Do exercise interventions improve participation in life roles among older adults? A systematic review and meta-analysis

Marla K Beauchamp, PhD,[1,2] Annemarie Lee, PhD,[2] Rachel Ward, PhD,[3,4] Samantha Harrison, PhD,[5] Paul A Bain, PhD,[6] Roger S Goldstein, MD,[2,7] Dina Brooks, PhD,[2,7] Jonathan F Bean, MD,[3,4] Alan M Jette, PhD[8]

[1]School of Rehabilitation Science and Department of Medicine, McMaster University, Hamilton, Ontario, Canada

[2] West Park Healthcare Centre, Toronto, Ontario, Canada

[3]New England Geriatric Research Education and Clinical Center, Veterans Administration Boston Health System, Boston, MA, USA

[4]Department of Physical Medicine and Rehabilitation, Harvard Medical School, Boston MA

[5]School of Health and Social Care, Teesside University, Middlesbrough, UK

[6]Countway Library of Medicine, Harvard Medical School, Boston, MA, USA

[7]Depatment of Physical Therapy, University of Toronto, Ontario, Canada

[8]Health and Disability Research Institute, Boston University School of Health, Boston, MA, USA

Address correspondence to:

Marla Beauchamp, PT, PhD

School of Rehabilitation Science

McMaster University

1400 Main Street West, Hamilton ON L8S 1C7

IAHS Room 428

Tel: 905-525-9140 ext. 21732

Fax: 905-524-0069

Email: beaucm1@mcmaster.ca

ABSTRACT

Background: The World Health Organization recognizes participation in meaningful life roles as a key component of health. However, the evidence-base for interventions to improve participation remains inconclusive. In particular, it is unclear if exercise interventions improve participation in life roles.

Purpose: The aim of this review was to evaluate the effect of physical exercise interventions on participation in life roles among community-dwelling older adults.

Data sources: Pubmed, Embase, CINAHL, Cochrane and PEDro were searched from inception through March 2015.

Study selection: Randomized controlled trials comparing the effects of an exercise intervention to usual care on participation in life roles in adults aged 60 and older were included in this review.

Data extraction: Teams of two investigators independently extracted data on participation. Methodological quality was appraised using Cochrane's tool for assessing risk of bias. The protocol was registered with PROSPERO, number CRD42014014880.

Data synthesis: 18 randomized controlled trials with a total of 2,315 subjects met inclusion criteria. Standardized mean differences (SMDs) with 95% CIs were calculated using a random-effect model. Meta-analysis of 16 studies showed no overall effect of the exercise interventions on participation (SMD 0.03; 95%CI -0.10 to 0.16; p =0.63). Exercise interventions lasting 12 months or more had a small positive effect on participation (SMD 0.15; 95%CI 0.02 to 0.28; p=0.03).

Limitations: Variability in definition and measures of participation.

Conclusions: In general, exercise interventions do not improve participation in life roles among older adults. Our results **do not support the implicit assumption that exercise-based interventions associated with improved function/activity also result in improved participation.** Investigation of complex interventions that go beyond exercise to address participation in life roles for older adults is warranted.

Key words: Disability, physical activity, rehabilitation, social role

Word count: 3414

INTRODUCTION

Participation, defined as a person's involvement in life situations, is well recognized as a critical aspect of health;[1] it is one of three main components in the World Health Organization's International Classification of Functioning, Disability and Health (ICF). The degree to which an individual is able to take part in their meaningful life roles, such as taking care of others and visiting with friends, is predictive of health-care utilization, morbidity and survival.[2,3] Among adults over age 50, more than 50% have participation restrictions with the prevalence increasing with age.[4] Distinct from more commonly measured outcomes of function or mobility, participation restrictions reflect a broader patient-centered outcome more meaningful to individuals than difficulties in performing basic movements or activities.[5]

Within the ICF framework, participation is described as resulting from the complex interaction between a health condition or disease, body functions and structures (anatomic and physiologic functioning of organs and body systems), activities (execution of actions by an individual), and personal and environmental factors.[1] Participation is thus also consistent with the concept of disability in Nagi's original disablement model.[6] Examples of participation include involvement in home or community life such as taking part in active recreation, while the activity domain includes discrete physical tasks such as walking and getting up from a chair.

Despite its importance, participation is not measured consistently in medical and rehabilitation research and the evidence-base for interventions to improve participation outcomes remains inconclusive. **In both the ICF and Nagi's disablement model, activity/functional limitations are depicted as having a direct effect on the development of subsequent participation**

restrictions. However, empirical evidence has shown that these types of physical functional deficits may in fact have only a modest effect on participation;[7,8] environmental and personal factors likely play a much bigger role. Consequently, although rehabilitative interventions often focus on improving function, these improvements may not necessarily translate to improvements in participation. In particular, while exercise is widely considered the cornerstone of chronic disease management and has **well-established effects on improving function**,[9] it is unclear whether exercise-based interventions have any impact on participation in life roles.[10,11] Earlier narrative reviews have called into question the evidence for exercise interventions to improve participation;[11] while a recent meta-analysis focusing specifically on fall prevention exercise programs noted a small favorable effect.[10]

The aim of this systematic review was to evaluate the effect of physical exercise interventions on participation in life roles among older adults. Secondary aims were to explore possible parameters of successful programs and the impact of the measurement method on results. In this review we focused broadly on any type of physical exercise intervention given to adults over the age of 60 that included an explicit measure of participation.

METHODS

The methodology is consistent with PRISMA guidelines[12] for systematic reviews and meta-analyses. The review protocol was registered on Prospero (CRD42014014880).

Data sources and searches

We searched PubMed/MEDLINE (NCBI), Embase (Elsevier), CINAHL (EBSCO), the Cochrane Central Register of Clinical Trials (EBSCO), and PEDro (The George Institute for Global Health) for randomized controlled trials addressing the effect of exercise or physical activity on participation, disability, role functioning, or community engagement in older adults (see Appendix for full search strategy). The searches were conducted in March 2015 and included all available dates for each database. The search strategies, which were designed and executed by a librarian (PB), included controlled vocabulary terms when available. For PubMed, Embase and CINAHL, we limited to randomized controlled trials using the simplified search strategy of Royle and Waugh.[13] No language limits were applied. Bibliographies of included studies and relevant reviews were examined for additional studies. An updated search of PubMed/Medline using the same search strategy was performed in October 2015 by the principal investigator (MB).

Study selection

Two investigators (MB and AL) independently screened abstracts of retrieved papers. Full texts of relevant studies were independently assessed by teams of two reviewers (MB, AL, RW, SH) with disagreements resolved by consultation with a third investigator (AJ). Two investigators (MB and AJ) evaluated the specific participation outcome measures for inclusion in the review. Inclusion criteria comprised:

- Types of studies: Randomized controlled trials**.**
- Types of participants: Studies including community-dwelling adults ≥ 60 years of age**.**
- Types of interventions: Any non-pharmacological intervention that included exercise or physical activity (defined as any planned activity or series of movements undertaken to

increase fitness or health) either alone or as a component of a multi-faceted intervention compared to usual care.

- Types of outcomes: Generic patient-reported instruments designed to measure some aspect of participation based on an existing conceptual framework (i.e., ICF or Nagi). In this study, we operationalized participation as involvement in life situations involving complex behaviors that can be accomplished using a variety of tasks or component actions (rather than activities that require only basic physical tasks).[14] To be included in this review instruments needed to have more than half of items devoted to participation according to our working definition.

