Do Exercise Interventions Improve Participation in Life Roles in Older Adults? A Systematic Review and Meta-Analysis

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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, whether exercise interventions improve participation in life roles is unclear.

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

Data sources. The PubMed, Embase, CINAHL, Cochrane, and PEDro databases 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 who were 60 years of age or older were included in this review.

Data extraction. Teams of 2 investigators independently extracted data on participation. Methodological quality was appraised using the Cochrane tool for assessing the risk of bias. The protocol was registered with Prospero (CRD42014014880).

Data synthesis. Eighteen randomized controlled trials with a total of 2,315 participants met the inclusion criteria. Standardized mean differences (SMDs) with 95% CIs were calculated using a random-effects model. A 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). Subgroup analysis showed that exercise interventions lasting 12 months or more had a small positive effect on participation (SMD = 0.15; 95% CI = 0.02 to 0.28).

Limitations. Limitations included variability in definitions and measures of participation.

Conclusions. In general, exercise interventions do not improve participation in life roles in older adults. The 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.
Participation, defined as a person’s involvement in life situations, is well recognized as a critical aspect of health; it is 1 of 3 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. More than 50% of adults over the age of 50 years have participation restrictions, and the prevalence increases with age. Distinct from more commonly measured outcomes of function or mobility, participation restrictions reflect a broader patient-centered outcome more meaningful to people than difficulties in performing basic movements or activities. 

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. Participation is thus also consistent with the concept of disability in Nagi’s original disablement model. 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; environmentally 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, it is unclear whether exercise-based interventions have any impact on participation in life roles.

Earlier narrative reviews have called into question the evidence for exercise interventions to improve participation, while a recent meta-analysis focusing specifically on fall prevention exercise programs noted a small favorable effect.

The aim of this systematic review was to evaluate the effect of physical exercise interventions on participation in life roles in 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 for systematic reviews and meta-analyses. The review protocol was registered with 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 (the full search strategy is shown in eAppendix Box 1, available at https://academic.oup.com/ptj). 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. 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 (M.K.B. and A.L.) independently screened abstracts of retrieved papers. Full texts of relevant studies were independently assessed by teams of 2 reviewers (M.K.B., A.L., R.W., S.H.), with disagreements resolved by consultation with a third investigator (AJ). Two investigators (M.K.B. and A.J.) evaluated the specific participation outcome measures for inclusion in the review. Inclusion criteria comprised the following:

- Types of studies: randomized controlled trials
- Types of participants: studies including adults who resided in the community and were 60 years of age or older
- 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 multifaceted intervention, compared with usual care
- Types of outcomes: generic patient-reported instruments designed to measure some aspect of participation based on an existing conceptual framework (ie, 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). To be included in this review, instruments needed to have more than half of the items devoted to participation, according to our working definition. Studies for which only conference abstracts were available and those not
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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 and Quality Assessment**

Teams of 2 investigators (M.K.B., A.L., R.W., S.H.) independently extracted data into a standardized form. Missing data were requested from authors. Only 1 author responded. 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, Australia, and the United Kingdom, followed by Finland, Canada, and Stockholm. Many studies focused on older adults dwelling in the community and meeting specific criteria (e.g., prefrail, frail, high fall risk); however, a number of distinct clinical populations were represented, including stroke, cancer survivors, Parkinson disease, veterans, and chronic obstructive pulmonary disease. The most widely used participation measure was the Late-Life Disability Instrument (LLDI) (9 studies), followed by the Frenchay Activities Index (FAI) (4 studies) and the Reintegration to Normal Living Index (RNLI) (2 studies). The remaining participation measures were the Adelaide Activities Profile (AAP), Activity Card Sort (ACS), and London Handicap Scale (LHS). More than 80% of the items in the 6 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

