Effect of Different Types of Physical Activity on Activities of Daily Living in Older Adults: Systematic Review and Meta-Analysis

Abstract

Physical activity is associated with greater independence in old age. However, little is known about the effect of physical activity level and activity type on activities of daily living (ADL). This review systematically analyzed the effects of physical activity level and activity type on ADL in older adults (mean age, 60+). Electronic search methods (up to March 2015) identified 47 relevant, randomized controlled trials. Random effects meta-analyses revealed significant, beneficial effects of physical activity on ADL physical performance (SMD = 0.72, 95% CI [0.45, 1.00]; $p < 0.01$), with the largest effects found for moderate physical activity levels, and for activity types with high levels of mental (e.g. memory, attention), physical (e.g. coordination, balance) and social (e.g. social interaction) demands. Inconsistent effects were observed on self-reported ADL measures. Interventions that include moderate physical activity levels with high mental, physical and social demands may produce greatest benefits on ADL physical performance.

Keywords: physical activity, activities of daily living, older adults, systematic review

Between 2015 and 2050, the global proportion of older adults aged 60 and over will nearly double from 12% to 22% (World Health Organization [WHO], 2015), resulting in significant economic, political and social consequences to society (United Nations, 2013).

Advanced age involves structural and functional deterioration of most physiological systems (Chodzko-Zajko et al., 2009) which may negatively impact an individuals' ability to carry out activities of daily living (ADLs) such as grooming, feeding, mobilizing, and continence, alonside instrumental activities of daily living (IADL) such as housework, managing money and shopping for groceries. A loss of ADL ability is often associated with poorer quality of life (Murakami & Scattolin, 2010) and increased strain on families and healthcare systems. Therefore, strategies designed to maintain ADL and IADL abilities during old age are of prime importance.

Mounting evidence from large-scale epidemiological studies, randomized controlled trials and meta-analytic reviews offer compelling evidence that physical activity positively influences older adults' ability to carry out ADLs (Chou, Hwang, & Wu, 2012; Tak, Kuiper, Chorus & Hopman-Rock, 2013) alongside improving ADL-related outcomes such as muscular strength (Paterson & Warburton, 2010), balance (Howe, Rochester, Neil, Skelton, & Ballinger, 2011), mobility (Yeom, Keller, & Fleury, 2009), flexibility (Peri et al., 2008), cognitive function (Blondell, Hammersley-Mather, & Veerman, 2014), executive functioning (Guiney & Machado, 2013), and reducing the risk of disability (Gretebeck, Ferraro, Black, Holland, & Gretebeck, 2012) and falls (Allan, Ballard, Rowan, & Kenny, 2009). These findings have led to questions regarding which characteristics of physical activity are most important for maintaining ADL in old age.

It is recommended that older adults undertake 150 minutes a week of moderate-intensity physical activity in bouts of 10 minutes or more (WHO, 2010) to achieve beneficial health outcomes. Although many older adults struggle to meet these guidelines (Sparling, Howard, Dunstan & Owen, 2015) a lower amount of physical activity may still be of some benefit. Physical activity patterns are commonly quantified by combining the weekly frequency, intensity and time spent engaging in physical activity (e.g. Hupin et al., 2015), which results in an overall *physical activity level.* Physical activity undertaken at a lower frequency, time, and intensity (i.e. *low* physical activity level) may have a differential impact on ADL than activities undertaken at a higher frequency, time, and intensity (i.e. *high* physical activity level). Currently, limited attention has been directed towards the impact of different physical activity levels (including *low* physical activity levels, which may be more acceptable to older adults) on ADL ability. Furthermore, the impact of different *types* of physical activity on ADL ability in old age is largely unexplored.

