In addition, individuals with health conditions likely to affect functioning (such as stroke and traumatic brain injury) report participation outcomes at the societal level are more important than outcomes at the anatomical/physiological level or the individual level of functioning [9].

The effects of fall prevention intervention on outcomes at a societal level are unclear. There is scant evidence to guide interventions targeting participation restriction, as previous research has focused on the cause and measurement of participation, rather than intervention. Exercise programmes are a promising therapy, as they reduce falls [10, 11] and target elements of functioning related to participation, such as balance, mobility and physical activity levels. Examination of the effect of falls prevention exercise on participation will increase our understanding of how interventions influence participation and may provide opportunities to enhance outcomes for people at risk of falling. We therefore conducted the first systematic review of measurement of participation in trials of falls prevention interventions and the first meta-analysis of the effect of exercise on participation in older people.

Focusing on randomised controlled trials that evaluated the effect of exercise intervention on falls in older people, the objectives of this systematic review are to: (i) identify outcome measures used to evaluate participation; (ii) quantify the extent to which participation was measured and (iii) use meta-analysis to determine whether exercise interventions targeting falls increase participation in older people.

**Methods**

**Identification of trials**

Trails included in Cochrane Reviews of interventions to prevent falls in the community [10] and nursing care facilities and hospitals [11] were identified. We updated the searches used in the Cochrane Reviews by re-running the search strategies from the date last searched to May 2010. The original Cochrane Review searches were not limited for earliest publication year. Our literature search (search strategy documented in Appendix 1 of Gillespie et al. [10] and Cameron et al. [11]) was conducted in May 2010 in six databases: MEDLINE, AMED, EMBASE and PsycINFO (searched via OVID), CINAHL (searched via EBSCO) and The Cochrane Central Register of Controlled Trials. Searches were performed without language restrictions. One investigator (N.F) screened titles and abstracts to determine whether a trial should be included. Relevant articles were obtained and their reference lists screened.

**Search strategy and selection criteria**

The full text of potentially eligible trial reports was independently evaluated against predetermined inclusion criteria by two authors (N.F and C.S.), on a pre-tested data collection form. Contrasting opinion about trial eligibility was resolved by discussion. Included trials were randomised or quasi-randomised controlled trials of exercise interventions for older people. Eligible studies either specified participants were aged 60 years or over, clearly recruited participants described as elderly or senior, or in the case of trials including younger participants with a specific diagnosis (e.g. stroke), had a mean age minus one standard deviation exceeding 60 years. Studies were based in participants’ homes, aged care facilities or hospital. Study interventions comprised exercise, either in isolation or as a component of a multi-faceted intervention, and were delivered as part of the study. Studies referring people to an exercise programme were excluded. The effects of the intervention were compared with placebo, alternate therapy or usual care. Outcome measures evaluated number of falls, rate of falls or number of fallers, indicating the intervention was designed to reduce falls in older people.

For the included studies, all reported outcome measures were collated. Copies of all measurement instruments potentially measuring participation were acquired. Instruments were identified if they were designed to measure the societal factors associated with health conditions, or they were health-related quality of life or generic health measures. The instruments’ items were linked to the ICF using established linking rules [12], then assessed against instrument selection criteria published by Noonan et al. [13], to determine whether the ICF concept of participation was measured. The criteria were: inclusion of at least three domains from chapters 3 to 9 of the activities and participation sections of the ICF; designed for community use. The use of ICF terminology in the instrument was not essential. Instruments meeting these criteria for participation were included if they were self or interview administered, generic and constructed for adults [13]. Instruments were classified as health-status instruments if they contained multiple ICF concepts [14], for example the EuroQol (EQ-5D) which evaluates body functions, activity and participation.

**Data extraction and quality assessment**

Data regarding trial characteristics and estimates of effect of the intervention were extracted from the included trials by one author (N.F) and checked by a second author (C. S.). Disagreement was resolved by consensus. Duplicate publication bias was avoided by comparing author names, sample sizes, interventions and outcomes. All outcome data were confirmed with the original articles and only published data were used.

Information about the method (i.e. design, participants, intervention) and outcomes (i.e. description of each
outcome, time points for data collection, number of participants and estimates of intervention effect) were extracted using a pilot-tested data extraction form.

Risk of bias of included studies was assessed (by N.F and C.S.) using the Cochrane risk of bias tool [15]. Author agreement was evaluated and disagreement was resolved by discussion. Trials were not excluded on the basis of this assessment.

