Eur Rev Aging Phys Act (2014) 11:95–106
DOI 10.1007/s11556-014-0144-1

ACADEMIC LITERATURE REVIEW

Systematic review of functional training on muscle strength, physical functioning, and activities of daily living in older adults

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Received: 24 January 2014 / Accepted: 15 August 2014 / Published online: 30 August 2014

Abstract Exercise programs are often recommended for preventing or delaying late-life disability. Programs that incorporate functional training, which uses movements similar to performing activities of daily living, may be suitable for such recommendation. The purpose of this systematic review was to examine the effects of functional training on muscle strength, physical functioning, and activities of daily living in older adults. Studies in three electronic databases (MEDLINE, CINAHL, and SPORTDiscus) were searched, screened, and appraised. Thirteen studies were included in the review. These studies vary greatly in participant recruitment criteria, functional training content, and selection of comparison groups. Mobility exercises were the most common element in functional training across studies. Results show beneficial effects on muscle strength, balance, mobility, and activities of daily living, particularly when the training content was specific to that outcome. Functional training may be used to improve functional performance in older adults.

Keywords Activities of daily living · Disability · Exercise · Functional training · Older adults · Physical functioning

The current study does not involve human or animal subjects.

The first author contributed to the study concepts and design, literature review and appraisal, and manuscript preparation. The second and third authors contributed to literature search, acquisition, and appraisal, as well as manuscript preparation. The fourth author contributed to the manuscript preparation.

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The ability to perform activities of daily living (ADL) is vital to living independently. Age-related loss in muscle strength can jeopardize this ability and lead to disability [19, 25, 24, 36, 41, 23]. For example, the progression of muscle weakness limits the ability to grasp an object which further impedes the ability to open a jar. Experiencing difficulty in ADL and relying on others is not only related to decreased quality of life [39, 22] but also increased likelihood of long-term nursing home placement [16, 34].

A large number of studies have shown that progressive resistance strength training improves muscle strength in older adults, including the oldest old [15, 48, 32]. Progressive resistance strength training increases load gradually over the training course to strengthen major muscle groups used for weight bearing or lifting. The training has been recommended to prevent or reduce late-life disability for older adults [2, 43].

However, improving muscle strength yields only a small change, sometimes even nonsignificant change, in reducing late-life disability in the outcome of ADL [48, 27, 26, 33, 4, 10, 29, 37]. For transfer of physical benefits of resistance strength training to ADL performance seems to be limited. It has been suggested that the relationship between muscle strength and physical performance is nonlinear [6]. When the muscle strength has reached a certain threshold, a further increase in muscle strength does not add to better performance, including in older adults with ADL disability [14]. Additionally, older adults may not explicitly learn how to transfer increased muscle strength to improve ADL performance when the training primarily focuses on increasing muscle strength.

Alternatively, functional training may be more beneficial for improving ADL performance in older adults. Functional training attempts to train muscles in coordinated, multiplanar movement patterns and incorporates multiple joints, dynamic tasks, and consistent alterations in the base of support for the purpose of improving function [5, 46]. Boyle defines functional training as purposeful training stating that "function is, essentially, purpose" [6]. Therefore, functional training can be any type of training that is performed with purpose to enhance a certain movement or activity.

With a definition this broad, the literature on functional training has incorporated a vast array of exercise programs with varying designs and focuses. Chin A Paw et al. used game-like and cooperative activities such as throwing and catching a ball as functional training activities [7], while other studies were more focused on exercises simulating locomotor ADL such as walking, stair climbing, or chair stands [9, 17, 1, 12, 31, 35, 47]. Still, other researchers included modified ADL tasks in the functional training component, such as dressing, laundry, vacuuming, or carrying groceries [12, 35, 11].

The principle of functional training is specificity of training, which means that training in a specific activity is the best way to maximize the performance in that specific activity [20, 42]. In other words, the closer the training is to the desired outcome (i.e., a specific task or performance criterion), the better the outcome will be. Accordingly, in order to improve performance in ADL, exercise training should be performed in similar movement patterns to how people perform daily tasks. Functional training may be a better exercise program for older adults if the aim is to improve independence in ADL.

There is a growing body of literature on functional training in which older adults are trained on specific tasks, such as chair rise or movements needed to carry out daily tasks. A systematic review of these studies would be informative on the design of functional training program and benefits of the training to reduce late-life disability. Therefore, the purpose of this systematic review is to synthesize empirical evidence and assess the effects of functional training in older adults. Although the outcome of ADL is the primary interest of this review, the outcome of muscle strength and physical functioning are also appraised because of strong associations between these measures and disability [19, 24, 36, 40, 38]. In order to narrow the focus of this review, the review limits to functional training as exercises that incorporate movement patterns common to performing ADL.

Methods

Search strategy

We searched electronic databases of MEDLINE (January 1946 to August 2013), CINAHL (January 1982 to August 2013), and SPORTDiscus (January 1948 to August 2013) with assistance from a university librarian. The following search terms were used: functional training, functional exercise, functional skills, functional task training, and therapeutic exercise. We set the age group to the older adult population, publication type to journal articles, and publication language to English in the database search. We also performed a reverse search by perusing references of eligible articles. Additionally, trial studies referred from colleagues were included for screening and review.