Studies where only conference abstracts were available and those not published in English were excluded. In addition, studies including measures assessing distinct but related constructs (e.g., quality of life, activities of daily living, physical activity) were excluded as well as sub-scales from multi-scale measures not designed to measure participation.

Data extraction & quality assessment

Teams of two investigators (MB, AL, RW, SH) independently extracted data into a standardized form. Missing data were requested from authors. Only one author responded.[15]

The same reviewer teams independently assessed the internal validity of the studies. Methodological quality was appraised using Cochrane's tool for assessing risk of bias.[16] It was planned that studies with greater than three biases would be considered of poor methodological quality and excluded from meta-analysis or analyzed separately.

Data synthesis and analysis

Where possible, trial data were combined using Review Manager 5.3 (Cochrane Collaboration's Information Management System), with all outcomes treated as continuous variables. Due to the heterogeneity in outcome measures, the standardized mean difference (SMD) using a random-effect model was selected when estimating the total effect of combined data. If all available data were obtained from a common outcome measure the weighted mean difference (WMD) was selected. Forest plots were used to visually depict results. Homogeneity across studies was tested for each outcome using the I^2 statistic. Subgroup analyses were planned for studies evaluating long-term exercise (≥ 12months), those with multiple components (e.g., exercise plus education) and for specific outcome measures where data were available to be pooled from more than one study.

RESULTS

Search results

The systematic search of electronic databases provided a total of 3642 records and 2049 records after eliminating duplicates (Fig. 1). Of these, 1849 were excluded after initial title and abstract screening by two reviewers. The full texts of the remaining 200 articles were examined in more detail with 18 studies[15,17-33] ultimately included in the review.

In total, 2,315 older adults were randomized to an exercise intervention or usual care. The study characteristics are shown in Table 1. The majority of studies were conducted in the United States[15,18,20,23,29,31,33] and Australia,[17,19,21,22,25,30] followed by the United Kingdom, [24,26] Finland,[27] Canada,[28] and Stockholm.[32] Many studies focused on community-dwelling older adults meeting

specific criteria (e.g., pre-frail, frail, high fall risk),[19-22,25,27,32] however a number of distinct clinical populations were represented including stroke,[17,18,24,26,28,31] cancer survivors,[15,33] Parkinson's Disease,[23] veterans,[29] and chronic obstructive pulmonary disease.[30] The most widely used participation measure was the Late-Life Disability Instrument (LLDI) (nine studies), followed by the Frenchay Activities Index (FAI) (four studies) and the Reintegration to Normal Living Index (RNLI) (two studies). The remaining participation measures were the Adelaide Activities Profile (AAP), Activity Card Sort (ACS) and the London Handicap Scale (LHS). **Over 80% of the items in the six instruments included in this review were deemed as addressing participation as per our operational definition.** The LLDI frequency scale, FAI and AAP assess frequency of participation, whereas the LHS, RNLI and LLDI limitation scale mainly assess perceived difficulty in participation. The ACS focuses on current levels of participation in relation to premorbid levels.

Exercise interventions

A detailed description of the exercise interventions is provided in Appendix Table 1. Most programs included mainly lower-extremity exercise targeting one or two impairments or activities (e.g. balance, strength, walking),[15,17,19,20,25,27,30-33] however some interventions also involved other components such as education and behavioral support often through telephone follow-up.[18,22,26,28,29] Of note, the study by Mayo et al.[28] included a multi-faceted intervention designed specifically to target participation and included project-based activities to promote social engagement as well as exercise sessions. Other types of interventions included a stroke tele-rehabilitation intervention,[18] a modified Sun tai chi program,[21] an Argentine Tango class,[23] and a Nintendo Wii-fit program.[20] Interventions were typically delivered in the

community,[17,21,23,26,28] home,[18,19,22,24,25,29] or hospital outpatient/centre-based setting,[15,24,30-33] and often involved physiotherapists or trained fitness instructors. Program durations ranged from 8 weeks[26] to 30 months[27] with most clustering either around the 3-month or 1-year mark. Training progression was typically reported as individualized however training intensity targets were rarely reported.

Risk of bias

There was consistent agreement between reviewers for study quality. Most studies were judged to have a high risk of bias for just one item, with no study deemed as having more than two biases (see Table 2). Eleven trials reported adequate randomization procedures, and 14 reported allocation concealment indicating minimal selection bias. Thirteen studies were judged to have a high risk of performance bias due to lack of participant blinding, which is largely unavoidable for trials involving exercise. Blinding of outcome assessors was also reported for most trials, with only one study at high risk of bias for this item. Potential for attrition bias due to handling of incomplete outcome data was judged to be low in all but one trial. The risk for reporting bias due to selective outcome reporting was unclear in 13 studies, due to few trials with published protocols available for verification. Nonetheless, in each of these trials all measures that were reported were accounted for. No other sources of bias were identified in any study.

Overall effect on participation

Data from 16 studies were available to be pooled for meta-analysis. Two studies were excluded from the quantitative synthesis due to missing data not available from authors[27] and insufficient follow-up numbers.[20] Random-effect meta-analysis from the 16 studies including 2,132 subjects

showed no overall effect of the exercise interventions on participation (SMD 0.03; 95%CI -0.10 to 0.16; p=0.63) (see Figure 2).

Subgroup analyses

Six studies were classified as long-duration programs or studies in which the intervention lasted 12 months or more.[15,19,22,23,29,33] Meta-analysis of those studies including 894 subjects showed a favorable effect of long-duration programs on participation (SMD 0.15; 95%CI 0.02 to 0.28; p=0.03) (see Figure 3).

Studies in which exercise was not the only component (i.e., included an education or behavioral component) were classified as multi-component interventions.[18,22,26,28,29] The pooled effect of these programs (five studies) on participation was not significant (SMD 0.03; 95%CI -0.19 to 0.26; p=0.77).

Pooled data from more than one study were available for three participation measures: the LLDI, the FAI and the RNLI. The effect of exercise interventions[15,18,19,21,29,31-33] (eight studies) on the LLDI limitation scale was not significant (WMD 1.19; 95%CI -0.47 to 2.85; p=0.16) (Figure 4), nor was the effect on the LLDI frequency scale[18,19,21,29,31,32] (six studies) (WMD 1.21; 95%CI -0.23 to 2.65; p=0.10). In the three studies that used the FAI,[24-26] the pooled effect was not significant (WMD -2.15; 95%CI -5.21 to 0.91; p=0.17). Similarly, there was no effect of exercise on the RNLI (SMD 0.02;95%CI -0.18 to 0.21; p=0.88). The SMD was chosen instead of the WMD for the RNLI as the scoring methods were not consistent across the two studies.[22,28]

Studies using participation measures assessing perceived difficulty or satisfaction with participation (LLDI limitation, RNLI, LHS) were also analysed separately from those assessing frequency of participation (LLDI frequency, FAI, AAP). There was no effect of exercise on participation difficulty (SMD 0.11;95%CI -0.01 to 0.22;p=0.09) nor on participation frequency (SMD 0.0;95%CI-0.18 to 0.18; p=0.99).