Data synthesis and analysis
Trials measuring participation at least once were included in evaluation of the proportion of trials that measured participation. Meta-analysis was performed as the authors deemed the included trials adequately homogeneous in terms of participants, intervention, outcomes and measurement time point. Trials with measurement of participation at baseline and follow-up were included in the meta-analysis. In the event that a trial reported results of more than one participation outcome, only one outcome was included in the meta-analysis. Measures that incorporated the individual’s perception of their participation were prioritised over measures assessing frequency of nominated activities, commensurate with the ICF construct of participation.

The first post-intervention time-point was used for meta-analysis as it reflected the effect of the intervention and was the most consistent time-point across the different trials. For trials with two intervention groups receiving similar intervention, we combined the data from both groups to create a single pair-wise comparison with the control group [15]. Where the study sample size exceeded 70, and the median and inter-quartile range were reported, the median was used as an approximation of the mean and the inter-quartile range was estimated as 1.35 standard deviations [15, 16]. Unadjusted values were used in the meta-analysis, but in the case that only adjusted values were reported, these values were entered. Effect sizes from studies evaluating multifaceted or single exercise interventions were combined. Random effects meta-analyses were conducted with Comprehensive Meta-Analysis software (Version 2, Biostat, Englewood, NJ, USA). The standardised mean difference (Hedges’g) was calculated for each meta-analysis, standardised by post-score standard deviation and calculated using the pre- and post-mean and standard deviation or, when this was unavailable, the mean change score and pre-post correlation of 0.6 (from our own data). Analyses were repeated using correlations of 0.4 and 0.8, with essentially no change in results. Egger’s test was used to assess publication bias. Heterogeneity between pooled trials was quantified using the $I^2$ and $Q$ statistics. Where there was substantial heterogeneity between studies ($I^2$ test value >50%) [15], we attempted to explain the variation; pre-specified univariate random effects meta-regression was conducted using the ‘metareg’ command in Stata v. 10 (College Station, Texas, USA) to assess the associations between the type of intervention (exercise only or multi-faceted with an exercise component) and estimates of the effect of intervention on participation.

Results
Trial flow and study characteristics
The database search yielded 5,427 records, of which 130 were assessed against inclusion criteria; the remainder were screened as clearly not meeting the inclusion criteria (Figure 1) [17]. Ninety-six of the 130 trials assessed in detail met the inclusion criteria. Extraction of outcome measures from the 96 trials identified 19 discrete trials containing nine instruments that met the criteria for a measure of participation. Four trials were excluded from the meta-analyses because they reported participation outcomes at only one time-point [18–21]. The meta-analysis contained 15 trials with a total of 3,616 participants. Characteristics of the included trials are summarised in Table 1 [22–36].

Twelve of the trials were undertaken in the community and three in aged care facilities [22–24]. History of falls, or presence of at least one fall risk factor, was an inclusion criterion in eight trials and four studies specified participants were recently discharged from hospital. The majority of trials ($n = 12$) delivered exercise as a single intervention, rather than a component of multiple [28, 34] or multifactorial [24] interventions.

The risk of bias assessment [15] for each included study is shown in Appendix 1 (please see Appendix 1 in the Supplementary data available in Age and Ageing online). The risk of bias from sequence generation was considered to be low in 11 of the studies and to be unclear in the remaining four trials. Risk of bias from concealment of allocation was assessed as low in eight studies and unclear in the remaining seven. Blinding of outcome assessment was judged at high risk of bias in all studies, as participation was measured via self-report. Registered trial protocols were identified for four of the included trials [22, 24, 30, 34], leaving potential for bias due to selective reporting in the remaining trials. Overall, the quality of 6 of the 15 trials was assessed as meeting the criteria for at least three of the five domains, indicating they were of moderate to high quality, with low risk of bias. The quality of the remaining nine trials was unclear, as there was insufficient information to make a clear judgment on risk of bias.

Measurement of participation
Participation was measured in 19 of the 96 trials (20%). Table 2 lists the nine instruments that met the criteria for measuring participation [37–45] and illustrates how they map to the activities and participation domain of the ICF.