Inclusion and exclusion criteria

We included randomized controlled trials, nonrandomized trials with two or more groups, and single-group trials with pretest and posttest design. The trial must include functional training as the primary intervention component. Functional training was defined as motions or exercises that incorporate movement patterns which are commonly used in ADL, such as walking, getting out of bed, or dressing. Functional training utilizes a combination of motions rather than isolated movements of individual muscle groups or body function. According to this definition, trials which focused primarily on balance were excluded in this review. Moreover, a trial was excluded from further review if the trial included participants aged less than 60 years; targeted older adults with specific degenerative neurological or musculoskeletal conditions, such as dementia, stroke, and hip replacement; or did not measure outcomes related to physical functioning or ADL performance. Physical functioning measures an individual's physical ability to perform functional tasks, for example balance and gait speed. ADL performance measures an individual's ability to do ADL, for example showering. Both physical functioning and ADL performance can be measured by either performance-based or self-report tests.

Selection and quality assessment

Two authors screened search results independently. In the initial screening phase, titles and abstracts were reviewed using predefined inclusion and exclusion criteria. If the title and abstract did not provide sufficient information, full text was appraised. In the second screening phase, full text of potential eligible studies was reviewed. When disagreement on the trial eligibility occurred, the two authors would discuss until consensus was reached.

The two authors rated methodological quality of each eligible trial with the Downs and Black rating scale independently [13]. The validity and reliability of the Downs and Black rating scale for randomized and non-randomized studies has been established [13]. The rating scale assesses reporting, external validity, internal validity (bias and confounding), and power on 27 questions. The maximum total score for the scale is 32 where a higher score indicates greater methodological quality. The two authors later compared rating results on each question item. If disagreement occurred, the two authors would discuss to reach consensus.

Data extraction

A standard form was used to extract trial information which included: participant inclusion and exclusion criteria, study design, sample size, the number of dropouts, demographic information, characteristics of the intervention program (i.e., content, duration intensity, and frequency), the adherence rate, and outcome measures of muscle strength, physical functioning, and ADL. Examples of physical functioning outcomes are balance and mobility. One author abstracted information into the standard form and the other author checked it.

Results

Figure 1 shows the study trial selection process of published studies. The electronic database search yielded 226 records (80 from MEDLINE, 92 from CINAHL, and 54 from SPORTDiscus). The authors also included 40 records obtained through reverse search or referred by colleagues. Records were excluded because (1) it was not an intervention trial (n=65), (2) the trial included participants under the age of 60 years (n=42), (3) the trial targeted a specific disease (stroke, n=47; hip or knee surgery, n=9; dementia or brain injury, n=9; critical illness, n=1; diabetic neuropathy, n=1), and (4) functional training was not the primary intervention component (n=63). After screening the full texts and removing duplicates (n=11) and non-English texts (n=5), 13 studies were eligible and included for this review.

Study characteristics

Quality assessment Table 1 shows results of methodological quality assessment. The average total score is 21.77 (SD=3.70). Four trials have quality scores of less than 20 [9, 17, 12, 51]. All of these trials were low in the rating of internal validity because of confounding issues, such as applied a nonrandomization design [9, 12, 51] or failed to address loss to follow-up [17, 51].

Cohort characteristics Table 2 summarizes participant inclusion and exclusion criteria of the 13 trials that were reviewed. Seven trials recruited older adults aged 70 years or above [17, 12, 47, 11, 8, 18, 21]. Three trials recruited older adults from either congregate housing or long-term care facilities [17, 1, 31]. Five studies specifically recruited older adults with some degree of difficulty or dependency in mobility or ADL [1, 31, 35, 47, 18]. Three trials exclusively recruited women [9, 47, 11].

Trial characteristics A summary of trial characteristics is presented in Table 3. Four trials enrolled more than 100 participants [1, 31, 51, 8]. The adherence rates in two trials were lower than 70 % [8, 21]. Both included unsupervised home exercise programs.

Both Dobek et al. and Whitehurst et al. used a one-group research design [12, 51]. Cress et al. used a two-group nonrandomization design [9]. Six trials applied a two-group randomized controlled trial design: three trials compared functional training to an attention placebo control group [17, 31, 18]; one trial compared functional training to a control group who engaged in flexibility exercises [1]; one trial compared two programs that differed in functional training dosage, home exercise versus combined home and group exercise [21]; and one trial compared functional training to strength training [28]. Among three trials that applied a three-group