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**Results**

**Search Results**

The systematic search of electronic databases provided a total of 3,642 records and 2,049 records after eliminating duplicates (Fig. 1). Of these, 1,849 were excluded after initial title and abstract screening by 2 reviewers. The full texts of the remaining 200 articles were examined in more detail, and 18 studies ultimately were 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, Australia, and the United Kingdom, followed by Finland, Canada, and Stockholm. Many studies focused on older adults dwelling in the community and meeting specific criteria (e.g., prefrail, frail, high fall risk); however, a number of distinct clinical populations were represented, including stroke, cancer survivors, Parkinson disease, veterans, and chronic obstructive pulmonary disease. The most widely used participation measure was the Late-Life Disability Instrument (LLDI) (9 studies), followed by the Frenchay Activities Index (FAI) (4 studies) and the Reintegration to Normal Living Index (RNLI) (2 studies). The remaining participation measures were the Adelaide Activities Profile (AAP), Activity Card Sort (ACS), and London Handicap Scale (LHS). More than 80% of the items in the 6 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

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**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-effects 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 I² statistic. Subgroup analyses were planned for studies evaluating long-term exercise (≥12 months), those with multiple components (e.g., exercise plus education), and for specific outcome measures where data were available to be pooled from more than 1 study.
Table 1. Study Characteristics

| Study          | Year | Country | Population                                                                 | Intervention                                                                 | Usual Care | Primary Outcome                                      | Participation Measure | Key Findings                                                                 |
|----------------|------|---------|----------------------------------------------------------------------------|------------------------------------------------------------------------------|------------|------------------------------------------------------|-----------------------|------------------------------------------------------------------------------|
| Ada et al 17   | 2013 | Australia | 102 people who had stroke and dwelled in the community (intervention group: 24% men, mean age = 70 y; control group: 19% men, mean age = 63 y) | 4-mo community walking program, 30 min, 3 × /wk; delivered by therapists   | No intervention | Walking distance                                      | AAP                   | 4-mo training group had greater improvements in walking distance, speed, and health than control group at 4-mo FU; no difference at 12-mo FU; no between-group difference in AAP |
| Chumbler et al 18 | 2012 | US      | 48 participants with stroke (intervention group: 96% men, mean age = 67 y; control group: 100% men, mean age = 68 y) | 3-mo tele-rehabilitation program delivered by therapist and in-home assistant: 3 home visits, 5 biweekly telephone calls, daily in-home messaging | Routine Veterans Affairs care | FIM and the Late-Life Function Instrument (LLFI) | LLDI                  | No between-group difference at 6-mo FU in motor FIM or LLFI; between-group difference in LLDI limitation scale but not LLDI frequency scale |
| Clemson et al 19 | 2012 | Australia | 317 people with 2 or more falls or 1 injurious fall in the past 12 mo; mean age = 83 y (intervention group: 31% men; control group: 32% men) | 12-mo home balance and strength program integrated into daily routines; delivered by therapists via 5 home visits, 2 booster visits, and 2 telephone calls | Gentle-exercise sham control | Falls                  | LLDI                  | 31% reduction in rate of falls for intervention group; between-group improvement in LLDI frequency scale |
| Daniel 20      | 2012 | US      | 23 adults before becoming frail; mean age = 77 y, 39% men                  | 15-wk laboratory-based Nintendo Wii exercise program with weighted vests   | Instructed to continue usual activities | Physical performance outcomes | LLDI                  | No between-group analyses reported                                            |
| Day et al 21   | 2012 | Australia | 503 adults who were preclinically disabled, dwelled in the community, and were >70 y old (intervention group: 34% men; control group: 30% men) | 24-wk modified Sun-style tai chi; classes held 2 × /wk for 60 min/ session | Stretching and flexibility program | LLDI                  | LLDI                  | No between-group difference; little change in mean LLDI scores in either group over 24-wk period |
| Fairhall et al 22 | 2012 | Australia | 241 older people who were frail and dwelled in the community; mean age = 83 y, 32% men | 1-y 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 12-mo FU; better activity limitation scores; no difference in RNLI |
| Foster et al 23 | 2013 | US      | 52 people with Parkinson disease; mean age = 69 y, 58% men               | 12-mo Argentine tango dance program; 1-h class, 2 × /wk                    | Normal life routine | Participation (ACS)                                  | ACS                   | Total current participation increased in intervention group at 3, 6, and 12 mo |
| Green et al 24  | 2002 | UK      | 170 patients with chronic stroke and persistent mobility problems; mean age = 72–74 y, 56% men | Routine community physical therapist service, at home or outpatient; maximum of 13 wk, minimum of 3 contacts/patient | No treatment | Mobility (RMI)                                      | FAI                   | Between-group difference in RMI scores at 3 mo but not at 6 or 9 mo; no difference in FAI scores between groups at 3-, 6-, or 9-mo FU |