Effect of exercise intervention on participation
The pooled estimate of the effect of exercise on participation was statistically significant in favour of intervention (Hedges’g = 0.16, 95% confidence interval (CI) 0.04–0.27, $P = 0.006$) (See Figure 2). There was a moderate to high level of heterogeneity in estimates of the effects of
intervention ($I^2 = 54\%, Q = 30.6$, degrees of freedom = 14, $P = 0.006$). No conclusive evidence of small sample bias was identified (Egger’s test of the intercept $B_0 = 0.64$, 95% CI = $-2.12$ to $3.39$, $t = 0.500$, degrees of freedom = 13, $P = 0.31$, and the funnel plot of precision by Hedges’ $g$ was reasonably symmetrical).

The point estimate of the effect of multi-faceted intervention with an exercise component on participation (Hedges’ $g = 0.25$, 95% CI = $-0.04$ to $0.53$, $P = 0.09$) was larger than the effect from exercise as a single intervention (Hedges’ $g = 0.09$, 95% CI = $-0.01$ to $0.19$, $P = 0.07$). Meta-regression showed that the difference in these estimates was not statistically significant (Hedges’ $g = 0.22$, 95% CI = $-0.05$ to $0.50$, $P = 0.10$).

**Discussion**

This systematic review with meta-analysis provides evidence that exercise intervention targeting falls may improve participation in life roles in older people. Several factors indicate the results of the meta-analysis may be cautiously generalised to the older population. The 15 included trials involved a total of 3,616 participants in the pooled estimate for participation, the quality of trials was either moderate to high or unclear and there was a low likelihood of publication bias.