Fig. 1 Flow chart showing selection process of published studies

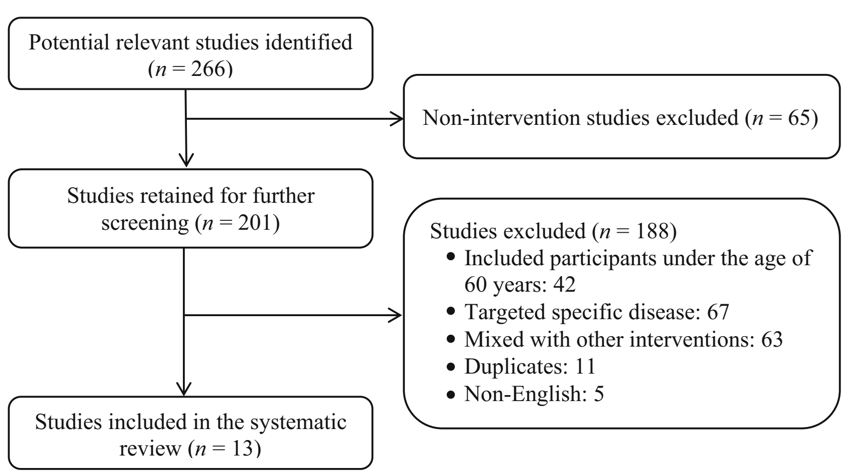

Table 1 Summary of methodological quality assessment scores

Author and publication year (possible score)	Reporting (11)	External validity (3)	Internal validity—bias (7)	Internal validity—confounding (6)	Power (5)	Total (32)
Alexander et al., 2001 [9]	11	3	5	3	1	23
Clemson et al., 2012 [13]	10	2	6	5	1	24
Cress et al., 1996 [46]	8	1	5	3	0	17
de Vreede et al., 2005 [35]	11	2	6	3	1	23
Dobek et al., 2006 [17]	9	0	4	1	1	15
Gillies et al., 1999 [7]	10	1	4	3	0	18
Giné-Garriga et al., 2010 [51]	11	2	5	5	1	24
Helbostad et al., 2004 [8]	11	0	6	6	1	24
Krebs et al., 2007 [18]	11	2	7	5	0	25
Littbrand et al., 2009 [1]	11	3	7	6	1	28
Manini et al., 2007 [12]	11	1	4	5	1	22
Skelton et al., 1996 [31]	10	2	5	4	1	22
Whitehurst et al., 2005 [38]	8	2	5	2	1	18

The number in parentheses indicates the possible maximum score of each rating category

randomized controlled trial design, in addition to a functional training group: two trials included a strength training group [35, 11]; two trials included a control group [11, 8]; one trial included a strength plus functional training group [35]; and one trial included a strength plus balance training group [8].

Intervention characteristics No two functional training programs were alike. Eight trials included a strength training component [9, 1, 31, 47, 51, 8, 18, 21], and five trials included a balance component in functional training [31, 51, 8, 18, 21].

The majority of the trials included mobility exercises in functional training. Nine trials included chair stand exercises [17, 1, 12, 31, 35, 47, 18, 21, 28], seven trials included stair climbing exercises [9, 17, 12, 31, 35, 18, 21], and five trials included walking exercises [17, 31, 47, 18, 21].

Some trials used daily tasks as a medium of training. Two trials had participants practice housework tasks, such as vacuuming, laundry, and carrying groceries [12, 35]. Clemson et al. had training programs embedded in daily routines [8]. For example, movements that challenge balance and strength were integrated into daily activities, such as ironing with one-leg stand. de Vreede et al. used principles of changing movement directions, speed, and postures within exercise movements required to perform daily tasks, and also used the same principles to practice real daily tasks [11].

The mode of intervention duration is 12 weeks, with the shortest being 6 weeks [28] and the longest being 50 weeks [9]. Duration of each training session usually lasted 45 to 60 min, and frequency was two to three times per week. Four trials used a circuit training format [17, 12, 51, 18]. The exercise intensity could be adjusted according to chair and stair height [17, 1, 35, 21], movement speed [12, 35, 11, 18, 28], resistance and weight [9, 1, 31, 47, 18, 21], and the number of repetitions or distance [17, 12].

Outcomes of muscle strength, balance, mobility, and ADL

Muscle strength Nine trials reported outcomes of muscle strength [9, 1, 35, 47, 11, 8, 18, 21, 28]. Six of the nine trials included a strength training component in the functional training program [9, 1, 47, 8, 18, 21].

When a functional training program which included a strength training component was compared to a control group which received no training or only flexibility exercise, four trials found that functional training significantly increased muscle strength of the lower extremity [9, 1, 47, 18]. When a functional training program which included a strength training component was compared to a structured balance and strength training program, Clemson et al. found no group differences [8]. Conversely, when a functional training program which did not include a strength training component was compared to a strength training group, the results favored the strength training group [35, 11].

Balance Seven trials reported outcomes of balance [1, 35, 47, 51, 8, 18, 28]. Three of these trials included a balance training component in the functional training program, and all showed positive results on the balance outcomes [51, 8, 18]. However, the outcomes in functional training programs that did not include a balance training component were mixed. Two trials showed positive results [1, 47], while two trials showed negative results [35, 28].

