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EXERCISE FOR REDUCING FEAR OF FALLING IN OLDER PEOPLE LIVING IN THE COMMUNITY: COCHRANE SYSTEMATIC REVIEW AND META-ANALYSIS

Kumar A[1], Delbaere K[2], Zijlstra GAR[3], Carpenter H[1], Iliffe S[4], Masud T[5], Skelton DA[6], Morris R[4], Kendrick D[1].

Affiliation:

[1]School of Medicine, Division of Primary Care, University of Nottingham, Nottingham, UK

[2] NeuRA, University of New South Wales, Randwick, Australia

[3]Department of Health Services Research, Maastricht University, and CAPHRI School for Public Health and Primary Care, Maastricht, The Netherlands

[4]Research Department of Primary Care and Population Health, University College London, London, UK

[5]Nottingham University Hospitals NHS Trust, Nottingham, UK

[6]School of Health & Life Sciences, Institute of Allied Health Research, Glasgow Caledonian University, Glasgow, UK

Correspondence to: Professor Denise Kendrick.

Email: denise.kendrick@nottingham.ac.uk

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ABSTRACT

Objective: To determine the effect of exercise interventions on fear of falling in community-living people aged ≥65 years.

Design: Systematic review and meta-analysis. Bibliographic databases, trial registers and other sources were searched for randomised or quasi-randomised trials. Data were independently extracted by pairs of reviewers using a standard form.

Results: Thirty trials (2878 participants) reported 36 interventions (Tai Chi and yoga (n=9); balance training (n=19); strength and resistance training (n=8)). The risk of bias was low in few trials. Most studies were from high income countries (Australia=8, USA=7). Intervention periods (<12 weeks=22; 13-26 weeks=7; >26 weeks=7) and exercise frequency (1-3 times/week=32; ≥4 times/week=4) varied between studies. Fear of falling was measured by single-item questions (7) and scales measuring falls efficacy (14), balance confidence (9) and concern or worry about falling (2). Meta-analyses showed a small to moderate effect of exercise interventions on reducing fear of falling immediately post intervention (standardised mean difference (SMD) 0.37, 95% CI 0.18, 0.56; 24 studies; low quality evidence). There was a small, but not statistically significant effect in the longer term (<6 months (SMD 0.17, 95% CI -0.05, 0.38 (four studies) and ≥ 6 months post intervention SMD 0.20, 95% CI -0.01, 0.41 (three studies)).

Conclusions: Exercise interventions probably reduce fear of falling to a small to moderate degree immediately post-intervention in community-living older people. The high risk of bias in most included trials suggests findings should be interpreted with caution. High quality trials are needed to strengthen the evidence base in this

area.

INTRODUCTION

One third of over 65 year olds fall once or more annually[1]. Falls result in injury, hospitalisation, disability and loss of independence in older people[2]. Fear of falling can be defined as a persistent feeling related to the risk of falling during one or more activities of daily living. It encompasses a range of constructs including falls self-efficacy, balance confidence and worry or concern about falling[3]. Amongst older people, about one in three without a falls history and about two in three with a falls history report some fear of falling[4]. Fear of falling can be associated with reductions in physical and social activities and negative impacts on quality of life[4]. High levels of fear of falling can increase the risk of future falls, whilst low levels can be protective for falling, irrespective of the presence of balance impairments[5]. Therefore, in addition to improving balance, it is important to understand how fear of falling can be reduced.

Several interventions have been shown to reduce fear of falling[6-10] with multifactorial interventions, including physical and behavioural components, being most successful[6, 9, 10]. Behavioural components usually comprise strategies to reduce catastrophic thinking and fear-related avoidance behaviours[9, 10], whilst physical components usually comprise falls prevention exercise programmes[6-8]. However, multifactorial programmes are not always feasible or preferred by older people. Exercise interventions may be the most promising single intervention[11] as there is evidence they can reduce falls[12], improve gait and balance[13], increase ability to get up following a fall[13] and improve mood[14]. Through these mechanisms, exercise may reduce fear of falling and enable performance of more

daily activities without falling, leading to a more positive appraisal of ability to maintain balance[15].

Numerous exercise intervention studies in community-living older adults have reported their effect on fear of falling. Two narrative systematic reviews found multifactorial fall prevention interventions with exercise as a main component were effective in reducing fear of falling[11, 16], as were home based-exercise and community group-based Tai Chi[16]. The objective of our review was to evaluate the effect of exercise interventions on fear of falling in community-living older adults. Our meta-analyses add to previous narrative reviews by updating the evidence and quantifying the effect of exercise interventions. Our review was undertaken as a Cochrane systematic review and full details are reported in the published review[17]. The protocol is available from http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD009848/full.

METHODS

Criteria for considering studies for this review

Study design

We included randomised and quasi-randomised (e.g. alternate allocation) controlled trials. Cluster allocated studies were included if they had ≥3 clusters per treatment arm.

Participants

We included trials with a majority of participants aged ≥65 years and community-living (i.e. living at home or places of residence without nursing care or rehabilitation). Trials were excluded where participants were restricted to specific conditions (e.g. stroke), or mixed population groups (i.e. community-living older adults and nursing home residents) where results were not reported for each group separately.

Interventions

Trials evaluating the effect of exercise interventions were included, whether an exercise 'prescription' or recommendation, performed individually or in groups and supervised or unsupervised. Exercise interventions included gait, balance and function; strength or resistance; flexibility; 3-dimensional (e.g. Tai Chi); and endurance. Multi-component interventions (e.g. exercises with home hazard assessments or medication reviews) were excluded. The comparators of interest were usual care and non-exercise interventions such as education. Trials were excluded if the comparator intervention may have increased exercise, e.g. lifestyle advice including guidance about exercise.