The proportion of studies that evaluated participation outcomes (20%) is similar to the frequency of measurement of participation in stroke rehabilitation trials (15%) [46] and is consistent with observations that participation is reported less than the other elements of function: body structure/function and activity [47, 48]. The infrequent measurement of participation was not surprising, as most trials targeted reduction in falls and falls risk factors at the level of body structure/function, such as impaired balance and strength. The included studies did not necessarily set out to evaluate the effect on functioning, or its components, and therefore measurement of participation was not essential. Functioning is an important outcome however, and the ICF is the recommended framework in which to describe it [2]. In future research, measurement of the consequences of falls prevention interventions at a
<table>
<thead>
<tr>
<th>First author, year</th>
<th>Participant age (years), mean (SD)</th>
<th>Residential aged care facility</th>
<th>Recruited on basis of history of falling or ≥1 falls risk</th>
<th>Control group: % with fall during follow-up period or falls per person-years</th>
<th>Sample size at randomisation</th>
<th>Single intervention: exercise</th>
<th>Multiple/multifactorial interventions (with exercise)</th>
<th>Intervention</th>
<th>Dose of exercise intervention</th>
<th>Follow-up (months)</th>
<th>Outcome instrument measuring participation</th>
<th>Data extracted</th>
<th>Standardised mean difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnett et al. [25]</td>
<td>74.9 (10.9)</td>
<td>N</td>
<td>Y</td>
<td>0.97</td>
<td>163</td>
<td>Y</td>
<td>N</td>
<td>Supervised group exercise, + unsupervised home exercise programme v’s AT</td>
<td>1 h/week, 9 months</td>
<td>6 PASE</td>
<td>Mean (SD) scores</td>
<td>−0.09 (−0.43 to 0.24)</td>
<td></td>
</tr>
<tr>
<td>Buchner et al. [26]</td>
<td>75</td>
<td>N</td>
<td>N</td>
<td>0.81</td>
<td>105</td>
<td>Y</td>
<td>N</td>
<td>Supervised endurance exercise class v’s supervised strength exercise class v’s supervised combination class v’s UC</td>
<td>1 h, 3×/week, 6 months</td>
<td>6 Lawton</td>
<td>Mean (SD) change</td>
<td>−0.16 (−0.59 to 0.27)</td>
<td></td>
</tr>
<tr>
<td>Campbell et al. [27]</td>
<td>84.1 (3.1)</td>
<td>N</td>
<td>N</td>
<td>1.34</td>
<td>233</td>
<td>Y</td>
<td>N</td>
<td>Physiotherapist visits × 4 + unsupervised individual strength, gait, balance, functional exercise v’s Placebo</td>
<td>30 min exercise plus 1 walk, ≥3×/week, 12 months</td>
<td>6 PASE,d Lawton,d</td>
<td>Mean (SD) change</td>
<td>0.25 (−0.005 to 0.51)</td>
<td></td>
</tr>
<tr>
<td>Clemson et al. [28]f</td>
<td>78 (5)</td>
<td>N</td>
<td>Y</td>
<td>58%</td>
<td>310</td>
<td>N</td>
<td>Y</td>
<td>Stepping On programme, v’s Placebo</td>
<td>2 h/week, 2 months, booster at 5 months</td>
<td>14 PASE</td>
<td>Mean (SD) change</td>
<td>0.21 (−0.04 to 0.45)</td>
<td></td>
</tr>
<tr>
<td>Faber et al. [23]g</td>
<td>84.9 (range = 63–89)</td>
<td>Y</td>
<td>N</td>
<td>2.5</td>
<td>238</td>
<td>Y</td>
<td>N</td>
<td>Supervised group balance, walking, functional exercise v’s supervised, group 3D exercises (based on Tai Chi) v’s UC</td>
<td>90 min, 1×/week, 1 month + 2×/week, 4 months</td>
<td>5 GARS</td>
<td>Mean (SD) scores</td>
<td>0.11 (−0.17 to 0.39)</td>
<td></td>
</tr>
<tr>
<td>Green et al. [29]</td>
<td>72.5 (8.5)</td>
<td>N</td>
<td>Y</td>
<td>31%</td>
<td>170</td>
<td>Y</td>
<td>N</td>
<td>Community physiotherapy programme v’s UC</td>
<td>≥3 visits over 3 months</td>
<td>3 FAI</td>
<td>Median (IQR) scores</td>
<td>0 (−0.31 to 0.31)</td>
<td></td>
</tr>
<tr>
<td>Haines et al. [30]</td>
<td>80.6</td>
<td>N</td>
<td>N</td>
<td>59%</td>
<td>53</td>
<td>Y</td>
<td>N</td>
<td>Supervised + unsupervised individual strength and balance exercise v’s UC</td>
<td>≥3×/week, 2 months</td>
<td>2 FAI</td>
<td>Mean (SD) scores</td>
<td>0.07 (−0.50 to 0.65)</td>
<td></td>
</tr>
<tr>
<td>Hauer et al. [35]</td>
<td>82 (4.8)</td>
<td>N</td>
<td>Y</td>
<td>60%</td>
<td>57</td>
<td>Y</td>
<td>N</td>
<td>Supervised, group resistance, functional and balance exercise v’s Placebo</td>
<td>3×/week, 3 months</td>
<td>3 FHI</td>
<td>Mean (SD) scores</td>
<td>0.95 (0.35 to 1.56)</td>
<td></td>
</tr>
<tr>
<td>Kerse et al. [22]f</td>
<td>84 (7)</td>
<td>Y</td>
<td>N</td>
<td>44%</td>
<td>682</td>
<td>Y</td>
<td>N</td>
<td>Staff training, goal setting, supervised individual functional exercise v’s Placebo</td>
<td>7×/week, 6 months</td>
<td>12 LLFDI</td>
<td>Mean (SE) change</td>
<td>0.05 (−0.13 to 0.23)</td>
<td></td>
</tr>
<tr>
<td>Author(s)</td>
<td>Sample Size</td>
<td>Exercise Details</td>
<td>Follow-Up Details</td>
<td>Outcome Measure</td>
<td>Raw Change</td>
<td>Mean (SD) Change</td>
<td>Notes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>-----------------</td>
<td>-------------</td>
<td>------------------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latham et al.</td>
<td>79 (7.9)</td>
<td>N/T N</td>
<td>2.7</td>
<td>243 N</td>
<td>Y N</td>
<td>Supervised and unsupervised strength exercise v/s AT</td>
<td>3×/week, 2.5 months</td>
<td>AAP</td>
<td>Raw (mean)</td>
<td>0 (−0.26 to 0.26)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lin et al.</td>
<td>76.5</td>
<td>N Y 0.88</td>
<td>150</td>
<td>Y N</td>
<td></td>
<td>Supervised and unsupervised strength and balance exercise v/s AT</td>
<td>1×/2 weeks, 4 months</td>
<td>OARS</td>
<td>Mean (SD) scores</td>
<td>0.14 (−0.23 to 0.52)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logan et al.</td>
<td>Median 82.5</td>
<td>N Y 7.68</td>
<td>204</td>
<td>N Y</td>
<td></td>
<td>Individual and group strength and balance exercise, hazard assessment and modification v/s UC</td>
<td>Group = 1 h 2×/week, Individual = ≥6 visits; 1.5 months</td>
<td>NEADL</td>
<td>Raw (median)</td>
<td>0.71 (0.43 to 0.99)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logghe et al.</td>
<td>77</td>
<td>N Y 45%</td>
<td>269</td>
<td>Y N</td>
<td></td>
<td>Supervised group 3D exercise (Tai Chi Chuan) + unsupervised individual 3D exercise v/s UC</td>
<td>Group = 1 h/week, Individual = 15 min, 2×/week; 3 months</td>
<td>GARS</td>
<td>Mean (SD) scores</td>
<td>0.12 (−0.16 to 0.41)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steadman et al.</td>
<td>82.7 (5.6)</td>
<td>N Y —</td>
<td>199</td>
<td>Y N</td>
<td></td>
<td>Conventional physiotherapy + supervised individual balance exercise v/s AT</td>
<td>2×/week, 1.5 months</td>
<td>FAI, FHI</td>
<td>Mean (SD) scores</td>
<td>0.09 (−0.21 to 0.40)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zijlstra et al.</td>
<td>77.9</td>
<td>N N 58%</td>
<td>540</td>
<td>N Y</td>
<td></td>
<td>Group cognitive behavioral intervention + physical strength exercise v/s UC</td>
<td>2 h/week; 2 months, booster at 8 months</td>
<td>FAI</td>
<td>Mean (SD) scores</td>
<td>0.16 (−0.01 to 0.32)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean(SD) scores, mean(SD) scores in each group at baseline and follow-up; Mean(SD) change, mean(SD) change in each group between baseline and follow-up; median(IQR) scores, mean(SD) scores in each group estimated from median(IQR) scores at baseline and follow-up; Mean(SE) change, mean(SD) change in each group estimated from median(IQR) scores between baseline and follow-up; Raw (mean), raw between group difference in means; Raw (median), raw between group difference in means estimated from medians; HEP, home exercise programme; AT, alternate therapy; UC, usual care; PASE, Physical Activity Scale for the Elderly; Lawton, Lawton Independent Activities of Daily Living Index; GARS, Groningen Activity Restriction Scale; FAI, Frenchay Activities Index; FHI, Falls Handicap Inventory; LLFDI, Late Life Function and Disability Instrument (disability component); AAP, Adelaide Activities Profile; OARS, Older Americans Resources and Services Activities of Daily Living Scale; NEADL, Nottingham Extended Activities of Daily Living Scale; Y, yes; N, no.