Table 2 Summary of trial inclusion and exclusion criteria and participant characteristics

Author and publication year	Inclusion criteria	Exclusion criteria	Living arrangements
Alexander et al., 2001 [9]	65 Years of age or above. Requiring assistance in transferring, walking, bathing, and/or toileting. Medically stable. No evidence of severe dementia or depression. Not participating in regular, strenuous exercise.	NS	Congregate housing residents
Clemson et al., 2012 [13]	70 Years of age or above. Had 2 or more falls in the past 12 months.	Moderate to severe cognitive problems. No conversational English. Inability to ambulate Independently. Neurological conditions that severely influenced gait and mobility. Resident in a nursing home or hostel. Having any unstable or terminal illness.	Recruited from the Department of Veterans Affairs and general practices databases.
Cress et al., 1996 [46]	Women from 65 years to 83 years of age. No known cardiovascular, neuromuscular, or metabolic disease.	NS.	Healthy community dwelling older women.
de Vreede et al., 2005 [35]	Women 70 years of age or above. Medically fit to participate in an exercise program.	Recent fractures, unstable cardiovascular or metabolic diseases, musculoskeletal disease or other chronic illnesses, severe airflow obstruction, recent depression or emotional distress, or loss of mobility for more than 1 week in the last 2 months. Respondents who exercised 3 times a week or more at a sports club.	Community dwelling.
Dobek et al., 2006 [17]	70 Years of age or above. Being ambulatory.	Unable to follow directions or complete baseline testing.	Community dwelling.
Gillies et al., 1999 [7]	70 years of age or above. Being mobile and able to perform test battery. No medical conditions which would interfere with the safe conduct of the training exercise.	NS.	Recruited from two residential homes.
Giné-Garriga et al., 2010 [51]	Between 80 and 90 years of age. Had some or a lot of difficulty rising from a chair or climbing a flight. Being physically frail.	Unable to walk. Undergoing an exercise program. Had severe dementia. Had stroke, hip fracture, myocardial infarction, or hip- or knee- replacement surgery within the previous 6 months.	Recruited from one health care center.
Helbostad et al., 2004 [8]	75 Years of age or above. Either suffered one or more falls during the last year, or use some kind of walking aid.	Participating in regular exercise more than once a week, terminal illness, cognitive impairment as indicated by a score of<22 on the MMSE, stroke during the last 6 months, or were deemed unable to tolerate exercise by a geriatrician.	Frail community dwelling older adults.
Krebs et al., 2007 [18]	60 Years of age or above. No cognitive impairments. Being able to ambulate for 15 ft.	Terminal illness, progressive neurological disease, major loss of vision, acute pain, non-ambulatory status.	Recruited through weekly screening of the outpatient physical therapy appointments.
Littbrand et al., 2009 [1]	65 Years of age or above. Dependent on one or more activities of daily living. Ability to stand up from a chair with assistance. MMSE scored 10 or higher. Having physician's approval.	NS.	Residential care facilities. High percentage of participants had a diagnosis of dementia.
Manini et al., 2007 [12]	Having difficulty to rise from a chair or climb a flight of stairs.	NS.	Recruited from community senior centers.
Skelton et al., 1996 [31]	Women 74 years of age or above. Having functional or mobility difficulties.	Disease or condition that would be adversely affected by exercise.	Patients of a local general medical practice.
Whitehurst et al., 2005 [38]	Older adults.	Did not pass medical clearance.	Community-dwelling