DISCUSSION

Although exercise has displayed consistently favorable effects on improving functional limitations in multiple clinical populations, results from the 18 randomized trials included in this review demonstrate that the benefits of exercise do not necessarily extend to participation in life roles for older adults presenting with a wide range of chronic diseases and mobility limitations. There was a small favorable effect of long-term exercise programs (i.e., those lasting ≥ 12 months) on participation suggesting that intervention duration might be an important parameter to target. Our results thus do not support the implicit assumption that exercise-based interventions associated with improved function/activity also result in improved participation. Given the importance of participation as a critical patient-centered health outcome, there is a need to develop complex interventions that go beyond exercise to address participation and its determinants for older adults.

In existing disablement paradigms, functional limitations (such as the inability to walk or get out of a chair) are described conceptually as having a direct impact on development of subsequent restrictions in participation.[1,6] Indeed, there is empirical evidence to support that functional limitations do occur temporally before the onset participation restrictions;[34] there is also data to

support a direct effect of functional limitations on participation in life roles.[7] However, less well appreciated is that the impact of functional deficits on participation is modest at best[7,8] with a host of other environmental and personal factors likely implicated. Therefore, any implicit assumption that an exercise-based intervention that results in improved function/activity outcomes will ultimately also lead to improvements in participation may be flawed. Our results in this meta-analysis certainly support this interpretation. Conversely, since participation also reflects the outcome of the interaction between individual capabilities and environmental demands, it is also possible that environmental factors could have outweighed small changes in individual capacity resulting from exercise, such that participation remained unchanged. Nevertheless, to achieve a clinically important effect, tailored interventions specifically designed to target participation and its determinants (be they individual or environmentally focused) are likely needed. Only one study in this review included such an intervention: the Getting on with the Rest of Your Life: Mission Impossible program by Mayo et al.[28] The intervention included a multi-modal group exercise component as well as project-based activities promoting learning, leisure and social activities in people with chronic stroke. Unfortunately, the delayed entry design of the trial was such that between-group comparisons could only be made after 3 months of enrolment in the 12-month intervention. While there was no between-group difference at 3 months, within-subject improvements in participation were demonstrated at 12 and 15 months highlighting the potential efficacy of such programs and the need for further more formal evaluation of similar targeted interventions. Also, the equivocal findings at 3-months are not surprising given the results from our subgroup analysis suggesting that programs lasting 12 months or longer may be necessary to have an impact on participation. Taken together, these

findings suggest that long duration programs with a focus on supporting both exercise and leisure and social engagement may prove to be most beneficial for enhancing participation.

After an extensive search of the literature, we could identify only 18 trials that included an explicit measure of participation as an outcome. Therefore, despite its importance and recognition as a critical aspect of health, participation is not a commonly measured outcome in the existing literature on rehabilitative exercise in older adults. Certainly one explanation is many exercise programs are prescribed with the intention of increasing capacity at the body function or activity level without a goal for improving participation. Additionally, although recent reviews have identified a number of instruments that appear to measure this participation;[35,36] to date, limited data exist regarding their psychometric properties and particularly their ability to detect change in response to interventions. In fact, this is one alternative explanation for the overall lack of effect of exercise on participation in this review; some of the measures may not have been able to detect change even if change had occurred. This is partially supported by our subgroup analyses which showed a trend for more favorable results of exercise on the LLDI - one of the participation measures with the most prior evidence supporting its ability to detect change.[3,37] However, the weighted mean difference was small (just over 1 point) and did not exceed prior estimates of the measure's minimal detectable change,[3] suggesting that lack of responsiveness of the measures alone is unlikely to explain our findings. This is further supported by a previous review on fall prevention exercise programs which found only a small pooled effect on participation[10] and by a systematic review in children which found exercise alone had little effect on participation.[38]

Exercise interventions are sometimes prescribed not with the view of increasing participation, but with the goal of increasing the ease and safety of the participation the patient is already engaged in. However, some participation measures are focused only on frequency of participation, and do not include an assessment of the value derived from participation or degree of limitation a person perceives in their participation. This can be problematic for measurement purposes as it is possible that an intervention improves the ease with which patients participate without affecting their frequency, particularly if a patient was already satisfied with their current level of participation. In fact, we have previously shown that how much difficulty a person perceives in their participation is more responsive to change than how often a person participates; this may also reflect the inherent difficulty in changing a person's actual behavior versus their perceived capability.[3,37] Despite this challenge, the frequency with which an older person participates in life situations is a better predictor of adverse outcomes than perceived limitations,[3] and remains an important therapeutic target for the older adult population. Of the six participation measures included in this review, only the LLDI[39] considers both perceived difficulty and frequency of participation and it is noteworthy that neither domain demonstrated a statistically or clinically important improvement following exercise. Similarly, although our subgroup analysis pooling studies with measures assessing participation frequency separately than those assessing perceived difficulty suggested a trend for a greater response on the latter measures, the effect was not statistically significant. Therefore, the negative findings of this review are unlikely to be explained by differences in the participation instruments.

A difficult aspect of this review related to the complexity in defining and measuring participation. Multiple definitions of participation exist in the literature and there remains no

clear consensus on how best to operationalize this construct for measurement. In particular, within the ICF, although participation and activity have distinct definitions (involvement in life situations vs. execution of a task or action) the two constructs are treated as one category. We addressed this by using a working definition of participation that focused on life situations involving complex behaviors that could be completed using a variety of tasks or actions (rather than activities requiring only basic physical tasks). According to our operational definition, over 80% of the items in the six instruments included in this review were judged as addressing participation. In contrast, a comprehensive review of over 100 instruments designed to measure participation found that most instruments assessed participation only to a limited extent.[35] According to their working definition which emphasized the need for social context, only three measures out of the 103 instruments identified consisted entirely of participation items and only 25% of items across all measures were classified as addressing participation. Given this complexity, the findings of this review must be viewed in the context of our interpretation of participation.

Our study had several other limitations. Given the wide range of possible terminology used to describe participation our search strategy may have overlooked relevant studies. Similarly, our criteria for identifying suitable measures of participation likely resulted in exclusion of studies that included measures in which some aspects of participation were embedded. For example, the large-scale Lifestyle Interventions and Independence for Elders (LIFE) trial[40] targeting mobility disability did not meet our inclusion criteria as the study outcomes were more consistent with the ICF concept of activity limitation than participation. Inclusion of such studies would have obscured the impact of the exercise intervention solely on participation. In addition, although

statistical heterogeneity was generally low, the composition and duration of the exercise interventions were heterogeneous which limits direct comparisons between studies. Finally, although trial quality may have been a limitation, most studies had a risk of bias only in the blinding of participants and personnel. Such blinding is difficult to achieve in exercise studies and likely of low impact on self-reported measures of participation.