1Majority resided in aged care facility.
2Follow-up of participation measure (months after randomisation).
3Participants randomised into six intervention groups (three MoveIT trial, three FICSIT trial) and one control group. Data from four groups (FICSIT trial and control) were reported and included in this meta-analysis.
4Outcome included in analysis.
5Insufficient data for inclusion in meta-analysis.
6Participants stratified by number of falls in past year and gender.
7Cluster randomisation.
8Participants had past stroke.
9Recently discharged from hospital.
10Factorial design.
11Participants randomised into four groups (exercise, exercise control, Vitamin D, placebo tablets). Data from two groups (exercise and exercise control) were included in this meta-analysis.
12Adjusted for baseline values.
societal level would increase understanding of the interventions’ effectiveness.

The size of the effect of exercise interventions on participation was small (standardised mean difference = 0.16) and may not be clinically important. Considering the trials in this study did not target participation, the effect of different types of intervention on participation outcomes warrants further investigation. The results of meta-regression suggest the effects were larger in studies where exercise was delivered in conjunction with additional interventions, however this result must be interpreted very cautiously as only three multifactorial trials were included and statistical significance was not reached. The ICF framework describes participation as the result of complex interaction between an individual’s personal characteristics, social and physical environment, impairments and activity

<table>
<thead>
<tr>
<th>Instrument</th>
<th>ICF chapters in the activities and participation domain</th>
<th>Concept captured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Communication</td>
<td>mobility</td>
</tr>
<tr>
<td>Adelaide Activities Profile [42]</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Falls Handicap Inventory [37]</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Frenchay Activities Index [38]</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>The Groningen Activity Restriction Scale [39]</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Late Life Function and Disability Instrumentª [45]</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lawton Instrumental Activities of Daily Living Scale [41]</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Nottingham Extended Activities of Daily Living Index [44]</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Old Americans Resources and Servicesᵇ [43]</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Physical Activity Scale for the Elderly [40]</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

ªDisability component.
ᵇActivities of daily living and Instrumental Activities of Daily Living Scale.