MMSE Mini-Mental State Examination, *NS* not specified

Table 3 Summary of trial characteristics, interventions, and relevant outcomes

Author and publication year	Origin Design Sample size (n) Drop out (D n) Adherence rate (AR%)	Participants Mean age (years) Sex (male/female)	Intervention Intervention site Duration Frequency training program	Relevant outcome measures Results
Alexander et al., 2001 [9]	USA RCT Total n=161 FG n=81 CG n=80 D n=37 AR=81 %	FG=82±6 CG=82±6 FG n=13/68 CG n=10/70	Congregate housing facilities. Twelve weeks, 60 min per session. Three times per week. FG: Bed- and chair-rise task-specific resistance training intervention. Three reps for each task at a comfortable rate. Adjusting weight or chair height to increase challenge. CG: Flexibility exercises.	Isometric strength tests. Trunk lateral balance. Bed-rise and chair-rise task assessment. The training effects on trunk flexion/extension strength (Cohen's d=0.22 and 0.16) and lateral balance (Cohen's d=0.83) were significant. The effect on bed- and chair-rise task performance is evident in poor performers at baseline; the training significantly decreased bed- and chair-rise time for 0.5–1.5 s (effect sizes range from 0.11 to 0.20).
Clemson et al., 2012 [13]	Australia RCT Total n=317 FG n=107 SBG n=105 CG n=105 D n=81 FG D n=24 SBG D n=18 CG D n=19 AR=43 % FG AR=47 % SBG AR=35 % CG AR=47 %	FG=83±4 SBG=84±4 CG=83±4 FG=48/59 SBG n=48/57 CG n=47/58	Home. Six months. Multiple times a day for FG; 3 times per week for SBG. FG: Movements specifically prescribed to improve balance or increase strength are embedded within everyday activities. SBG: Seven exercises for balance and six for lower limb strength using ankle cuff weights. FG and SBG were taught over five sessions with two booster sessions and two follow-up phone calls. Both programs were prescribed, tailored, and upgraded. CG: 12 gentle and flexibility seated exercise. The CG was taught over two sessions with one booster session, and six follow-up phone calls. The exercise was not upgraded.	Isometric lower limb strength. Static and dynamic balance. Late-life Function and Disability Index. There were no group differences in knee and hip muscle strength outcomes. Both FG and SBG showed significant improvement in right/left ankle strength (effect size=0.40/0.40 and 0.26/0.17, respectively). FG showed moderate effect sizes (0.42–0.63) in balance measures while SBG showed small to moderate effect sizes (0.29–0.49). Compared with CG, the FG had 31 % reduction in the rate of falls, and the SBG had 19 %. FG showed a large effect size in the Late Life Function Index (0.73) while SBG showed a moderate effect size (0.41). FG showed a moderate effect size in the Late Life Disability Frequency Index (0.49) while SBG showed a nonsignificant effect (0.17). Note that these outcomes included 12 month follow-ups.
Cress et al., 1996 [46]	USA Two groups, pre-post tests. Total n=13 FG n=7 CG n=6 D n=0 AR=86 %	FG=70±4 CG=73±7 Sex n=0/13	NS. 50 Weeks, 60 min per session. Three times per week. FG: Combined aerobic and resistance training. 10 min warm-up and stretch, 20 min stair climbing with weighted backpacks (10 % of body weight), and 30 min of endurance dance. CG: NS.	Isokinetic strength. Stair performance. The training significantly increased muscle strength (effect size=6.3). A significant positive relationship between muscle strength and maximal step height (eta^2=0.65).
de Vreede et al., 2005 [35]	The Netherlands RCT Total n=98 SG n=34 FG n=33 CG n=31 D n=14 SG AR=74 % FG AR=83 %	SG=75±4 FG=75±4 CG=73±3 Sex n=0/98	Local leisure center. Twelve weeks, 60 min per session. Three times per week. Ten minutes warm-up, 40 min core exercise, and 10 min cool-down. Both FG and RG exercise at high intensity. SG: Progressive resistance strength training using dumbbells and elastic tubing. 10 reps/3 sets. FG: Exercise phase-moving with vertical and horizontal components, carrying an object, changing between lying, sitting, and standing position. 5–10 reps. Increasing speed and weight. Daily task phase—combining training components in the exercise phase to make training tasks similar to daily tasks. CG: No active or placebo intervention was prescribed.	Isometric muscle strength, leg extension power, and grip strength. TUG. ADAP. FG improved in leg extensor power (mean change=11.2 W) and the ADAP (mean change=6.8). The effects were sustained 6 months after training. SG showed no improvement in the ADAP (mean change=3.2), but increased knee extensor strength (mean change=23.7 N) and leg extensor power (mean change=10.8 W). No training effect on TUG.

Table 3 (continued)

Author and publication year	Origin Design Sample size (n) Drop out (D n) Adherence rate (AR%)	Participants Mean age (years) Sex (male/female)	Intervention Intervention site Duration Frequency training program	Relevant outcome measures Results
Dobek et al., 2006 [17]	USA One group with a control period. Total n=14 D n=0 AR=85 %	82±4 Sex n=4/10	Retirement community. Ten weeks. Two times per week. Five to 10 min warm-up and cool-down. The training consisted of multistation exercises: sit-to-stand, stair climbing, laundry, grocery shopping, vacuuming, sweeping, dressing, traveling, and recovering from a fall. Two minutes on each station.	Senior Fitness Test. Physical Performance test. Physical-Functional Performance-10. The training improved 3 items on the Senior Fitness Test (arm curl, chair stand, and 6-min walk) (improvements range from 11 to 33 %), and Physical Performance test and Physical Functional Performance-10 (improvements range from 7 to 31 %).
Gillies et al., 1999 [7]	UK RCT Total n=20 FG n=10 CG n=10 D n=5 AR=92 %	FG=88±5 CG=87±4 FG n=0/10 CG n=1/9	Residential home. Twelve weeks. Two times per week. FG: 7 min warm-up, 8 circuits focused on walking, stair decent, stair ascent, chair rising, and trunk stretches. CG: The control group received reminiscing sessions, crossword puzzles, games, and gentle seated range-of-motion exercises, 2 times per week for 12 weeks.	Four functional tests: stair ascent, stair descent, chair rising, and walking. FG significantly improved in walking distance (2 to 5 m more than CG). No group differences in chair rise, and stair ascent and decent.
Giné-Garriga et al., 2010 [51]	Spain RCT Total n=51 FG=26 CG=25 FG D=4 CG D=6 FG AR=90 % CG AR=76 %	Participants FG=84±3 CG=84±3 FG n=9/13 CG n=7/12	Primary care facility Twelve weeks, 45 min per session. Two times per week. FG: 10 min warm-up, 30 min of exercises, 5 min cool-down. One day of balance-based exercises (static and dynamic balance training, varying gait patterns speed) with function focused activities (walking with obstacles, walking and carrying a package, walking and picking up objects from the floor). One day of lower body strength-based exercises with function focused activities (chair rise, stair climb, knee bends, floor transfer, lunges, leg squat, leg extension, leg flexion, calf raise, and abdominal curl). Load was added to increase intensity. CG: The CG met one time per week for social meetings.	Lower body strength. Semitandem and tandem stands. Gait speed. Chair stand. Modified TUG. Barthel Index. Compared to the CG, the FG significantly improved in all outcomes after training (Cohen's d ranges from −6.62 to 7.76). The effects on the Barthel Index, gait speed, and chair stand were sustained 6 months after training.
Helbostad et al., 2004 [8]	Norway Two group, randomized trial Total n=77 HT=38 CT=39 D n=11 HT D n=6 CT D n=5 Group session HT AR=83 % CT AR=88 % Home program HT AR=65 % CT AR=68 %	HT=81±4 CT=81±5 HT n=7/31 CT n=8/31	Home. NS for group sessions. Twelve weeks, 60 min per session HT: Home exercises twice per day. CT: Group session two times per week and home exercises twice per day. HT: 10 reps twice daily. Chair rise, standing rise to tiptoe, one leg standing with knee flexion on weight bearing leg, and one leg standing with hip flexion of non-weight bearing leg. CT: 10 min warm-up, 20 min progressive strength training, 20 min functional balance training, 10 min relaxation and stretching. Strength training exercises include 10 reps/3 sets of chair rise, stepping in different directions and heights, rising to tip-toe, and knee bending. Load was added to increase intensity. Balance training includes standing, walking on flat surface and over obstacles, walking upstairs, and carrying objects. Instructed to perform same home exercises as HT group.	Isometric muscle strength of quadriceps. Walking speed. Sit-to-stand. TUG. Barthel Index. Both groups significantly improved from baseline to 3 months, except isometric muscle strength. There were no differences between groups at 3 months. The HT showed stronger leg strength than CT at 9 months (Cohen's d=0.59).