In summary, this review did not show an overall positive effect of exercise on participation in meaningful life roles in older adults. Although exercise interventions lasting 12 months or longer may have a small impact, there is a need for targeted interventions that go beyond exercise to address participation and its determinants. Participation involves a person's health, the individual's preferences, as well as the physical, social and cultural environment; it is likely that complex interventions addressing these underlying concepts will have the greatest impact. **There is a need for development of novel interventions aimed at enhancing this critical aspect of health for older adults.**

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Table 1: Study Characteristics

Study/ country	Population	Intervention	Usual care	Primary outcome	Part. measure	Key between-group findings
Ada et al. 2013 Australia	102 community dwelling people with stroke (Intervention 24% male, mean age 70,Control 19% male, mean age 63)	4mth community walking program, 30 mins, 3x/wk delivered by therapists.	No interventi on	Walking distance	AAP	4mth training group had greater improvement in walking distance, speed and health compared to controls at 4mth FU. No differences at12mth FU. No between group differences in AAP.
Chumbler et al. 2012 United States	48 individuals with stroke. Intervention 96% male, mean age 67, Control 100% male, mean age 68	3mth tele-rehabilitation program delivered by therapist and in-home assistant: 3 home visits, 5 biweekly phone calls, daily in-home messaging.	Routine Veteran Affairs care	FIM and the Late-Life Function Instrumen t (LLFI)	LLDI	No between group differences at 6mth FU in the motor FIM or the LLFI. Between group differences in LLDI limitation but not LLDI frequency scale.
Clemson et al. 2012 Australia	317 people with 2 or more falls or 1 injurious fall in past 12mth, mean age 83 (Intervention 31% male, control 32% male).	12mth home balance and strength program integrated into daily routines. Delivered by therapists via 5 home visits, 2 booster visits and 2 phone calls.	Gentle exercise sham control	Falls	LLDI	31% reduction in the rate of falls for the intervention group. Between-group improvement in LLDI frequency scale.
Daniel 2012 United States	23 pre-frail adults, mean age 77, 39% male	15 wk lab-based Nintendo Wii exercise program with weighted vests.	Instructed to continue usual activities	Physical performan ce outcomes	LLDI	No between-group analyses reported.
Day et al. 2012 Australia	503 preclinically disabled community-dwelling adults > 70 yrs.	24wk modified sun style tai chi. Classes held 2x/wk for 60mins per session.	Stretching and flexibility program	LLDI	LLDI	No between-group differences. Little change in mean LLDI scores in either group over 24wk period.

	(Intervention 34% male, Control 30% male)					
Fairhall et al. 2012 Australia	241 frail community-dwelling older people, mean age 83, 32% male	1yr interdisciplinary intervention targeting frailty phenotype. 10 home-based sessions with outpatient specialist visits as required.	Usual care	Mobility-related disability – levels of participation and activity limitation.	RNLI	Better goal attainment by intervention group at 12mth FU. Better activity limitation scores. No difference in RNLI.
Foster et al. 2013 United States	52 people with Parkinson's disease, mean age 69, 58% male	12mth Argentine Tango dance program. 1hr class, 2x/week.	Normal life routine.	Participation (ACS)	ACS	Total current participation increased in intervention group at 3, 6 and 12 months
Green et al. 2002 United Kingdom	170 patients with chronic stroke and persisting mobility problems. (Mean age from 72-74, 56% male)	Routine community physiotherapy service treated at home or as outpatient. Maximum of 13 wks, minimum of 3 contacts per patient.	No treatment	Mobility (RMI)	FAI	Between-group difference in RMI scores at 3 mths but not 6 or 9 mths. No difference in FAI scores between groups at 3,6 or 9mth FU.
Haines et al. 2009 Australia	53 older adults with mobility aid discharged from local hospital. (Mean age 81, 40% male)	Home exercise DVD – strength and balance work for 8 weeks. Weekly phone calls by physiotherapist for subsequent 8 wks.	Usual care	Falls, HRQOL, Physical capacity, fear of falling, FAI	FAI	No between group differences in any outcome at 2mth FU. Non-significant reduction in rate of falls in intervention group.
Harrington et al. 2010 United Kingdom	243 stroke survivors, mean age 70-71 yrs, 54% male	Leisure and community centre activities 2x/week for 8 weeks, total of 16 sessions. 1 hr of exercise and 1 hr education.	Information sheet on local groups and contact numbers – visit by stroke coordinator	SIPSO FAI RMI	FAI	Between-group difference in SIPSO physical integration at 9 wks and 1 yr. No difference in other primary outcomes.

Korpelainen et al. 2006 Finland	160 elderly women at risk for fracture (100% female, mean age 73yrs)	30mths of impact, balance and strengthening exercises. Weekly PT supervised sessions for 6 mths/yr and home exercises for remaining 6 mths.	Instructed to continue usual activities	Body sway and leg strength	FAI	Improvements in body sway and strength vs. controls. No effect on FAI.
Mayo et al. 2015 Canada	186 community dwelling persons within 5y of stroke onset, mean age 61yrs, 61% male	12mth multi-component group intervention targeting participation 2x week for 3h in 3 3mth blocks.	4mth delayed entry	CHAMPS, RNLI	RNLI	*Note:* Between-group comparison only available at 3mth FU. No differences between groups at 3mths. Within-subject analyses at 12 and 15mth FU showed improvements in CHAMPS and RNLI.
Morey et al. 2009 United States	398 older male Veterans (mean age 78 yrs, 100% male)	12mths of physical activity counseling by lifestyle health counselor. Instructed to walk 5x/wk and strength train 3x/wk. Telephone counseling biweekly for 6wks and monthly thereafter.	Continue normal daily activities	Usual and rapid gait speed by 8ft walk test	LLDI	Greater improvement in rapid gait speed in intervention vs. controls. Higher score for LLDI limitations after 12 mths, no difference in LLDI Frequency.
O'Shea et al. 2007 Australia	54 older adults with chronic obstructive pulmonary disease (39% male, Intervention mean age 67 yrs, Control 68 yrs)	12wk progressive resistance exercises, 3x/wk, led by physiotherapist once/wk and performed independently 2x/wk.	Instructed not to change baseline exercise routine.	Strength. walking capacity	LHS	Improvement in knee extensor strength vs. controls. No between-group difference in participation restrictions.

Ouellette et al. 2004 United States	42 adults after mild to moderate stroke (33% female, mean age 66 yrs)	12wk high-intensity resistance training, 3x/week, supervised (does not report by whom)	Upper extremity stretching 3x/wk	Muscle strength, function, disability	LLDI	Between-group improvements in most strength measures in intervention vs. controls. No differences in functional performance measures. Improvement in self-reported function and in LLDI limitation scale in intervention vs. controls.
Roaldsen et al. 2014 Stockholm	59 older adults (29% male, mean age 77yrs)	12-wks of progressive task-specific group balance training 3x/wk for 45min by physiotherapists	Instructed to maintain usual lifestyle	Self-reported function and disability	LLDI	Improvements in lower extremity function vs. controls. No improvement in disability.
Winters-Stone et al. 2012 United States	106 postmenopausal breast cancer survivors (100% female, mean age 62yrs)	1-yr resistance + impact exercise program, two 1-hr supervised classes (not reported by whom) and one 1-hr home-based session/wk	1-yr stretching and relaxation exercises	Strength, functional performance, self-reported function and fatigue	LLDI	Improvement in maximal leg and bench press strength vs. control. No between-group differences for LLDI or other outcomes.
Winters-Stone et al. 2015 United States	51 prostate cancer survivors on androgen deprivation therapy (100% male, mean age 70yrs)	1-yr moderate to vigorous intensity resistance training, two 1-hr supervised classes (not reported by whom) and one 1-hr home-based session/wk	1-year stretching and relaxation exercises	Strength, physical function, disability	LLDI	Improvement in maximal leg and bench press strength, and self-reported physical function and LLDI limitation scale vs. control.