Outcome measures

We included trials assessing fear of falling as a primary or secondary outcome, measured using:

- Fear of falling: single-item question (e.g. Are you afraid of falling?)
- Falls efficacy: the Falls Efficacy Scale FES[18], mFES[19], rFES[20] and FES-UK[21]

- Balance confidence: the Activities-specific Balance Confidence scale (ABC)[22] and the ABC-UK[21]
- Concern about falling: the FES-I[23], Short FES-I[24], Mobility Efficacy Scale (MES)[25], aFES[25] and amFES[25]
- Worry about falling: the Survey of Activities and Fear of Falling in the Elderly (SAFFE)[26]

Search strategy and selection criteria

Search strategies were designed in conjunction with the Cochrane Bone, Joint and Muscle Trauma Group (BJMTG). We searched the Cochrane BJMTG Specialised Register (July 2013), the Central Register of Controlled Trials (2013, Issue 7), MEDLINE (1946 to July 2013), EMBASE (1980 to 2013 Week 30), CINAHL (1982 to July 2013), PsycINFO (1967 to August 2013) and Allied and Complementary Medicine (AMED) (1985 to August 2013) without language restrictions. The MEDLINE search strategy is shown in Appendix 1 online. We searched Current Controlled Trials (7 August 2013) and the WHO International Clinical Trials Registry Platform (7 August 2013), and reference lists of relevant reviews [11-13, 16] and of our included trials. Published, unpublished and ongoing trials were identified by contacting authors, experts in the field and the Falls and Bone Section of the British Geriatrics Society.

Data collection

Pairs of reviewers independently assessed titles, abstracts and full texts of potentially eligible articles against inclusion criteria. We used a hierarchy of reasons

for exclusion, based in turn on: study design, participants, interventions and outcomes. Pairs of reviewers independently extracted data using a standard form, and used the Cochrane tool to assess risk of bias [27]. Disagreements were resolved by referral to a third reviewer. Trial authors were contacted for clarification where necessary and to obtain missing data. We used risk of bias assessments to judge the quality of the evidence and interpreted findings in light of this.

Data synthesis

We estimated risk ratios with 95% confidence intervals (CI) for binary outcomes. For continuous outcomes, we estimated standardised mean differences (and 95% CI) (SMDs, being the difference in means for a particular trial divided by the within group standard deviation) since different measures were reported or the same measure was reported in different formats. If means and standard deviations (SDs) were reported for change from baseline scores, we entered these in preference to follow up means. Where a SD of zero was reported for the FES score[a] we replaced this with 0.00001.

For cluster-RCTs we adjusted standard errors (SEs) of SMDs using the square root of the design effect with an intraclass correlation coefficient (ICC) of 0.02[28]. Raw data were entered into meta-analyses. For cross-over trials we used outcome scores before the cross-over. If trials reported more than one intervention meeting inclusion criteria, we combined results from intervention arms in meta-analyses. Comparisons were made separately for each intervention arm, where appropriate, for subgroup analyses. Some trials measured fear of falling at multiple time points.

We undertook meta-analyses (a) immediately post intervention (at the point of completing the intervention), (b) short-term follow-up (<6 months post intervention) and long-term follow-up (≥6 months post intervention). Most fear of falling scales used a higher score to represent less fear. Where scales used higher scores to represent greater fear, we multiplied mean scale scores by -1 to ensure scales pointed in the same direction.

Where SDs were not reported but 95% CI were, we divided the CI width by 3.92 and multiplied by the square root of the sample size. We did not impute missing values. Heterogeneity between effect sizes was assessed by inspection of forest plots, the χ^2 test for heterogeneity ($P < 0.1$) and the I^2 statistic. If there was no statistical heterogeneity we combined effect sizes using fixed-effect models, otherwise we used random-effects models. Where there were more than 10 studies we assessed publication bias using funnel plots and Egger's test.

Where a minimum of two trials existed, we undertook pre-defined subgroup analyses, assessing statistical significance through overlap of 95% CI and the test for subgroup differences in Review Manager software[29]:

1. Exercise characteristics: (a) type classified using the ProFaNE taxonomy (http://profane.co/2011/03/24/profane-taxonomy-manual) (b) individual versus group, (c) frequency (1-3 times/week, ≥4 times/week) and (d) duration (0-12, 13-26 and >26 weeks)
2. Comparator group (alternative intervention versus no intervention)

3. Baseline falls risk (trials recruiting participants at increased risk of falls, versus those not exclusively recruiting these participants)
4. Primary aim of the trial (to reduce fear of falling versus other).

We conducted four sensitivity analyses: (a) using ABC scores rather than FES scores for trials using both scales (b) removing one trial that had a much greater effect size than other trials, (c) varying the ICC for adjusting cluster RCTs and (d) restricting to trials with >80% participants followed up.

Ethical approval

Ethical approval was not required.

RESULTS

Figure 1 shows the process of trial selection. A total of 916 citations were identified from bibliographic databases and an additional 130 from other sources. Full texts were obtained for 209 articles, of which 30 trials (from 53 articles) were included.

[Insert Figure 1 here].

Description of studies

The characteristics of included trials are shown in table 1 online. The 30 trials included a total of 2878 participants with mean ages ranging from 68 to 85 years. Women comprised more than 50% of participants in 24 (80%) trials. Twelve (40%) trials recruited participants at increased falls risk, of which three (10%) also

recruited those with a fear of falling. Twenty six (87%) trials came from higher income countries, most commonly Australia (n=8) and the USA (n=7).