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Table 1. Continued

| Study                | Year | Country | Population | Intervention | Usual Care | Primary Outcome | Participation Measure | Key Findings                                                                 |
|----------------------|------|---------|------------|--------------|------------|-----------------|-----------------------|----------------------------------------------------------------------------|
| Haines et al<sup>3</sup> | 2009 | Australia | 53 older adults discharged from local hospital with mobility aid; mean age = 81 y, 40% men | Home exercise DVD of strength and balance work for 8 wk; weekly telephone calls by physical therapist for subsequent 8 wk | Usual care | Falls, HRQOL, physical capacity, fear of falling, and FAI | FAI | No between-group difference in any outcome at 2-mo FU; nonsignificant reduction in rate of falls in intervention group |
| Harrington et al<sup>10</sup> | 2010 | UK | 243 people who survived stroke; mean age = 70–71 y; 54% men | Leisure and community center activities; 2x/wk for 8 wk; total of 16 sessions; 1 h of exercise and 1 h of education | Information sheet on local groups and contact numbers; visit by stroke coordinator | SIPSO, FAI, and RMI | FAI | Between-group difference in SIPSO physical integration at 9 wk and 1 y; no difference in other primary outcomes |
| Korvelainen et al<sup>27</sup> | 2010 | Finland | 160 elderly women at risk for fracture; mean age = 73 y | 30 mo of impact, balance, and strengthening exercises; weekly physical therapist-supervised sessions for 6 mo/y and home exercises for remaining 6 mo | Instructed to continue usual activities | Body sway and leg strength | FAI | Improvements in body sway and strength in intervention group vs control group; no effect on FAI |
| Mayo et al<sup>28</sup> | 2015 | Canada | 186 people who were within 5 y of stroke onset and dwelled in the community; mean age = 61 y, 61% men | 12-mo multicomponent group intervention targeting participation 2 × /wk for 3 h in three 3-mo blocks | 4-mo delayed entry | CHAMPS and RNIL | RNLI | Between-group comparison available only at 3-mo FU; no difference between groups at 3 mo; within-subject analyses at 12- and 15-mo FU showed improvements in CHAMPS and RNL |
| Morey et al<sup>29</sup> | 2009 | US | 398 older male veterans; mean age = 78 y, 100% men | 12 mo of physical activity counseling by lifestyle health counselor; instructed to walk 5/x/wk and strength train 3/x/wk; telephone counseling biweekly for 6 wk and monthly thereafter | Instructed to continue normal daily activities | Usual and rapid gait speed in 8-ft walk test | LLDI | Greater improvement in rapid gait speed in intervention group than in control group; higher score for LLDI limitations after 12 mo; no difference in LLDI frequency |
| O’Shea et al<sup>30</sup> | 2007 | Australia | 54 older adults with chronic obstructive pulmonary disease; 39% men (intervention group: mean age = 67 y; control group: mean age = 68 y) | 12 wk of progressive resistance exercises, 3 × /wk; led by physical therapist once/wk and performed independently 2×/wk | Instructed not to change baseline exercise routine | Strength and walking capacity | LHS | Improvement in knee extensor strength in intervention group vs control group; no between-group difference in participation restrictions |
| Ouellette et al<sup>31</sup> | 2004 | US | 42 adults after mild to moderate stroke; 33% women; mean age = 66 y | 12 wk of high-intensity resistance training, 3x/ wk; supervised (not reported by whom) | Upper extremity stretching, 3/x/wk | Muscle strength, function, and disability | LLDI | Between-group improvements in most strength measures in intervention group vs control group; no difference in functional performance measures; improvements in self-reported function and LLDI limitation scale in intervention group vs control group |