AAP = Adelaide Activities Profile. LLDI= Late-Life Disability Instrument. LLFI = Late-Life Function Instrument. RNLI= Reintegration to Normal Living Index. ACS = Activity Card Sort. FAI = Frenchay Activities Index. FIM= Functional Independence Measure. RMI= Rivermead Motor Index. SIPSO= Subjective Index of Physical and Social Outcome. CHAMPS=

Community Healthy Activities Model Program for Seniors Physical Activity Questionnaire.

LHS = London Handicap Scale.

Table 2: Risk of bias assessment

Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding outcome assessment	Incomplete outcome data	Selective reporting
Ada et al. 2013	Low risk	Low risk	High risk	Low risk	Low risk	Low risk
Chumbler et al. 2012	Low risk	Low risk	High risk	Low risk	Low risk	Low risk
Clemson et al. 2012	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Daniel 2012	Unclear risk	Unclear risk	High risk	Unclear risk	Low risk	Unclear risk
Day et al. 2012	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear risk
Fairhall et al. 2012	Low risk	Low risk	High risk	Low risk	Low risk	Low risk
Foster et al. 2013	Unclear risk	Unclear risk	High risk	Low risk	Low risk	Low risk
Green et al. 2002	Low risk	Low risk	High risk	Low risk	Low risk	Unclear risk
Haines et al. 2009	Unclear risk	Low risk	High risk	Low risk	Low risk	Unclear risk
Harrington et al. 2010	Low risk	Low risk	High risk	Low risk	Low risk	Unclear risk
Korpelainen et al. 2006	Low risk	Low risk	High risk	Low risk	Low risk	Unclear risk
Mayo et al. 2015	Low risk	Low risk	High risk	Low risk	Low risk	Unclear risk
Morey et al. 2009	Low risk	Low risk	High risk	Low risk	Low risk	Unclear risk
O'Shea et al. 2007	Unclear risk	Low risk	High risk	Low risk	Low risk	Unclear risk
Ouellette et al. 2004	Unclear risk	Unclear risk	Low risk	Unclear risk	Low risk	Unclear risk
Roaldsen et al. 2014	Unclear risk	Low risk	High risk	High risk	Low risk	Unclear risk
Winters-Stone et al. 2012	Low risk	Low risk	Low risk	Low risk	Unclear risk	Unclear risk
Winters-Stone et al. 2015	Unclear risk	Unclear risk	Unclear risk	Low risk	Low risk	Unclear risk

FIGURE LEGENDS

Figure 1: Flow diagram illustrating selection of process for included studies.

Figure 2: The overall effect of exercise interventions on participation. Squares represent the point estimate; the size of the square is determined by how much weight the study contributes to the pooled effect estimate. The diamond represents the pooled effect estimate.

Figure 3: The effect of long duration (≥ 12 months) exercise interventions on participation. Squares represent the point estimate; the size of the square is determined by how much weight the study contributes to the pooled effect estimate. The diamond represents the pooled effect estimate.

Figure 4: The effect of exercise interventions on the Late-Life Disability Instrument Limitation Scale. Squares represent the point estimate; the size of the square is determined by how much weight the study contributes to the pooled effect estimate. The diamond represents the pooled effect estimate.

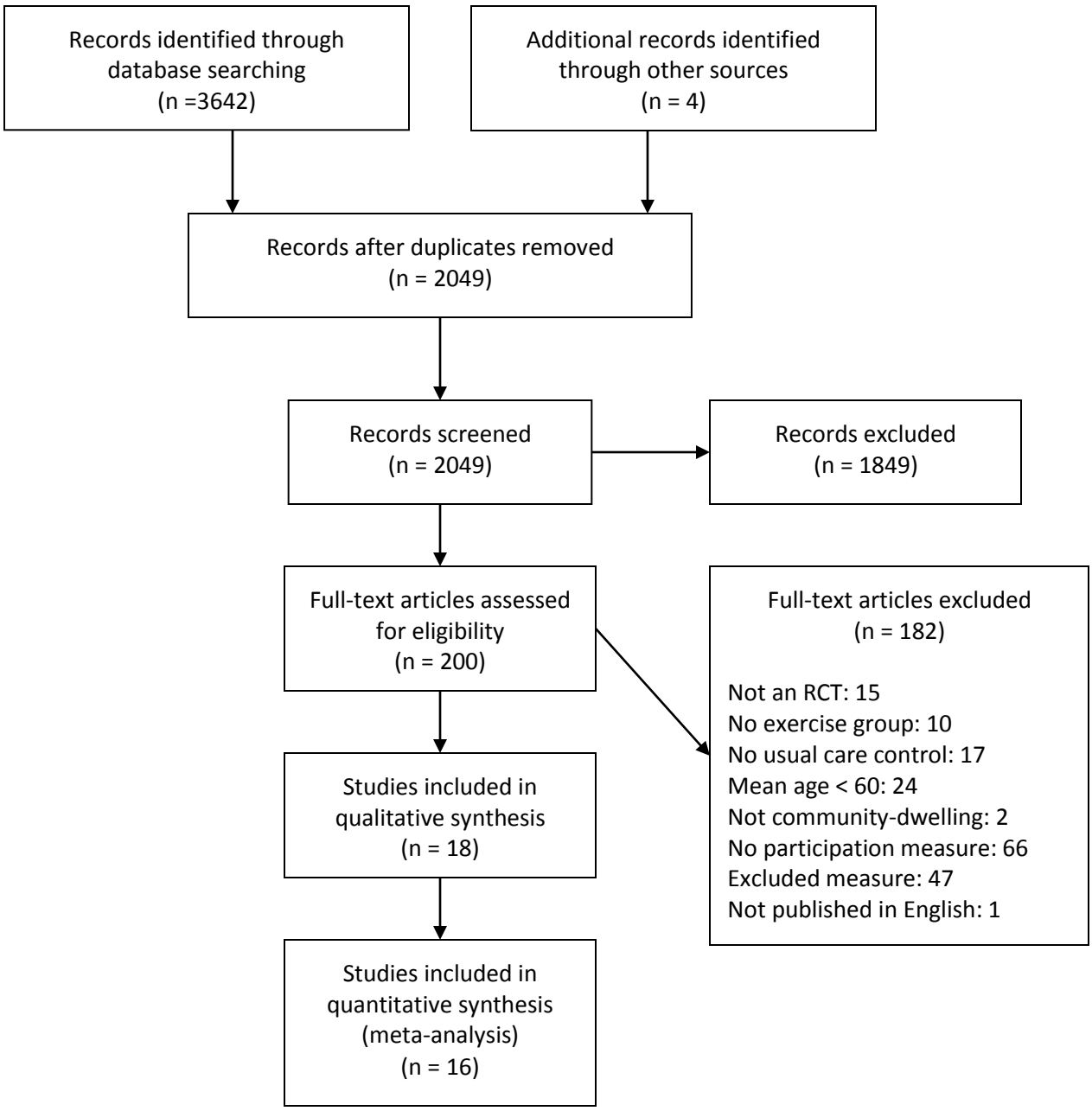
Records identified through database searching (n =3642)
Additional records identified through other sources (n = 4)
Records after duplicates removed (n = 2049)
Records screened (n = 2049)
Records excluded (n = 1849)
Full-text articles assessed for eligibility (n = 200)
Full-text articles excluded (n = 182)
Not an RCT: 15
No exercise group: 10
No usual care control: 17
Mean age < 60: 24
Not community-dwelling: 2
No participation measure: 66
Excluded measure: 47
Not published in English: 1
Studies included in qualitative synthesis (n = 18)
Studies included in quantitative synthesis (meta-analysis) (n = 16)

Figure 1: Flow diagram illustrating selection of process for included studies.