Golf (Fan, Kowaleski-Jones & Wen, 2013; Kolt, Driver & Giles, 2004; Stenner, Mosewich & Buckley, 2016), bowling (Crombie et al., 2004; Fan et al., 2013; Kolt et al., 2004) and dancing (Department of Culture, Media and Sport, 2011; Fan et al., 2013) are examples of physical activities commonly undertaken during old age, which vary in terms of their mental (e.g. memory, attention), physical (e.g. balance, coordination), and social (e.g. level of social interaction required) demands. Golf involves mental demands such as problem-solving, ability to read the greens, make tactical decisions and keep score (Weeks & Nye, 2008), thus golf is more mentally demanding than simpler activities such as walking. Bowling, on the other hand, involves physical skill demands such as dynamic balance, mobility, reaction time and postural stability (Brooke-Wavell & Cooling, 2009), thus lawn bowls is more physically demanding than other activities such as stationary cycling. Finally, dancing involves intrinsic, social interaction demands (Lakes et al., 2016) such as cooperation and interaction with a partner or a group, thus dancing is more socially demanding than activities that are often performed alone, such as housework. It is possible, therefore, that activity types which combine greater amounts of mental, physical and social demands (i.e. *high* multitask activities) may have a stronger, beneficial effect on ADL ability than simpler physical activities (i.e. *low* multitask activities).

Several systematic reviews have attempted to investigate physical activity type (Chou et al., 2012; de Vries et al., 2012; Giné-Garriga, Roque-Figuls, Coll-Planas, Sitja-Rabert, & Martin-Borras, et al., 2014), but the inclusion of interventions that incorporated a combination of different types of physical activity prevented statistical, comparative analyses. In a recent Cochrane review, Howe et al., (2011) analyzed the effects of different types of physical *exercise* (a subcategory of physical activity) on balance performance, concluding that the more effective interventions involved standing dynamic exercise, but an analysis of the specific types of activities and their underlying demands was not conducted. To the best of our knowledge, no studies have investigated specific types of physical activities (with their underlying mental, physical and social demands) and whether these differences affect ADL outcomes.

This systematic review aimed to synthesize data from randomized controlled trials to investigate the effect of physical activity level and multitask activity level on ability to carry out ADLs in older adults. Given that physical performance measures are more likely to be sensitive to change over time (Goldman, Glei, Rosero-Bixby, Chiou, and Weinstein, 2014), self-reported and physical performance measures were analyzed separately.

Method

Study Design

This study was a systematic review of published, randomized controlled trials (RCTs). A protocol (available on request) was developed prior to undertaking the review, which adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (Liberati et al., 2009).

Study Selection

Details of the selection process are shown in Figure 1. Included studies met the following criteria:

Studies.

Pre-posttest RCTs investigating the effect of specific types of physical activities on ADLs in older adults were included. All methods of randomization were accepted. Trials with multiple study arms were also accepted, providing that each intervention met with specified inclusion criteria (see *Interventions*). Where this was not the case, that study arm was excluded but all other remaining study arms were included. Studies included, but were not limited to, community and home-based interventions, laboratory-based interventions, and care facility settings such as retirement home interventions.

Participants.

Studies included older adult participant samples with a mean age of 60+ years. Several potentially relevant studies with this desired mean age included participants as young as 40 years old, which may not conform to generally accepted definitions of old age (e.g. WHO, 2012). Therefore, participant samples also had to have a minimum age of 55 years to be eligible for inclusion in the present study. Given that an older adult sample free of disease is not likely to be representative of this population (Chodzko-Zajko et al., 2009), studies containing participants with conditions/diseases typical of old age were included. However, studies that exclusively recruited volunteers with a particular disease (e.g. stroke, cancer, dementia) were excluded, with the exception of ADL-related limitations, namely: balance impairment; frailty; mild cognitive impairment; dependence in ADLs; disability; and history of falls.

Interventions.

Included interventions comprised of one specific type of physical activity, as specified within the Compendium of Physical Activities (Ainsworth et al., 2011), with the exceptions of balance and functional training, which are not included within the compendium but are highly relevant modes of exercise training among older adults. Multicomponent interventions (e.g. including an educational or nutritional component, electrical/vibrational stimulation) were excluded to ensure that any observed effects were due to the physical activity alone. Controls could have no intervention, a placebo non-active contact intervention (e.g. arts and crafts), or standard care. The frequency, intensity, time and type of activities were recorded. All durations of interventions were accepted, although interventions with physical activity sessions of less than 10 minutes each were excluded as this is the minimum bout of time for activity recommended for older adults by the American College of Sports Medicine (ACSM) (Chodzko-Zajko et al., 2009) and the WHO (2010) to improve health.