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Table 1. Continued

| Study            | Year | Country | Population | Intervention                                                                 | Usual Care | Primary Outcome                  | Participation Measure | Key Findings                                      |
|------------------|------|---------|------------|-------------------------------------------------------------------------------|------------|----------------------------------|-----------------------|---------------------------------------------------|
| Roaldsen et al12 | 2014 | Stockholm | 59 older adults; 29% men, mean age = 77 y | 12 wk of progressive task-specific group balance training, 3x/wk for 45 min; provided by physical therapists | Instructed to maintain usual lifestyle | Self-reported function and disability | LLDI | Improvement in lower extremity function in intervention group vs control group; no improvement in disability |
| Winters-Stone et al13 | 2012 | US | 106 women who were postmenopausal and survived breast cancer; mean age = 62 y | 1-y resistance and impact exercise program; two 1-h supervised classes (not reported by whom) and one 1-h home-based session/wk | 1 y of stretching and relaxation exercises | Strength, functional performance, and self-reported function and fatigue | LLDI | Improvements in maximal leg and bench press strength in intervention group vs control group; no between-group difference for LLDI or other outcomes |
| Winters-Stone et al13 | 2015 | US | 51 men who survived prostate cancer and were on androgen deprivation therapy; mean age = 70 y | 1-y moderate- to vigorous-intensity resistance training; two 1-h supervised classes (not reported by whom) and one 1-h home-based session/wk | 1 yr of stretching and relaxation exercises | Strength, physical function, and disability | LLDI | Improvements in maximal leg and bench press strength and self-reported physical function and LLDI limitation scale in intervention group vs control group |

*AAP = Adelaide Activities Profile, ACS = Activity Card Sort, CHAMPS = Community Healthy Activities Model Program for Seniors Physical Activity Questionnaire, FAI = Frenchay Activities Index, FIM = Functional Independence Measure, FU = follow-up, HRQOL = health-related quality of life, LHS = London Handicap Scale, LLDI = Late-Life Disability Instrument, LLFI = Late-Life Function Instrument, RMI = Rivermead Motor Index, RNLI = Reintegration to Normal Living Index, SIPSO = Subjective Index of Physical and Social Outcomes.

on current levels of participation in relation to premorbid levels.

Exercise Interventions
A detailed description of the exercise interventions is provided in eAppendix Table 1. Most programs included mainly lower-extremity exercise targeting 1 or 2 impairments or activities (eg, 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.18,22,26,29 Of note, the study by Mayo et al28 included a multifaceted 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-style tai chi program,21 an Argentine tango class,23 and a Nintendo Wii Fit program.20 Interventions were typically delivered in the community,17,21,25,26,28 home,18,19,22,24,25,29 or hospital outpatient center–based setting,15,24,30–33 and often involved physical therapists or trained fitness instructors. Program durations ranged from 8 weeks26 to 30 months,27 with most clustering either around the 3-month or 1-year mark. Training progression was typically reported as individualized, but 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 1 item, with no study deemed as having more than 2 biases (Tab. 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 masking, which is largely unavoidable for trials involving exercise. Masking of outcome assessors was also reported for most trials, with only 1 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 1 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 authors27 and insufficient follow-up numbers.20 A random-effects meta-analysis of the 16 studies including 2,132 participants showed no overall effect of the exercise interventions on participation (SMD = 0.03; 95% CI = −0.10 to 0.16; P = .63) (Fig. 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 participants
showed a favorable effect of long-duration programs on participation (SMD = 0.15; 95% CI = 0.02 to 0.28; \( P = .03 \)) (Fig. 3).

Studies in which exercise was not the only component (ie, included an education or behavioral component) were classified as multicomponent interventions.\(^{18,22,26,28,29} \) The pooled effect of these programs (5 studies) on participation was not significant (SMD = 0.03; 95% CI = −0.19 to 0.26; \( P = .77 \)).

Pooled data from more than 1 study were available for 3 participation measures: the LLDI, the FAI, and the RNLI. The effect of exercise interventions\(^{15,18,19,21,29,31–35} \) (8 studies) on the LLDI limitation scale was not significant (WMD = 1.19; 95% CI = −0.47 to 2.85; \( P = .16 \)) (Fig. 4), nor was the effect on the LLDI frequency scale\(^{18,19,21,29,31,32} \) (6 studies) (WMD = 1.21; 95% CI = −0.23 to 2.65; \( P = .10 \)). In the 3 studies in which the FAI was used,\(^{24–26} \) the pooled effect was not significant (WMD = −2.15; 95% CI = −5.21 to 0.91; \( P = .17 \)). Similarly, there was no effect of exercise on the RNLI (SMD = 0.02; 95% CI = −0.18 to 0.21; \( P = .88 \)). The SMD was chosen instead of the WMD for the RNLI as the scoring methods were not consistent across the 2 studies.\(^{22,28} \)

Studies using participation measures assessing perceived difficulty or satisfaction with participation (LLDI limitation, RNLI, LHS) were also analyzed 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; \( P = .09 \)) or on participation frequency (SMD = 0.0; 95% CI = −0.18 to 0.18; \( P = .99 \)).