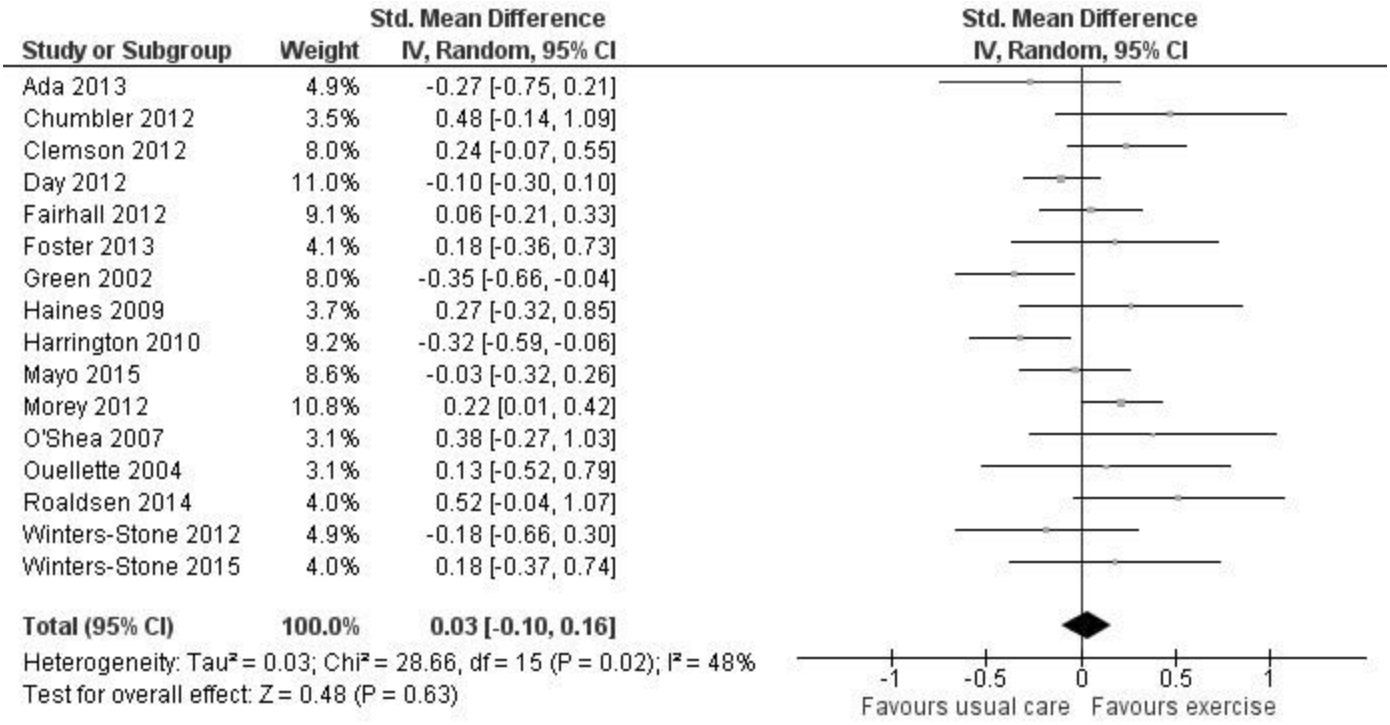

Figure 2: The overall effect of exercise interventions on participation. Squares represent the point estimate; the size of the square is determined by how much weight the study contributes to the pooled effect estimate. The diamond represents the pooled effect estimate.

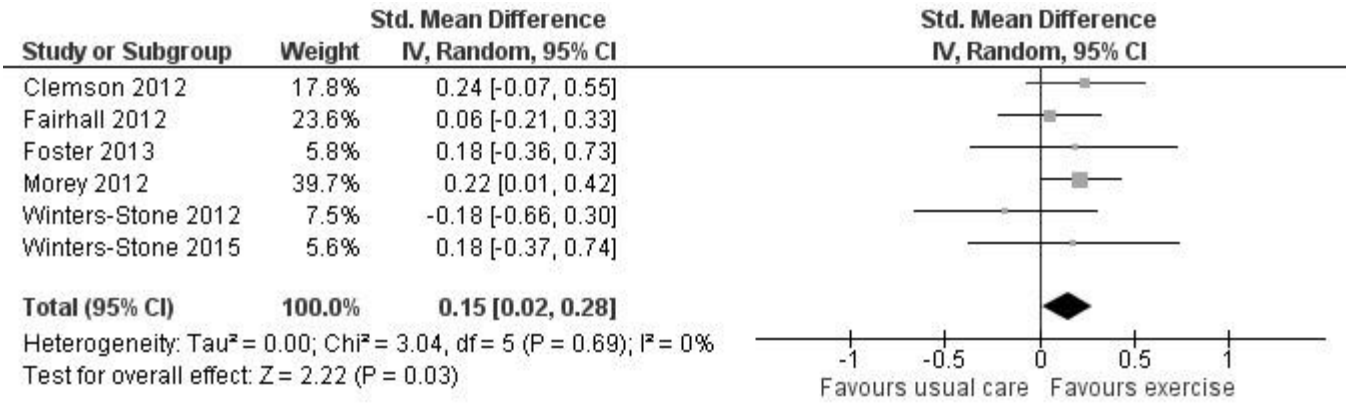

Figure 3: The effect of long duration (≥ 12 months) exercise interventions on participation.

Squares represent the point estimate; the size of the square is determined by how much weight the study contributes to the pooled effect estimate. The diamond represents the pooled effect estimate.

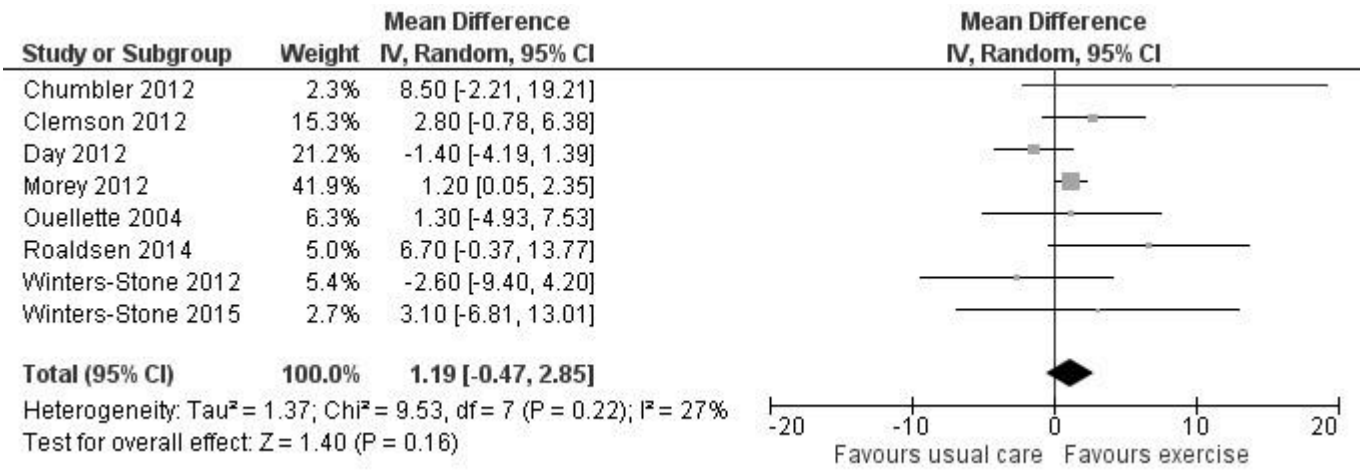

Figure 4: The effect of exercise interventions on the Late-Life Disability Instrument Limitation Scale. Squares represent the point estimate; the size of the square is determined by how much weight the study contributes to the pooled effect estimate. The diamond represents the pooled effect estimate.