Twenty nine (97%) trials were RCTs (including two cluster-RCTs and two cross-over trials) and one was a quasi-randomised trial. Reducing fear of falling was the primary aim in seven (23%) trials. Five trials had more than one intervention arm, with a total of 36 interventions, of which nine (25%) were 3D (Tai Chi, Yoga); 19 (53%) were gait, balance, coordination and functional tasks; and eight (22%) were strength and resistance based interventions. Most (n=27, 75%) were supervised interventions and just over half (n=20, 56%) were delivered to groups. Most interventions were delivered for ≤12 weeks (n=22, 61%) with 19% (n=7) each delivered over 13-26 weeks and >26 weeks. Most (n=32, 89%) exercises were to be performed 1-3 times/week with only 11% (n=4) to be performed ≥4 times/week (Table 1 online).

Risk of bias in included studies

Risk of bias assessment is shown in Table 1. The risk of bias was low in few trials: random sequence generation (n=12,40%), allocation concealment (n=2, 7%), attrition bias (n=17, 57%), selective reporting (n=1, 3%) and other potential sources of bias (n=4, 13%). Participants were not blinded to treatment group allocation and outcomes were self-reported, so all trials were judged at high risk of performance and detection bias. Full details of the risk of bias assessment are given in the published review[17].

[Insert Table 1 here].

Effect of exercise interventions on fear of falling

The data used in the meta-analysis is shown in online Table 2. Twenty four trials were included in the meta-analysis immediately post intervention. Effect sizes were combined for all fear of falling scales (FES (all versions), ABC, plus other numerical scales). Exercise interventions were associated with a small to moderate, and statistically significant reduction in fear of falling (Figure 2; SMD 0.37, 95% CI 0.18, 0.56; 24 trials; 1692 participants) with significant heterogeneity between effect sizes (χ^2=75.01, df=23, P<0.00001, I^2=69%). Pooled effect sizes did not differ significantly between the different fear of falling scales (test for subgroup differences: χ^2=5.21, df=3, P=0.16). One small trial[b] had a much larger effect size than other trials in the analysis.

[insert Figure 2 here]

Sensitivity analyses

Findings were similar to those in the main analysis (SMD 0.37, 95% CI 0.18, 0.56) when we (a) used ABC scores instead of FES scores for two trials reporting both (SMD 0.34, 95% CI 0.15, 0.53), (b) restricted analyses to trials with at least 80% follow up (SMD 0.31, 95% CI 0.13, 0.49) or (c) used an ICC of 0 or 0.05 (SMD 0.37, 95% CI 0.18, 0.56 for both ICCs). Removing the trial by Nguyen[b] resulted in a smaller, but still statistically significant reduction in fear of falling and no

significant heterogeneity between effect sizes (SMD 0.24, 95% CI 0.12, 0.36; χ^2=28.67, df=22, P=0.15; I^2=23%).

Subgroup analyses

The effect of exercise interventions on fear of falling did not vary by type of exercise (χ^2=3.46, df=2, P=0.18), exercise frequency (χ^2=0.20, df=1, P=0.66), duration of interventions (χ^2=0.88, df=2, P=0.64), falls risk (trials recruiting participants at high risk of falls and those which did not; χ^2=1.18, df=1, P=0.28) or trial aim (to reduce fear of falling or other primary aim; χ^2=0.17, df=2, P=0.68). The effect may be greater where interventions are delivered in groups (SMD 0.49, 95% CI 0.22, 0.76) rather than to individuals (SMD 0.14, 95% CI -0.06, 0.35; χ^2=3.99, df=1, P=0.05) and may be smaller in trials where control groups received alternative interventions (SMD 0.11, 95% CI -0.08, 0.29) rather than no intervention (SMD 0.48, 95% CI 0.22, 0.73; χ^2=5.45, df=1, P=0.02). Removal of the trial by Nguyen[b] from these analyses resulted in non-significant tests of sub-group differences (P=0.23 and P=0.09, respectively).

Studies not included in the meta-analysis

Six trials (666 participants) were not included in the meta-analysis due to using single item measures[c,d], results not reported in a suitable format[e-g], or not reporting outcomes immediately post-intervention[h]. Four trials found exercise interventions were associated with significant reductions in fear of falling[d-g].

Effect of exercise interventions beyond the end of the intervention

Exercise interventions were associated with small and non-significant reductions in fear of falling beyond the end of the intervention (<6 months post-intervention: SMD 0.17, 95% CI -0.05, 0.38; P=0.12, four trials; 356 participants; χ^2=2.86, df=3, P=0.41; I^2=0%; ≥6 months post-intervention: SMD 0.20, 95% CI -0.01, 0.41; P=0.06, three trials; 386 participants; χ^2=0.78, df=2, P=0.68; I^2=0%).

Publication bias

The funnel plot (Figure 1 online) and Egger's test (bias coefficient 2.98, 95% CI 0.68, 5.28; P=0.01) suggest publication bias may have occurred.

DISCUSSION

Main findings

Exercise interventions are associated with a small to moderate reduction in fear of falling in community-living older adults immediately post-intervention (SMD 0.37, 95% CI 0.18, 0.56). One trial[b] had a much larger effect than others and removing this from the analysis resulted in a smaller but still significant reduction in fear of falling (SMD 0.24, 95% CI 0.12, 0.36). The effect of exercise interventions did not vary by type, frequency or duration of exercise, falls risk or between trials aimed at reducing fear of falling and those with other primary aims. Subgroup analyses suggested the effect of exercise interventions may be smaller where control groups received an alternative intervention rather than no intervention and may be greater where group rather than individual exercises were used. No significant reduction in fear of falling was found beyond the end of the exercise interventions.