Outcome measures.

Studies were required to report at least one ADL or ADL-related outcome. Accepted physical performance measures of ADL were: Timed Up and Go Test (TUG); Berg Balance Scale (BBS); 8-Foot Up and Go (8FUG); Sit Up and Go (SUG); 6-minute walk test (6MW); 5-times sit to stand (5STS); Group of Development Latin-American for Maturity (GDLAM's) protocol of Functional Autonomy evaluation (FA); and the Physical Performance Test (PPT). Accepted self-reported ADL measures were: MOS Short form, physical functioning subscale (SF36-PF); Barthel Index (BI); Lawton and Brody Instrumental Activities of Daily Living Scale (IADL); Katz Index of Independence in Activities of Daily Living (Katz ADL); Functional Independence Measure (FIM); Groningen Activities Restriction Scale (GARS); and the Assessment of Daily Activity Performance (ADAP). This review only included pre and post-test intervention outcome measures. Any additional follow-up measures were not included in the analyses.

Search Strategy and Identification of Trials

Studies included in this review were identified from five electronic databases:

MEDLINE; EMBASE; PsycINFO; SPORTDiscus; and the Cochrane Library Register of Controlled Trials. There were no restrictions on year of publication up until March 2015. The search was limited to randomized controlled trials, human subjects, and English language. The electronic search strategy was initially developed in MEDLINE (Supplementary file 1) by combining a string of relevant Medical Subject Headings (MeSH) terms and text words (e.g. *older adults, elderly; physical activity, sport, exercise;* and *activities of daily living, physical function, independence*), which were then adapted for all remaining databases. Reference lists of potentially relevant studies were also hand-searched, and additional studies identified via researcher knowledge of relevant literature were also added. The first author performed each search, and forwarded results to a centralized data bank (RefWorks) for the removal of duplicates. The same author performed initial screening of all titles and abstracts to determine relevance. To ensure accuracy of screening, 10% of the same studies were independently screened by a second reviewer, resulting in an initial 71.62% agreement. Remaining disagreements were resolved through discussion until 100% agreement was achieved. Following this, one author performed full text screening of all selected studies to ensure they met the review inclusion/exclusion criteria. Study eligibility doubts were resolved by discussion with all authors. Five authors of included studies were contacted via email (of which, 4 responded) to clarify information and/or request missing data, resulting in a response rate of 80%.

Data Extraction and Quality Assessment

The first author performed data extraction on all included studies using a piloted data extraction form, where data to be extracted was tightly specified. To determine reliability, three other authors independently performed data extraction for a total of 25.5% of included studies. Results were cross-checked, demonstrating 100% agreement across authors, thus further cross-checking was deemed unwarranted. Quality of all included studies was assessed by the first author, using the PEDro (Physiotherapy Evidence Database) Scale. This 11-item scale analyzes methodological quality of clinical trials (RCT's) by assessing the following criteria: specified eligibility criteria; random allocation; allocation concealment; homogeneity of participants at baseline; blinding of subjects; intention to treat analysis; group statistical analysis; and point measures and measures of variability (Moseley, Herbert, Sherrington, & Maher, 2002). Items receive a *yes* or *no* response, and (as utilized in Lopez Fernadndez-Arguelles, Rodriguez-Mansilla, Espejo Antunez, Maria Garrido-Ardila, & Perez Munoz, 2015) a total score of study quality is calculated (9-10 = *excellent*; 6-8 = *good*; 4-5 = *fair*; <4 = *poor*). In randomized trials, reliability of this total PEDro score is *fair* to *good* (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003). Studies with a *poor* quality rating were excluded from this review.

Data Synthesis

Similar to previously used methods (Paterson & Warburton, 2010; Hupin et al., 2015; Weauve et al., 2004), physical activity level was determined by multiplying the weekly volume of each activity (i.e. frequency and time) by the metabolic output (METs) of the type of physical activity (i.e. intensity), which resulted in a value of weekly MET-minutes for each intervention group. MET values were taken from Ainsworth et al.'s (2011) Compendium of Physical Activities, which lists 822 different physical activities alongside their corresponding metabolic expenditures. Following a careful inspection of the intervention activity descriptions, the most representative compendium activity was selected. Where types of physical activity interventions existed that were not included in the compendium (in the case of this review, balance training and functional training), a description of the physical activity (and its intensity) was matched to the closest available activity listed in the compendium.