Appendix for online only

Appendix Box 1: Search Strategies for Electronic Databases

PubMed/MEDLINE (NCBI)
Search Date: March 2, 2015
Number of Records: 1,340

("Exercise"[Mesh:noexp] OR "Physical Conditioning, Human"[Mesh] OR "Resistance Training"[mesh] OR "Swimming"[mesh] OR "Walking"[mesh] OR "Yoga"[mesh] OR "tai ji"[mesh] OR exercise*[tiab] OR physical activit*[tiab] OR physical training[tiab] OR strength training[tiab] OR weight lifting[tiab] OR strengthening program[tiab] OR resistance training[tiab] OR swimming[tiab] OR walking[tiab] OR yoga[tiab] OR tai chi[tiab] OR tai ji[tiab])
AND
("Social Participation"[Mesh] OR participation[tiab] OR handicap[tiab] OR disability[tiab] OR life role[tiab] OR social role[tiab] OR role function*[tiab] OR community engagement[tiab] OR integration[tiab] OR reintegration[tiab])
AND
("aged"[mesh] OR elder*[tiab] OR oldest old[tiab] OR aged patient*[tiab] OR aged individual*[tiab] OR older patient*[tiab] OR older adult*[tiab] OR oldest adult*[tiab] OR old patient*[tiab] OR old people[tiab] OR older people[tiab] OR older veteran*[tiab] OR geriatric*[tiab] OR age 60[tiab] OR age 65[tiab] OR age 70[tiab] OR age 75[tiab] OR age 80[tiab] OR late life[tiab])
AND
random*[tw]

Embase (Elsevier)
Search Date: March 4, 2015
Number of Records: 1,072

('exercise'/de OR 'aerobic exercise'/de OR 'aquatic exercise'/de OR 'resistance training'/de OR 'physical activity'/de OR 'swimming'/de OR 'walking'/exp OR 'weight bearing'/de OR 'weight lifting'/de OR 'yoga'/de OR 'tai chi'/de OR exercise*:ab,ti OR (physical NEAR/1 (activit* OR training)):ab,ti OR 'strength training':ab,ti OR 'weight lifting':ab,ti OR 'strengthening program':ab,ti OR 'resistance training':ab,ti OR swimming:ab,ti OR walking:ab,ti OR yoga:ab,ti OR 'tai chi':ab,ti OR 'tai ji':ab,ti)
AND
('social participation'/exp OR 'community integration'/de OR participation:ab,ti OR handicap:ab,ti OR disability:ab,ti OR 'life role':ab,ti OR 'social role':ab,ti OR (role NEXT/1 function*):ab,ti OR 'community engagement':ab,ti OR integration:ab,ti OR reintegration:ti,ab)
AND
('aged'/exp OR elder*:ab,ti OR 'oldest old':ab,ti OR ((aged OR old OR older) NEXT/1 (patient* OR individual* OR veteran* OR people)):ab,ti OR geriatric*:ab,ti OR 'age 60':ab,ti OR 'age 65':ab,ti OR 'age 70':ab,ti OR 'age 75':ab,ti OR 'age 80':ab,ti OR 'late life':ab,ti)
AND
random*:de,it,ab,ti

CINAHL (EBSCO)
Search Date: March 4, 2015
Number of Records: 591

MH ("Exercise" OR"Group Exercise" OR "Resistance Training" OR "Muscle Strengthening" OR "Walking" OR "Physical Activity" OR "Swimming" OR "Yoga" OR "Tai Chi") OR TI (exercise* OR

"physical activit*" OR "physical training" OR "strength training" OR "weight lifting" OR "strengthening program" OR "resistance training" OR swimming OR walking OR yoga OR "tai chi") OR AB (exercise* OR "physical activit*" OR "physical training" OR "strength training" OR "weight lifting" OR "strengthening program" OR "resistance training" OR swimming OR walking OR yoga OR "tai chi")
AND
MH ("Social Participation" OR "Community Role") OR TI (participation OR handicap OR disability OR "life role" OR "social role" OR "role function*" OR "community engagement" OR "integration" OR "reintegration") OR AB (participation OR handicap OR disability OR "life role" OR "social role" OR "role function*" OR "community engagement" OR "integration" OR "reintegration")
AND
MH ("Aged") OR TI (elder* OR "oldest old" OR ((aged OR old OR older) W1 (patient* OR individual* OR veteran* OR people)) OR geriatric* OR "age 60" OR "age 65" OR "age 70" OR "age 75" OR "age 80" OR "late life") OR AB (elder* OR "oldest old" OR ((aged OR old OR older) W1 (patient* OR individual* OR veteran* OR people)) OR geriatric* OR "age 60" OR "age 65" OR "age 70" OR "age 75" OR "age 80" OR "late life")
AND
TI (random*) OR AB (random*) OR SU (random*) OR MH (random*) OR PT (random*)

Cochrane Central (EBSCO)
Search Date: March 4, 2015
Number of Records: 354

(exercise* OR "physical activit*" OR "physical training" OR "strength training" OR "weight lifting" OR "strengthening program" OR "resistance training" OR swimming OR walking OR yoga OR "tai chi")
AND
(participation OR handicap OR disability OR "life role" OR "social role" OR "role function*" OR "community engagement" OR "integration" OR "reintegration")
AND
(elder* OR "oldest old" OR ((aged OR old OR older) W1 (patient* OR individual* OR veteran* OR people)) OR geriatric* OR "age 60" OR "age 65" OR "age 70" OR "age 75" OR "age 80" OR "late life")

PEDro (George Institute)
Search Date: March 16, 2015
Number of Records: 285

(exercise* OR "physical activity" OR "physical training" OR "strength training" OR "weight lifting" OR "strengthening program" OR "resistance training" OR swimming OR walking OR yoga OR "tai chi")
AND
(participation OR handicap OR disability OR "life role" OR "social role" OR "role function" OR "role functioning" OR "community engagement" OR integration OR reintegration)

limit to clinical trials (method) and gerontology (population).