**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...
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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 (ie, 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. Indeed, there is empirical evidence to support that functional limitations do occur temporally before the onset of participation restrictions; there is also data to support a direct effect of functional limitations on participation in life roles. However, less well appreciated is that the impact of functional deficits on participation is modest at best, 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 1 study in this review included such an intervention: the Getting On with the Rest of Your Life: Mission Possible program by Mayo et al. The intervention included a multimodal 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 enrollment 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
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| Study or Subgroup   | Weight | Std. Mean Difference | IV, Random, 95% CI |
|---------------------|--------|----------------------|--------------------|
| Clemson 2012       |        | 17.9%                | 0.24 [0.07, 0.55]   |
| Fairhall 2012      |        | 23.8%                | 0.10 [0.01, 0.20]   |
| Foster 2013        |        | 5.9%                 | 0.18 [0.08, 0.33]   |
| Morey 2012         |        | 39.7%                | 0.22 [0.01, 0.42]   |
| Winters-Stone 2012 |        | 7.5%                 | -0.18 [0.06, 0.36]  |
| Winters-Stone 2015 |        | 5.6%                 | 0.18 [0.07, 0.29]   |
| Total (95% CI)      |        | 100%                 | 0.15 [0.02, 0.28]   |

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

| Study or Subgroup   | Weight | Mean Difference | IV, Random, 95% CI |
|---------------------|--------|----------------|--------------------|
| Chumbley 2012      | 2.3%   | 8.50 [-2.21, 19.21] |
| Clemson 2012       | 15.3%  | 2.80 [-0.78, 6.38]  |
| Day 2012            | 21.2%  | -1.40 [-4.19, 1.38] |
| Morey 2012         | 41.9%  | 1.20 [0.05, 2.36]   |
| Ouellette 2004     | 6.3%   | 1.30 [0.93, 1.67]   |
| Roldersen 2014     | 5.0%   | 0.70 [0.37, 1.07]   |
| Winters-Stone 2012 | 5.4%   | -2.60 [-9.40, 4.20] |
| Winters-Stone 2015 | 2.7%   | 3.10 [0.61, 13.01]  |
| Total (95% CI)      | 100.0% | 1.19 [-0.47, 2.85]  |

Figure 4.
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 (diamond).

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 that 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 participation, to date, limited data exist regarding their psychometric properties and particularly their ability to detect change in response to interventions. In fact, this is an 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. However, the weighted mean difference was small (just over 1 point) and did not exceed prior estimates of the measure's minimal detectable change, 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 and by a systematic review in children which found exercise alone had little effect on participation.

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. Despite this challenge, the frequency with which an older person participates in life situations is a better predictor of adverse outcomes than perceived limitations, and remains an important therapeutic target for the older adult population. Of the 6 participation measures included in this review, only the LLDI 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 2 constructs are treated as 1 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 6 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. According to their working definition, which emphasized the need for social context, only 3 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 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 masking of participants and personnel. Such masking 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.

Author Contributions and Acknowledgments
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We thank Anne Moseley of The George Institute for Global Health for her assistance in retrieving records from PEDro.

Systematic Review Registration
The systematic review protocol was registered with PROSPERO (no. CRD42014014880).

Disclosures
The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest. A.M. Jette is recipient of a fellowship grant from the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR). He is the editor in chief of PT.

M.K. Beauchamp was supported by the Canadian Institutes of Health Research; R.S. Goldstein, by the University of Toronto, National Sanitarium Association Chair; D. Brooks, by a Canada Research Chair; J.F. Bean, by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (K24HD070966-01); A.M. Jette, in part by the National Institute on Disability and Rehabilitation Research (H133P120001). The sponsors had no role in any aspect of the study.

DOI: 10.1093/ptj/pzx082

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