Table 3 (continued)

Author and publication year	Origin Design Sample size (n) Drop out (D n) Adherence rate (AR%)	Participants Mean age (years) Sex (male/female)	Intervention Intervention site Duration Frequency training program	Relevant outcome measures Results
Krebs et al., 2007 [18]	USA RCT Total n=15 FG n=9 SG n=6 D n=0 AR=100 %	FG=78±5 SG=70±7 FG n=3/6 SG n=2/4	Outpatient PT. Six weeks, 50 min per session. Three to five times per week. Ten minutes warm-up, 30 min exercise, and 10 min cool-down. FG: Exercises simulating locomotor ADL (e.g., chair rise, reach) performed at 3 different speeds with progressive levels of difficulty. SG: Progressive resistance training in hip, knee, and ankle muscles. 10 rep maximum. All exercised were conducted in seating positions.	Lower-extremity isometric muscle strength. Quiet standing balance. Chair rise. Gait speed. SF 36. Both groups improved in lower-extremity strength, standing balance, chair rise, and SF 36. No group differences were found in these measures. The FG showed a greater improvement in gait velocity.
Littbrand et al., 2009 [1]	Sweden RCT Total n=191 FG n=91 CG n=100 D n=25 AR=72 %	FG=85±6 CG=84±7 FG n=24/67 CG n=28/72	Residential care facilities. Thirteen weeks, 45 min per session. Five times every 2 weeks. FG: The exercises included lower-limb strength and balance exercises, in standing and walking, performed at a high intensity. The exercises also mimicked movements used in everyday tasks: standing up from a sitting position, step-ups, squats, turning trunk and head while standing, and walking over obstacles. CG: The CG received the control activity program which included activities while sitting, such as reading or watching a film.	Barthel Index. The training improved indoor mobility in FG, but no group differences were found in the total Barthel Index score. The training effect on the Barthel Index was found in participants with dementia at 3 months (effect size=0.47) but not 6 months.
Manini et al., 2007 [12]	USA RCT with a control period Total n=43 SG n=14 FG n=11 SFG n=18 D n=11 SG D n=3 FG D n=1 SFG D n=7 AR=100 %	SG=74±11 FG=79±7 SFG=74±7 SG n=1/10 FG n=0/10 SFG n=1/10	A training facility. Ten week, 30–45 min per session. Two times per week. SG: Progressive resistance strength training. 10 rep maximum. Using exercise machines. Three upper body and three lower boy exercises. FG: Five functional exercises: rising from a chair, rising from a kneeling position, stair climbing, vacuuming a carpet with a weighted vacuum cleaner, and lifting and carrying a weighted laundry basket. SFG: 1 day of strength exercises and 1 day of functional exercises.	Isokinetic dynamometer. Single-leg balance. Gait speed. Short-form 12 (self-report physical function). Performance test on eight tasks. Greater improvement in arm muscle strength was observed in SG and SFG than FG. No group differences were found in self-reported physical function, gait speed, time to vacuum, and single-leg balance. Both FG and SFG but not SG reduced times to perform 8 functional tasks, such as lifting a laundry basket.
Skelton et al., 1996 [31]	UK Multiple baseline design, two groups and randomized Total n=20 FG n=10 CG n=10 D n=2 AR=74 %	Median=81 Sex n=0/19	Clinic and home. Eight weeks, 50–60 min per session. Three times per week (one supervised by a PT in a clinic, two unsupervised at home). FG: 10 min warm-up and stretch, 30–40 min strength component, and 10 min cool-down. The exercise mimicked functional ability tasks and balance tests: floor exercises, and getting up off the chair and walking, following a progressive resistance protocol. 4–8 reps/1–3 sets. CG: No active or placebo intervention was prescribed.	Isometric knee extensor strength. One-leg standing balance. Lifting a 2-kg bag on to a shelf. Chair rise. TUG. 6.1 m walk. Floor rise. Star climbing. Getting into and out of a bath. The training significantly increased knee extensor strength, improved balance, decreased time rise from a chair (single time), time to rise from the floor, and time to walk up and down a staircase, and improved TUG. No effects on lifting a bag, time to rise out of a low chair 10 times, time to get in and out of a bath or time to walk 6.1 m.