Appendix Table 1: Description of study interventions

Study	Intervention
Ada et al. 2013	4-month community exercise program delivered by therapists. Treadmill training, without any body weight support, was structured to increase step length, speed, workload, and automaticity. Overground walking comprised 20% of intervention time in week 1 and was progressively increased each week so that it comprised 50% of the 30min intervention time.
Chumbler et al. 2012	3-month stroke telerehabilitation program (STeleR intervention) delivered by a teletherapist and an in-home assistant. STeleR included: 3 1-hour home visits (assessment of physical function and goal setting, exercise prescription focusing on 3-4 strength and balance exercises), 5 telephone calls (occurring every 2 weeks), and a daily in-home messaging device to provided positive encouragement and feedback. A 4th visit was arranged in the event of any problems. Telephone calls: established rapport, reviewed and progressed exercises, explored barriers and identified solutions, reviewed concerns related to functional mobility.
Clemson et al. 2012	12-month home balance and strength exercise program (LiFE approach) integrated into patients' daily routines and designed to prevent falls. Strategies to improve balance include:"reduce base of support", "move to limits of sway", "shift weight from foot to foot", "step over objects", and "turning and changing direction". Strategies to increase strength include "bend your knees", "on your toes", "up the stairs", "on your heels", "sit to stand", "walk sideways", and "tighten muscles". The LiFE training was delivered by physical and occupational therapists in 5 sessions with 2 booster visits and 2 phone calls.
Daniel 2012	15-week staff-directed small group laboratory-based exercise sessions using a Nintendo Wii, utilizing basic games such as bowling, tennis, and boxing. Wii-fit participants also wore a weight vest with 2% of their body weight added to the weight vest every 2 weeks, so that their core and quadriceps muscle groups were progressively overloaded throughout the study period.
Day et al. 2012	24 weeks of modified Sun style tai chi (46 forms—a series of whole-body movements performed continuously) covering agility, mobility, balance, breathing, and relaxation. The curriculum covered the 6 basic (and reverse) and the 6 advanced (and reverse) movements of part I and 1 side of the 11 movements of part II (35 of the 46 forms). Hour-long classes were delivered by trained instructors in the community twice weekly.
Fairhall et al. 2012	1-year interdisciplinary intervention targeting frailty components. Team of physiotherapists, dietician, geriatrician, rehab physician and nurse. Intervention delivered mainly at home with outpatient specialist visits as necessary. Individually tailored to decrease frailty phenotype – coordinated by case conferences and case management with regular liaison between team. 10 home based mobility sessions - 45-60 mins duration, 5 sessions in first 3 months and 5 over following 9 months. Two sessions devoted to a specific mobility-related participation goal and 8 sessions targeting weakness, slowness and low energy expenditure.
Foster et al. 2013	12-month community-based Argentine Tango dance program. 1-hr dance class, 2x/week taught by experienced instructor. Flexible step patterns with small step elements, spontaneous multidirectional changes and rhythmic variation. Change of partners every 10 mins.
Green et al. 2002	Routine community physiotherapy at home or as an outpatient. Standard maximum contact period of 13 weeks, with minimum of 3 contacts per patient. Focus of treatment on: gait re-education, exercise therapy, functional exercise and balance re-education.

Haines et al. 2009	A DVD thrice weekly home exercise program (Kitchen Table Exercise program) – DVD focused on lower limb strength and balance, 6 types of exercises, 6 levels of difficulty. Home visit(s) provided by a physiotherapist to ensure safety and engagement with DVD and selection of appropriate starting exercise level. Home visits provided on one or multiple occasions as needed in first 8 weeks. Weekly phone calls after home visits ceased for first 8 weeks; thereafter patients encouraged to continue with DVD as often as possible.
Harrington et al. 2010	Leisure and community centre based activities, 2x/week for 8 weeks (total of 16 sessions). 1hr exercise, 1hr education. Exercise to address balance, endurance, strength, flexibility, function and well being (circuit approach) provided by a trained exercise instructor and supported by a physiotherapist as necessary. Patients received home exercise manuals and encouragement to explore options for ongoing exercise after 8 weeks. Interactive education sessions: goal setting, social sessions and unstructured sessions. Caregivers/family encouraged to attend.
Korpelainen et al. 2006	30 months of impact, balance and strength exercises provided on alternating schedule of 6-months of supervised weekly hour long sessions (with instructions to exercise at home for 20 min daily) followed by 6-months of unsupervised home exercise. Supervised sessions provided by a physiotherapist to groups of 5-8. Specific exercises included walking, rapid walking, knee bends, leg lifts, heel rises, dancing, stamping, stair climbing, step-ups and jumping.
Mayo et al. 2015	12-month multi-component community-based program targeting participation (Getting on with the Rest of Your Life: Mission Possible program). Exercise and project based activities promoting learning, leisure and social activities. Group meetings twice a week for 3 hours in three blocks, each lasting 3 months for a total duration of 12 months. Multidisciplinary group leaders. Leisure/learning/social component: focus on making life goals that are then staged into a series of realistic projects supported by developing internal and existing community-based resources. Exercise component: 45 mins twice a week; aerobic training, strength, balance, flexibility and speed of movement.
Morey et al. 2009	12 months of physical activity (PA) counseling individually prescribed by lifestyle health counselor with objectives to walk or perform lower extremity PA for 30mins or more, 5x/week and 15mins lower-extremity strength training 3x/week. Patients received: exercise workbook, elastic bands, pedometer, strength exercise poster, telephone counseling biweekly for 6 weeks and monthly thereafter. Primary care provider provided support and monthly personalized automated messages. Tailored progress reports mailed to participants quarterly.
O'Shea et al. 2007	12-week resistance exercise program performed 3 times per week. One session per week conducted in outpatient clinic led by physiotherapist; the remaining two performed at home. Exercises included hip abduction, simulated lifting, sit-to-stand, seated row, lunges, and chest press. Resistance with elastic bands was increased when participants could perform three sets of 12 repetition maximum with correct technique through full range. After 12 weeks, resistance bands left with participants for ongoing use if desired.
Ouellette et al. 2004	12-week high-intensity resistance training, 3x/week, supervised (does not report by whom). Exercises included seated bilateral leg press, unilateral paretic and nonparetic limb knee extension, unilateral ankle dorsiflexion, and plantarflexion. Four warm-up repetitions at 25% of the 1-repetition maximum were performed followed by 3 sets (8 to 10 repetitions per set) at 70% of the 1RM. Training intensity adjusted biweekly by reassessing the 1RM.

Roaldsen et al. 2014	12 weeks of task-specific balance training, 3 times a week for 45 minutes, in groups of 6-7 subjects led by 2 physiotherapists. Included exercises aimed at maintaining balance in sitting, standing, walking and reacting to loss of balance. Secondary cognitive tasks (dual and multi-tasking) were also provided. Progression individualized by varying base of support, speed, adding dual tasks and changing arm positions.
Winters-Stone et al. 2012	1-year resistance + impact exercise program designed to improve strength and function - Prevent Osteoporosis with Impact + Resistance (POWIR). Two 1-hr supervised classes and one 1-hr home-based session/week. Progressive resistance training consisted of 1–3 sets of 8–10 exercises at a weight that can be done for 8–12 repetitions with 1–2 min rest between sets. Dumbbells, barbells and weighted vests were used for exercises that targeted the legs, hip, chest and back and using movement patterns similar to activities of daily living. Two-footed jumps from the floor were performed with weighted vests. The home-based program was performed without weight vests and replacing free weights with resistance bands.
Winters-Stone et al. 2015	1-year moderate to vigorous intensity resistance training program designed to improve strength and function designed to improve strength and function - Prevent Osteoporosis with Impact + Resistance (POWIR). Two 1-hr supervised classes and one 1-hr home-based session/week. Progressive resistance training used dumbbells, barbells and weighted vests for exercises that targeted the legs, hip, chest and back and using movement patterns similar to activities of daily living such as wall-sits, squats, bent-knee dead lifts, multidirectional lunges, 1-arm row, chest press, lateral raise, and push-ups. Two-footed jumps from the floor were performed with weighted vests. The home-based program was performed without weight vests and replacing free weights with resistance bands.