Strengths and limitations of the review

This is the largest review of the effect of exercise interventions on fear of falling in community-living older people. Most included trials came from higher income countries, limiting generalisability to other settings. The quality of evidence in our review was low; hence further research is likely to change effect sizes and their precision. Few trials were at low risk of most types of bias. All trials were judged at high risk of performance and detection bias because blinding intervention deliverers or participants was not possible, and outcomes were self-reported. Publication bias may have occurred, so our review may overestimate the effect of exercise interventions on reducing fear of falling. A very small number of trials reported fear of falling beyond the end of the intervention, leading to imprecise effect sizes. There was significant heterogeneity between effect sizes in our main analysis, which appeared to be explained by one small trial with a much larger effect size than other trials[b]. Excluding this trial resulted in a smaller, but statistically significant reduction in fear of falling. This trial evaluated group-based Tai Chi classes (delivered for one hour, twice weekly for six months to adults aged 60-79 years) in Vietnam. The trial was judged to be at high risk of performance, detection and attrition bias and at unclear risk for other types of bias and it is possible that bias may explain the larger effect size.

Our analyses included a range of measures of fear of falling, which measured varying concepts (fear of falling, falls efficacy, balance confidence and concern about falling). The heterogeneity of measurement outcomes for fear of falling is well documented along with their strengths and limitations[3]. This may have contributed to the statistically significant heterogeneity in our analyses, adding to

our difficulty in drawing conclusions from our findings. We did not find significant subgroup differences between measures, but power will have been limited by small numbers of trials in subgroups. Many included trials did not measure fear of falling as a primary outcome, so searches may not have identified trials that measured, but did not report fear of falling. We attempted to minimise this by contacting authors where trials met other inclusion criteria but did not report fear of falling as an outcome measure. We also contacted authors of included trials to obtain unpublished data, successfully obtaining data for seven trials.[i-o].

Comparisons with existing research

Our finding that the effect of interventions did not vary with type of exercise are consistent with a narrative review evaluating interventions aimed at improving balance confidence in older adults which found most effective interventions included an exercise component[11]. In contrast, a second narrative systematic review [16]concluded that community-based Tai Chi and home-based exercise interventions reduced fear of falling in community-living older people, but community-based group exercise and computerised balance training did not. Differences in our findings may reflect the inclusion of more trials in our review and our use of meta-analysis.

Implications for practice and research

Previous meta-analyses show exercise interventions are effective in reducing falls amongst community-living older people. Our review suggests such interventions probably also reduce fear of falling to a small to moderate degree immediately after

the intervention. The best interventions for reducing fear of falling remain unclear and further well-designed RCTs are needed, including those evaluating alternative approaches to reducing fear of falling (e.g. behavioural and psychological interventions). Trials should be explicit about the tools used to measure fear of falling and the constructs measured by the tools and outcomes should be measured immediately post intervention and at suitable time points (e.g. up to 6 months and longer than 6 months) beyond the end of the intervention. Outcome heterogeneity was observed in this systematic review. A concerted effort by those working in the field to achieve consensus on measures of fear of falling is needed.[30, 31]

Declaration of sources of funding

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PLEASE NOTE: References for studies included in the review are identified in the text and tables using superscript letters and are available on the journal website http://www.ageing.oxfordjournals.org/ as Appendix 2.

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Figure 1. Identification and selection of studies for the review