Figure 2. Forest plot from the meta-analysis of exercise interventions and multifactorial interventions including exercise on measures of participation, showing estimates effect size with 95% confidence intervals. PASE, Physical Activity Scale for the Elderly; Lawton, Lawton Independent Activities of Daily Living Index; GARS, Groningen Activity Restriction Scale; FAI, Frenchay Activities Index; FHI, Falls Handicap Inventory; LLFDI, Late Life Function and Disability Instrument (disability component); AAP, Adelaide Activities Profile; OARS, Older Americans Resources and Services Activities of Daily Living Scale; NEADL, Nottingham Extended Activities of Daily Living Scale.
limitations. This theory is supported by evidence that affective-cognitive variables are important mediators of the relationship between impairment and avoidance of activities [49] and decreased social participation [1], and environmental modifications improve participation outcomes [50]. Future research is indicated to investigate the optimal intervention to increase participation.

This systematic review had limitations. There was considerable heterogeneity between the included studies so overall conclusions must be regarded with caution. We chose to present estimates from meta-analyses despite the moderate to high I² statistic, as effect estimates from most individual trials were in the same direction and we deemed the included trials adequately homogeneous in terms of participants, intervention, outcomes and measurement time point [51, 52]. Meta-regression analyses explored type of intervention as a possible source of heterogeneity, however the true differences in effects between studies may be due to the variability of other factors.

A further limitation is the absence of a gold standard for evaluating participation outcomes, due to poor consensus on how to conceptualise or measure the construct of participation [53]. Noonan et al.'s method of classifying participation instruments [13, 54] was replicated for this study because we judged the criteria conceptually sound and the application more reliable than other published methods for identifying measures of participation [14, 46, 53, 55]. This is a broad approach to identifying participation however; it will capture items and instruments arguably measuring activity and may overestimate the measurement of participation, for example the Physical Activity Scale for the Elderly score may include exercise performed as part of the intervention. While most instruments measured objective performance (e.g. ‘can you go shopping independently?’), only the Falls Handicap Inventory and Late Life Function and Disability Instrument assessed individual centred viewpoints such as perceived difficulty and limitation in participation (e.g. ‘how limited do you feel in working as a volunteer?’). The importance of separately measuring both objective and subjective concepts is being increasingly recognised [53]. Although nine instruments identified in the included trials met the criteria, none were developed specifically to measure participation. To evaluate the consequences of falls prevention programmes on functioning at a societal level, future research should contain instruments developed explicitly to measure participation. The content [54] and properties [13] of such instruments are well described by Noonan et al., yet there is a need for further research in the areas of validation and development of instruments measuring participation.

The ICF is a useful framework for describing functional outcomes, however limitations are evident. A potential way to standardise reporting of functional outcomes is the development of an ICF core set for older people with demonstrable falls risk. Core sets are subsets of the most relevant ICF categories for a given health condition, according to the perspective of the individual and developed upon international research and consensus [56]. A core set would describe the spectrum of functioning problems characterising older people at risk of falls. It would be applicable to documentation of health and functioning in research and the clinical setting.

We hope that examining the measurement of participation in falls research will add to understanding of how functioning is measured in falls trials and contribute to the use of the ICF conceptual framework. Although participation is measured infrequently, the findings of this meta-analysis suggest that exercise intervention targeting falls may improve participation in life roles in older people; however due to the considerable heterogeneity and small effect size, the results must be interpreted with caution. Participation is an important component of functioning and we recommend ongoing evaluation of participation outcomes and research into the efficacy of intervention for increasing participation in older people who fall or are at risk of falling. Interventions effective at improving participation would improve both quality of life and societal integration in older people.

Conflicts of interest

None declared.

Funding

This work was supported by the Australian National Health and Medical Research Council (402791 to N.F., 632929 to C.S.). The funding body did not play a part in the research design, analyses, data interpretation or writing of the report.

Supplementary data

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

References

The long list of references supporting this review has meant that only the most important are listed here and are represented by bold type throughout the text. The full list of references is available as Supplementary data at Age and Ageing online.


Received 14 November 2010; accepted in revised form 22 April 2011