Table 3 (continued)

Author and publication year	Origin Design Sample size (*n*) Drop out (D *n*) Adherence rate (AR%)	Participants Mean age (years) Sex (male/female)	Intervention Intervention site Duration Frequency training program	Relevant outcome measures Results
Whitehurst et al., 2005 [38]	USA One group, pre-post tests Total *n*=119 D *n*=NS AR=83 %	73±5 Sex *n*=NS	NS. Twelve weeks. Three times per week. Ten functional exercises: wall exercise, single leg balance, cross-legged seated torso, modified push-up, crunch, superman, stretch and balance, weight transfer, v-sit, and star exercise. One min per exercise. Circuit format. 10–30 reps/3 sets. High intensity.	Balance on standing reach. Sit-to-stand. TUG. SF 36. The training significantly improved TUG, standing reach, and self-reported physical functioning in SF36 (percentage change=8.4, 12.9, and 8.5, respectively). The sit-to-stand outcome was not significant.

ADAP Assessment of Daily Activity Performance, *ADL (s)* activities of daily living, *CG* control group, *CT* combined training, *FG* functional training group, *HT* home training, *NS* not specified, *PT* physical therapist, *rep* repetition, *RCT* randomized controlled trials, *SBG* strength plus balance training group, *SF 36* Short Form 36, *SFG* strength plus functional training group, *SG* strength training group, *TUG* timed up and go test

Mobility Twelve trials reported outcomes of mobility [9, 17, 1, 12, 35, 47, 11, 51, 8, 18, 21, 28]. Seven trials included chair stand exercises in functional training and reported related physical measurement outcomes. Five trials found functional training improved chair stand results [1, 12, 47, 18, 21] while the other two found no superior effects of functional training [17, 28].

Although several studies included stair climbing in functional training, only two reported related physical measurement outcomes. Cress et al. found improved performance in healthy elder women [9] whereas Gillies et al. found no improvement in long-term care residents [17]. Five trials used the Timed Up and Go test or a modified Timed Up and Go test [47, 11, 51, 18, 21]. Four trials found positive results when compared to the baseline or to a comparison group [47, 51, 18, 21].

Seven trials measured walking performance which includes timed walking or walking speed [17, 12, 35, 47, 18, 21, 28]. Five trials showed improvement either in walking distance [17, 12] or walking speed [18, 21, 28]. Additionally, Littbrand et al. found that functional training increased indoor mobility when compared to strength training alone [31]. Clemson et al. found that ADL embedded functional training significantly reduced falls compared to structured strength and balance exercise [8].

ADL Seven trials reported outcomes of ADL [12, 31, 35, 11, 8, 18, 21]. The Barthel Index was used in three trials [31, 18, 21]. Two trials found positive results of functional training [18, 21]. One trial did not find a group difference but the effect was prominent in participants with dementia [31]. The other four trials found positive results either on self-report tests [8] or on task performance tests [12, 35, 11]. Moreover, three trials compared functional training and structured muscle strength training [35, 11, 8], and found favorable results of functional training on the ADL outcome.

Five trials reported long-term effects of functional training on ADL [31, 11, 8, 18, 21]. Three trials identified that the training effect was sustained after 6 months when compared to strength training [35] or attention controls [8, 18]. Two trials did not show the long-term effect. One trial compared home-based functional training to combined format of group and home-based functional training [21]. The other trial compared functional training to attention controls and is the only trial among the seven that was conducted in residential care facilities [31].

Discussion

This systematic review included 13 trials with 1,139 participants to evaluate the effects of functional training on muscle strength, physical functioning, and ADL in older adults. The intervention must include motions or exercises that use movement patterns similar to performing daily tasks to be considered as functional training in the review. Reviewed trials have incorporated a strength component, a balance component, mobility tasks, or daily tasks in functional training. Although functional training content varied greatly in these trials, mobility exercises were the most common element in functional training across trials. Most training programs were 12 weeks, two or three times per week, and 45 to 60 min per session.

The review identified positive effects of functional training. The effects are in accord with the specificity of training principle [20, 42]. When the functional training program includes the element of strength training, the training improves the outcome of muscle strength [9, 1, 47, 8, 18]. Similarly, when the training program includes the element of balance, the training improves the outcome of balance [51, 8, 18]. When the training program includes the element of chair standing, the training reduces time in standing up from a chair or improves chair standing performance [1, 12, 47, 18, 21]. When the training program includes the element of practicing actual daily life tasks, the training improves the outcome of ADL [12, 35, 11, 8].