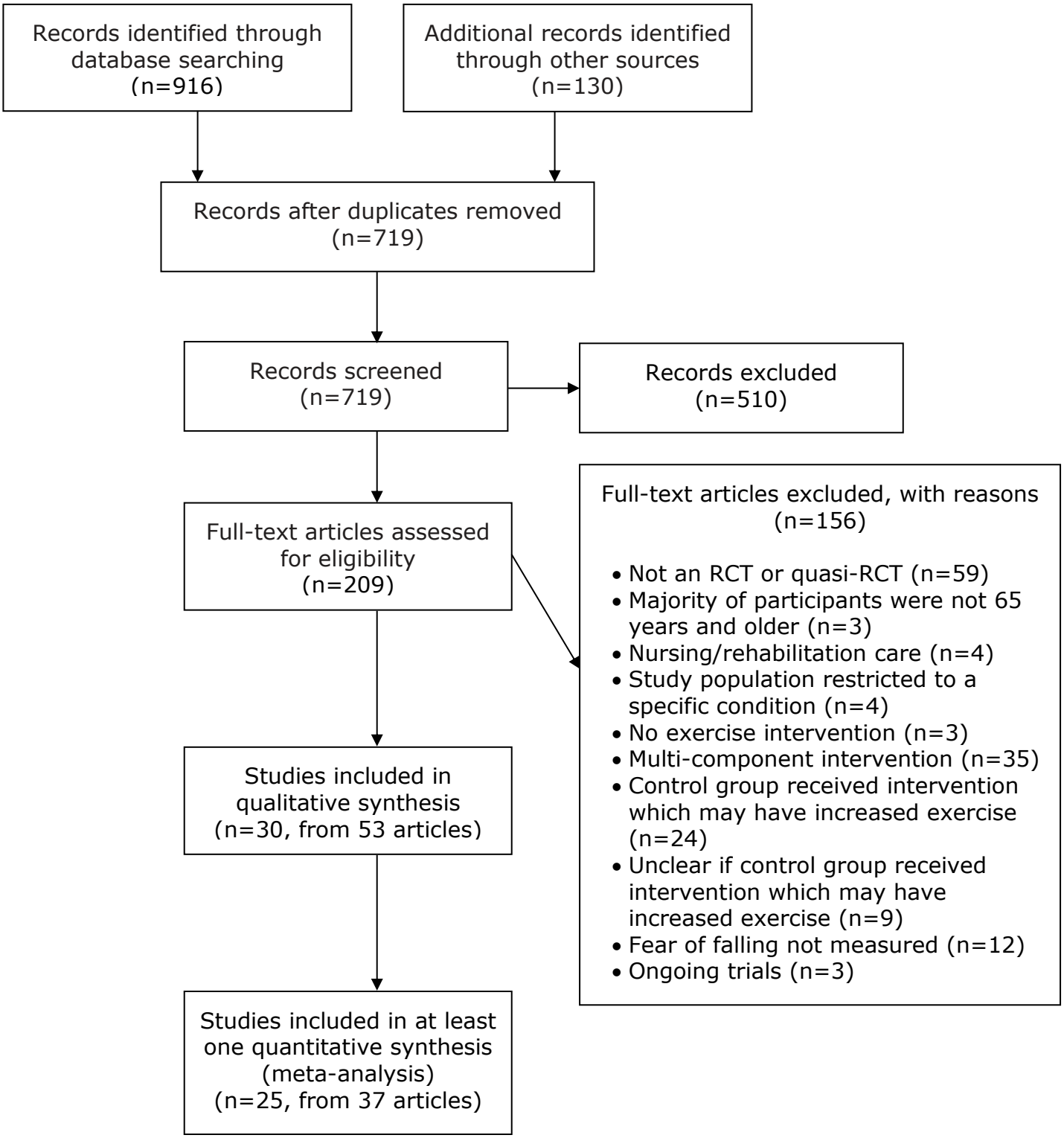
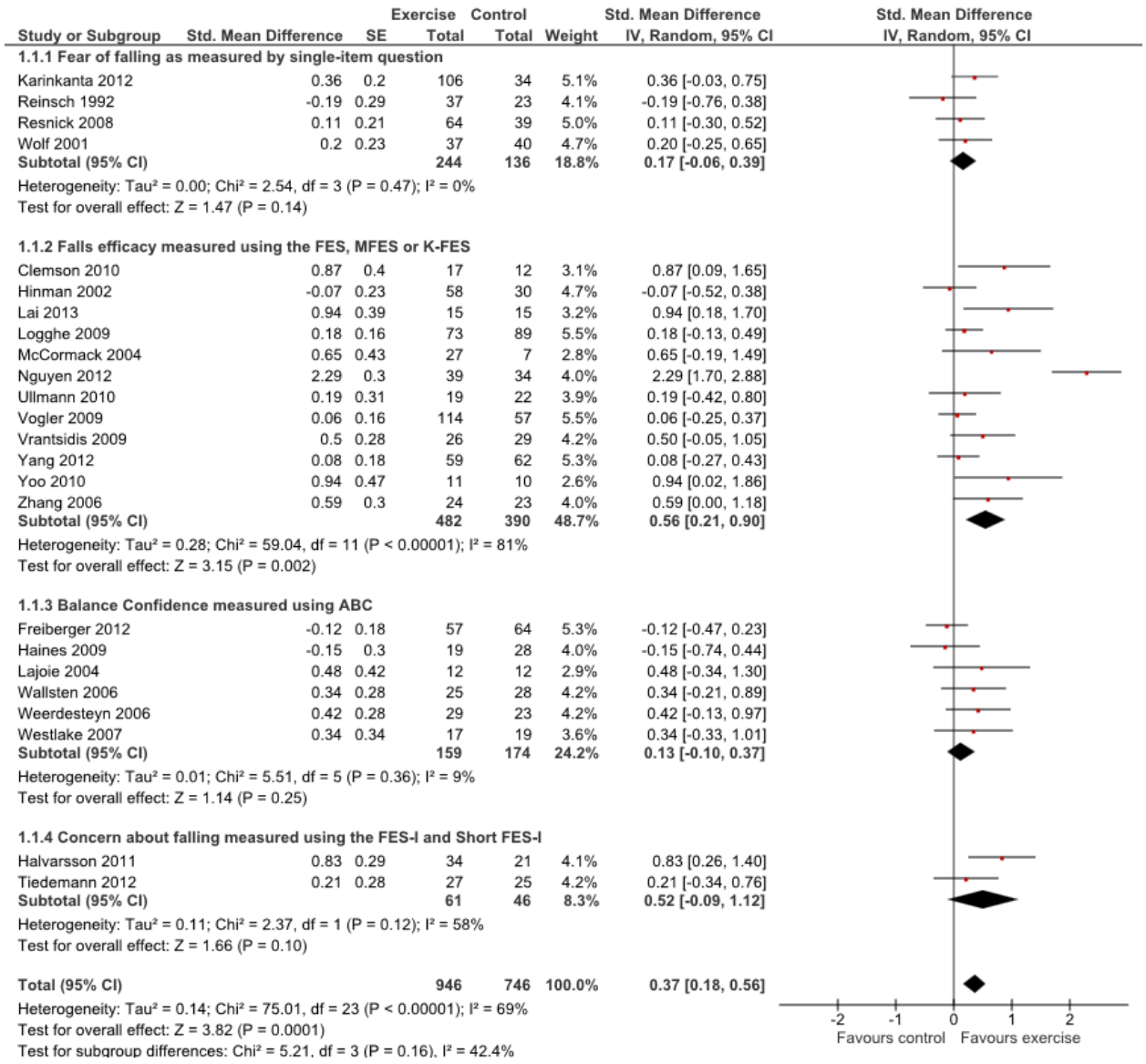


Figure 2. Effect of exercise interventions on fear of falling immediately post-intervention



Risk of bias assessment suggests the quality of evidence is low and results should be interpreted with caution

Table 1. Risk of bias in included studies

Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias
Barnett 2003[c]	Unclear	Unclear	High	High	Low	Unclear	Unclear
Campbell 1999[e]	Low	Low	High	High	Low	Unclear	Low
Clemson 2010[i]	Low	High	High	High	High	High	Unclear
Freiberger 2012[p]	Low	Unclear	High	High	High	Unclear	Unclear
Haines 2009[q]	Low	Low	High	High	Low	Unclear	Unclear
Halvarsson 2011[j]	Unclear	High	High	High	Low	High	Low
Hinman 2002[r]	Unclear	Unclear	High	High	Low	Unclear	Unclear
Karinkanta 2012[s]	Low	Unclear	High	High	Low	Unclear	Unclear
Lai 2013[t]	Unclear	Unclear	High	High	Low	Unclear	Unclear
Lajoie 2004[k]	High	High	High	High	Low	Unclear	Unclear
Lin 2007[h]	Unclear	Unclear	High	High	High	Unclear	Unclear
Logghe 2009[u]	Low	Unclear	High	High	High	Low	Unclear
McCormack 2004[v]	Unclear	Unclear	High	High	High	Unclear	Unclear
Nguyen 2012[b]	Unclear	Unclear	High	High	High	Unclear	Unclear
Reinsch 1992[w]	Unclear	Unclear	High	High	High	Unclear	Unclear
Rendon 2012[f]	Unclear	Unclear	High	High	Low	Unclear	Unclear
Resnick 2008[x]	Low	Unclear	High	High	High	Unclear	Unclear
Sihvonen 2004[d]	Low	Unclear	High	High	Low	Unclear	Unclear

Tiedemann 2012[y]	Low	Unclear	High	High	Low	Unclear	Unclear
Ullmann 2010[l]	Unclear	Unclear	High	High	Low	Unclear	Unclear
Vogler 2009[m]	Low	Unclear	High	High	Low	Unclear	Low
Vrantsidis 2009[z]	Unclear	Unclear	High	High	Low	Unclear	Unclear
Wallsten 2006[n]	Unclear	Unclear	High	High	High	High	Unclear
Weerdesteyn 2006[o]	Unclear	Unclear	High	High	Low	Unclear	Unclear
Westlake 2007[aa]	Unclear	Unclear	High	High	Unclear	Unclear	Unclear
Wolf 1996[g]	Low	Unclear	High	High	Low	High	Unclear
Wolf 2001[bb]	Unclear	Unclear	High	High	High	High	Unclear
Yang 2012[aa]	Low	Unclear	High	High	High	Unclear	Low
Yoo 2010[a]	Unclear	Unclear	High	High	High	Unclear	Unclear
Zhang 2006[dd]	Unclear	Unclear	High	High	Low	Unclear	Unclear

Appendix 1. Search strategy

MEDLINE (Ovid Online)

1 Aged/ (2296985)
2 ((old$ or aged or elder$ or geriatric$ or senior$) adj5 (people or adult$ or person$1)).tw. (122481)
3 1 or 2 (2336369)
4 Exercise/ (66495)
5 Exercise therapy/ (25373)
6 Exercise Movement Techniques/ (353)
7 "Physical Education and Training"/ (11702)
8 Walking/ (19465)
9 Postural Balance/ (14173)
10 Resistance Training/ (2878)
11 Tai Ji/ (579)
12 Breathing Exercises/ (2697)
13 Dance Therapy/ (206)
14 (exercis$ or training).tw. (377131)
15 (balance adj3 (retraining or re-training or reeducation or re-education)).tw. (41)
16 (aerobic adj exercise$).tw. (4523)
17 or/4-16 (438843)
18 *Accidental Falls/pc [Prevention & Control] (3335)
19 *Fear/ (12030)
20 (fright$ or fear$ or afraid).tw. (49908)
21 19 or 20 (52676)
22 18 and 21 (189)
23 ((fear$ or fright$ or afraid) adj5 fall$).tw. (780)
24 "fear of falling".tw. (667)
25 ("Falls Efficacy Scale" or "Mobility Efficacy Scale" or "Survey of Activities and Fear of Falling in the Elderly" or "University of Illinois
at Chicago Fear of Falling Measure" or "SAFFE" or "UICFFM" or "Activities Specific Balance Confidence Scale" or "Confidence in
Maintaining Balance Scale" or "CON-Fbal").tw. (267)
26 or/22-25 (951)
27 3 and 17 and 26 (415)
28 Randomized controlled trial.pt. (379376)

29 Controlled clinical trial.pt. (88638)
30 randomized.ab. (276583)
31 placebo.ab. (149709)
32 Drug therapy.fs. (1726877)
33 randomly.ab. (193902)
34 trial.ab. (288497)
35 groups.ab. (1243213)
36 or/28-35 (3217356)
37 exp Animals/ not Humans/ (4002688)
38 36 not 37 (2738483)
39 38 and 27 (186)

Appendix 2. References to studies included in the review

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Online table 1 . Characteristics of included studies