The goal of functional training is to optimize competence of an individual to do a certain task [45]. Both simple daily tasks, such as getting up from a chair, and complex daily tasks, such as vacuuming, require cooperation between multiple muscle groups and body motor elements in order to carry out the task. Depending on the task demand, some motor elements of the body may be more essential than others. For example, Fig. 2 illustrates the possible body elements required

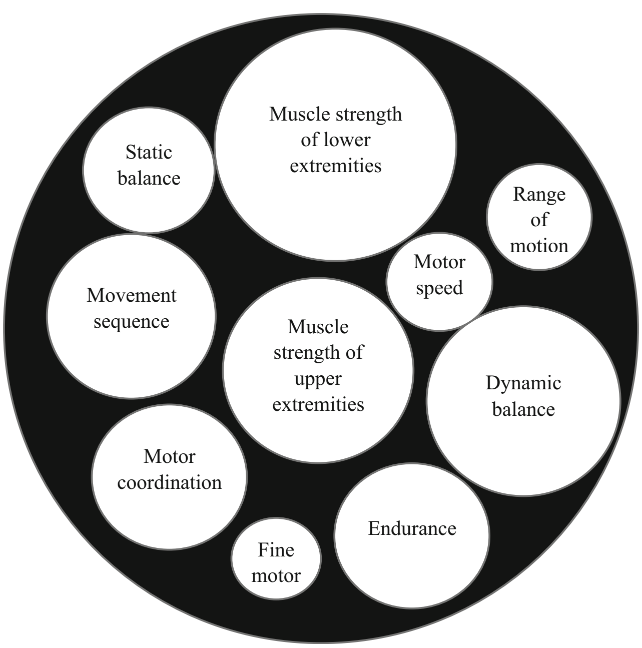

Fig. 2 Illustration of possible body motor elements required to vacuum a room

to vacuum a room. Each element required to perform the vacuuming task is represented by a circle. Although all elements are necessary to successfully vacuum a room, these more essential elements are represented by larger circles in the figure.

Functional training designed to improve an individual's ability to perform a certain daily task can target either these essential elements (element-based functional training) or all elements (task-specific-based functional training). We have observed both element-based functional training and task-specific-based functional training in this review. An example of element-based functional training is performing exercises such as step-ups or squats to improve lower extremity strength [31]. An example of task-specific-based functional training is combining functional movements with weight or speed, such as practicing chair rising while wearing a weighted vest [47] or practicing chair rising at difference speeds [28]. We have also observed combination of the two (hybrid functional training)—performing daily tasks in a slightly challenging way in order to practice the elements, such as practicing balance while washing dishes with a tandem stand [8]. We cannot conclude which type of functional training is the most effective from this review because each reviewed study differs in participant recruitment criteria, selection of comparison groups, and target functional tasks. Moreover, it is unclear whether element or task-specific training is most effective, as it may differ by the activity (e.g., stair climbing versus dressing). Further research is needed to compare these two types of functional training.

An element-based functional training may be similar to a multicomponent intervention which has been examined in the literature of late-life disability prevention [3, 30, 49]. A multicomponent intervention program includes several elements, usually muscle strength, balance, flexibility, and endurance, to improve physical capacity and to prevent functional decline in older adults. Multicomponent exercise is the most common exercise protocol for frail older adults [50]. Both element-based functional training and multicomponent interventions work on the fundamental elements through structured exercises. A multicomponent intervention could be considered functional training if the training includes purposeful movements or activities, according to our definition. Nearly half of the trials included in this review applied functional training that included balance component and strength training component [31, 47, 51, 8, 18, 21]. There is moderate evidence in this review showing that functional training includes multi-components improves physical functioning.

Three trials yield a consistent and conversing result showing that functional training is more effective than structured strength training alone on improving ADL [12, 35, 13]. Two of these trials show that such effect can be sustained for 6 months [11, 8]. Although age-related decline in muscle strength is strongly related to functional decline in older adults

[19, 25, 24, 36, 41, 23], the process of aging also influences other motor elements that are essential for ADL performance such as coordination [44]. If the training only targets one essential body motor element and ignore other elements, the training effect on ADL may be compromised. Conversely, functional training facilitates multiple muscles and body motor elements acting together which is more approximate to the way people perform an ADL. The finding also supports the specificity of training principle.

A limitation of this review is that some trials might have been missed by the search terms despite the intervention fitting within the concept of functional training. Another limitation is that meta-analysis could not be conducted because heterogeneous training content, participant selections, comparison groups, and outcome measures exist among study trials. However, this review shed some light on the potential for functional training to reduce late-life ADL disability and the loss of independence.

Conclusion

We appraised 13 trials of functional training in this review and the results support the specificity of training principle; that is, the best gains in performance are achieved when the training closely mimics the performance. Therefore, functional training may be a better option than muscle strength training alone if the goal is to reduce ADL disability in older adults. Moreover, reviewed trials show a great difference in research design, participant recruitment criteria, and functional training programs. We identified three patterns of functional training: element-based functional training, task-specific-based functional training, and hybrid functional training. Additional research to examine the effect of functional training according to the three patterns on reducing functional decline in older adults is encouraged.

Conflict of interest All the authors declare no conflict of interest.

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