Study (Design), Country,	Number of participants (% female)	Mean age in years (SD)	Study population	Primary Aim	ProFaNE 2011 taxonomy	Supervised exercise	Group/ individual exercise	Control group intervention
Barnett 2003 (RCT) Australia[c]	163 (67)	75 (5.5)	Older people aged 65 and older recruited from general practice with one or more risk factors for falls.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Supervised	Group	Education (falls prevention)
Campbell 1997 (RCT) New Zealand[e]	233 (100)	84 (3.3)	Women aged 80 and over recruited from general practice.	Improve balance, physical performance and/or prevent falls	Strength/ resistance	Unsupervised	Individual	Social visits
Clemson 2010 (RCT) Australia[i]	34 (47)	82 (6.0)	Older people aged 70 and older with two or more falls in the past year.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Unsupervised	Individual	No intervention
Freiberger 2012 (RCT) Germany[p]	144 (47) Fitness and Control groups	76 (4.1)	Older people aged 70 to 90 recruited from a health insurance database who had fallen in past 6 months or reported fear of falling	Reduce fear of falling	Strength/ resistance	Supervised	Group	No intervention
Haines 2009 (RCT)	53 (60)	81 (7.7)	Older people aged 65 years	Improve balance,	Gait, balance, co-	Unsupervised	Individual	No intervention

Australia[q]			and over discharged from geriatric rehabilitation or surgical units of a local hospital.	physical performance and/or prevent falls	ordination, functional tasks			
Halvarsson 2011 (RCT) Sweden[j]	59 (71)	77 (range 67 – 93)	Older people aged 65 years or older who had fallen in the last year or reporting a fear of falling.	Reduce fear of falling	Gait, balance, co-ordination, functional tasks	Supervised	Group	No intervention
Hinman 2002 (RCT) USA[r]	97 (63)	72 (range 63-87)	Recruited from local community	Improve balance, physical performance and/or prevent falls	Home exercise programme: Gait, balance, co-ordination, functional tasks	Supervised	Individual	No intervention
					Computerised balance training: Gait, balance, co-ordination, functional tasks	Unsupervised	Individual	No intervention
Karinkanta 2012 (RCT) Finland[s]	149 (100)	73 (2.3)	Women aged 70 to 79 years old living in Tampere, Finland.	Reduce fear of falling	Resistance training: Strength/resistance	Supervised	Group	No intervention
					Balance jumping: Gait, balance, co-ordination, functional	Supervised	Group	No intervention

					tasks			
					Combined resistance and balance jumping: Gait, balance, co-ordination, functional tasks	Supervised	Group	No intervention
Lai 2013 (RCT – Cross over design) Taiwan[t]	30 (57)	72 (4.6)	Older people aged 65 and older living in the community.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Supervised	Individual	No intervention
Lajoie 2004 (Quasi – randomised trial) Canada[k]	24 (83)	71	Older people aged 65 and older living in the community and residential care facilities.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Supervised	Individual	No intervention
Lin 2007 (RCT) Taiwan[h]	100 (51)	77	Older people aged 65 and older recruited from clinics and hospitals who had fallen in the past 1 month.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Supervised	Individual	Home safety assessment
Logghe 2009 (RCT) The Netherlands[u]	269 (71)	77 (4.7)	Older adults aged 70 years and over living at home reporting a high falls risk.	Improve balance, physical performance and/or prevent falls	3D (tai chi, qi gong, dance, yoga)	Supervised	Group	No intervention
McCormack	43 (70)	79 (5.9)	Older adults	Reduce	Holistic	Supervised	Group	No

2004 (RCT) Australia[v]			aged 65 and over recruited from the community.	fear of falling	exercise: 3D (tai chi, qi gong, dance, yoga)			intervention
					Conventional exercise: Strength/resistance	Supervised	Group	No intervention
Nguyen 2012 (RCT) Vietnam[b]	96 (50)	69 (5.1)	Older adults aged 60 to 79 years old.	Improve balance, physical performance and/or prevent falls	3D (tai chi, qi gong, dance, yoga)	Supervised	Group	No intervention
Reinsch 1992 (Cluster-RCT) USA[w]	107 (89) in exercise only and control group	75 (7.5)	Older adults aged 60 and older living in 16 senior centres located in low socioeconomic areas.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Unsupervised	Individual	Discussion group
Rendon 2012 (RCT) USA[f]	40 (65)	85 (5.4)	Older adults aged 60 to 95 years old able to participate in 45 min to 60 min of physical activity and with normal vision.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Supervised	Individual	No intervention
Resnick 2008 (Cluster-RCT) USA[x]	166 (81)	73 (8.2)	Older adults aged 60 and older recruited from 13 senior centres.	Improving self-efficacy for exercise and overall	Strength/resistance	Supervised	Group	Education (nutrition)

				physical activity				
Sihvonen 2004 (RCT) Finland[d]	28 (100)	82 (5.2)	Older women recruited from residential care homes.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Unsupervised	Individual	No intervention
Tiedemann 2012 (RCT) Australia[y]	54 (80)	68 (7.1)	Older adults aged 59 and older recruited from community.	Improve balance, physical performance and/or prevent falls	3D (tai chi, qi gong, dance, yoga)	Supervised	Group	Education (falls prevention)
Ullmann 2010 (RCT) USA[l]	47 (70)	76 (7.3)	Older adults aged 65 and older recruited from community.	Improve balance, physical performance and/or prevent falls	3D (tai chi, qi gong, dance, yoga)	Supervised	Group	No intervention
Vogler 2009 (RCT) Australia[m]	180 (79)	80 (7.0)	Older adults aged 65 or older recently discharged from aged care and rehabilitation hospital.	Improve balance, physical performance and/or prevent falls	Seated exercise: Strength/resistance	Unsupervised	Individual	Social visits
					Weight bearing exercise: Strength/resistance	Unsupervised	Individual	Social visits
Vrantsidis 2009 (RCT) Australia[z]	62 (76)	75 (8.2)	Older adults aged 55 or over living in the community who had at least 1 fall in previous 6	Improve balance, physical performance and/or prevent falls	3D (tai chi, qi gong, dance, yoga)	Supervised	Group	No intervention

			months.					
Wallsten 2006 (RCT – Cross over design) USA[n]	77 (74)	81 (range 61-92)	Older adults aged 61 and over living independently in a retirement community.	Reduce fear of falling	3D (tai chi, qi gong, dance, yoga)	Supervised	Group	No intervention
Weerdesteyn 2006 (RCT) The Netherlands[o]	58 (72) Exercise group and Control group	74 (5.7)	Older adults aged 65 and older with at least one previous fall.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Supervised	Group	No intervention
Westlake 2007 (RCT) Canada[aa]	36		Older adults aged 65 years and older recruited from the community.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Supervised	Group	Education (falls prevention)
Wolf 1996 (RCT) USA[g]	200 (81)	76 (4.7)	Older adults aged 70 and older recruited from the community.	Improve balance, physical performance and/or prevent falls	Tai chi: 3D (tai chi, qi gong, dance, yoga)	Supervised	Group	Education (gerontology)
					Computerised balance training: Gait, balance, co-ordination, functional tasks	Supervised	Individual	Education (gerontology)
Wolf 2001 (RCT) The Netherlands[bb]	94 (73)	84 (5.6)	Older adults aged 75 years and older, living independently or in a	Improve balance, physical performance and/or prevent	Gait, balance, co-ordination, functional tasks	Supervised	Individual	Crafts/games

			residential care facility.	falls				
Yang 2012 (RCT) Australia[cc]	165 (44)	81 (6.2)	Older adults aged 65 years and older who did not have more than 1 fall in the previous year.	Improve balance, physical performance and/or prevent falls	Gait, balance, co-ordination, functional tasks	Unsupervised	Individual	No intervention
Yoo 2010 (RCT) South Korea[a]	21 (100)	71 (2.7)	Older women aged 65 and over who could participate in moderate exercises.	Reduce fear of falling	Strength/resistance	Supervised	Group	No intervention
Zhang 2006 (RCT) China[dd]	49 (47)	70 (4.3)	Older adults aged 60 and over recruited from the community.	Reduce fear of falling	3D (tai chi, qi gong, dance, yoga)	Supervised	Group	No intervention

Online table 2. Data (immediately post-intervention) used in meta-analyses

Study	Scale	Scale direction	Intervention group			Control group		
			Mean	SD	No. of participants	Mean	SD	No. of participants
Clemson 2010[42]	MFES	High score = Low FOF	49.4	6.1	17	42.6	9.4	12
Clemson 2010[42]	ABC	High score = Low FOF	995.3	377.9	17	805.0	297.1	12
Freiberger 2012[50]	ABC	High score = Low FOF	148.6	16.8	57	150.3	12.4	64
Haines 2009[51]	ABC	High score = Low FOF	5.3	2.0	19	5.6	2.0	28
Halvarsson 2011[43]	FES-I	High score = High FOF	-22.6	6.1	34	-28.9	9.3	21
Hinman 2002[52]	MFES	High score = Low FOF	134.6	10.9	58	135.4	14.1	30
Karinkanta 2012[53]	100mm VAS	High score = High FOF	-10.7	15.7	106	-16.9	21.2	34
Lai 2013[54]	MFES	High score = Low FOF	136.0	6.1	15	116.4	27.9	15
Lajoie 2004[44]	ABC	High score = Low FOF	92.0	8.0	12	82.5	26.0	12
Logghe 2009[55]	FES	High score = High FOF	-4.9	4.4	73	-5.8	5.3	89
McCormack 2004[56]	MFES	High score = Low FOF	9.1	1.5	27	8.1	2.4	7
Nguyen 2012[35]	FES	High score = High FOF	-35.2	5.9	39	-51.4	8.1	34
Resnick 2008[58]	Scale*	High score = High	-1.6	1.8	64	-1.8	1.8	39

		FOF						
Reinsch 1992[57]	Scale**	High score = High FOF	-1.5	0.8	44	-1.7	1.3	42
Tiedemann 2012[59]	FES-I	High score = High FOF	-9.8	4.5	27	-10.6	3.2	25
Ullmann 2010[45]	FES	High score = Low FOF	9.3	1.4	19	9.0	1.7	22
Ullmann 2010[45]	ABC	High score = Low FOF	83.5	13.5	19	86.4	10.6	22
Vogler 2009[46]	MFES	High score = Low FOF	8.6	1.8	114	8.5	1.8	57
Vrantsidis 2009[60]	MFES	High score = Low FOF	8.6	1.6	26	7.7	1.9	29
Wallsten 2006[47]	ABC	High score = Low FOF	76.2	20.3	25	70.5	12.3	28
Weerdesteyn 2006[48]	ABC	High score = Low FOF	76.3	13.4	29	69.7	17.8	23
Westlake 2007[61]	ABC	High score = Low FOF	85.7	9.5	17	79.1	24.2	19
Wolf 2001[62]	100mm VAS	High score = High FOF	-38.6	29.7	37	-44.7	29.9	40
Yang 2012[63]	MFES	High score = Low FOF	9.2	1.2	59	9.1	1.4	62
Yoo 2010[30]	K-FES	High score = Low FOF	100.0	0.0	11	95.4	6.8	10
Zhang 2006[64]	FES	High score = Low FOF	78.3	4.0	24	75.3	5.9	23

***** Participants asked to rate fear of falling on a scale of 0 to 4 (0 = low, 4= high).

** Participants asked to rate worry about falling on a scale of 1 to 5 (1 = not at all worried, 5 = extremely worried)