The WHO (2010) recommends that older adults undertake 150 minutes of moderate intensity physical activity in bouts of 10 minutes or more per week. According to Ainsworth et al. (2011), moderate intensity ranges from 3-5.9 MET's. Thus, *moderate* physical activity levels for older adults were classified as 450-885 MET-minutes (i.e. 150 x 3 to 150 x 5.9), with <450 and >885 MET-minutes classified as *low* and *high* physical activity levels respectively. Where intervention groups had been pooled for meta-analysis (i.e. a study with more than one intervention group), the mean MET-minutes of the two intervention groups was accepted.

A coding system (supplementary file 4) for analyzing multitask activity level was developed by the research team, which categorized each activity as *high, moderate*, or *low*. These methods were adapted from the work of Karp and colleagues (2006) in their assessment of the mental, physical and social components of different leisure activities. Using existing literature (e.g. Corbin, Pangrazi & Franks, 2000; Goldstein, 2008; Rolls, 2008), eight non-metabolic, mental (i.e. *attention/concentration, decision-making and strategy, memory*), physical (i.e. *flexibility, balance, coordination, speeded reactions*) and social (i.e. *level of interaction*) demands of different types of physical activity were identified. These demands were then rated by three researchers during two rounds of scoring. In round one, researchers independently scored each of the nine demands within the 15 physical activities included in the present review (totaling 120 individual scores), using a points system of: 1 = little/none required; 2 = a moderate amount required; 3 = a high amount required. Scores were accepted when 100% agreement was reached. Seventy-seven of the 120 scores reached 100% agreement in round one, and were therefore, accepted as complete. In round two, the remaining 43 non-agreed scores were discussed among the same three researchers until a consensus was reached. All scoring was based upon specific intervention content reported within the selected study papers, alongside researcher knowledge of the different types of physical activity. The total score for each physical activity was calculated, revealing three natural clusters. These clusters, were used to form three subcategories of multitask activity level for subsequent analyses. The first cluster contained activities requiring minimal cognitive demands and simple, repetitive movements. These *low* multitask activities (8-11 points) were flexibility training, gardening, stationary cycling, strength training, and walking. The middle cluster contained activities with a moderate level of mental and physical functioning that can be performed alone or in a group setting. These *moderate* multitask activities (13-16 points) were: aquafit, balance training, exergaming, functional training, Pilates, qigong, tai chi, and yoga. The third cluster contained inherently social activities, requiring continuous interaction with others, complex movement skills and high levels of cognitive processing. These *high* multitask activities (19-20 points) were dancing, and handball. Consequently, a *high* multitask activity has high mental, physical, and social demands, and a *low* multitask activity involves little or no mental, physical, and social demands.

A narrative synthesis was used to evaluate key findings, and where data allowed, meta-analyses were undertaken to determine the effect of physical activity level (subcategorized as *high, moderate* and *low*) and multitask activity level (subcategorized as *high, moderate* and *low*) relative to control on both physical performance and self-reported ADL measures. The meta-analyses were performed using Review Manager Software (version 5.0). Due to the variety of outcome measures, a standardized mean difference approach (*SMD*) with a random effects model was used. Given that the combination of post and change data is not advised for standardized mean difference (Higgins & Green, 2011), only studies (individually randomized, parallel trials) providing post data were included in the meta-analyses. For physical activity level meta-analyses (Figures 2 and 3), intervention groups were pooled. This was not possible for multitask activity level meta-analyses (Figures 4 and 5) unless both intervention groups used the same type of activity or if both types of activities fell into the same multitask level subcategory. To facilitate comparisons across studies, outcomes with a lower score indicating a beneficial effect of physical activity were converted by multiplying the means by -1 (Higgins & Green, 2011). Means and standard deviations were extracted for use, or where necessary, calculated from other statistical data.

Sensitivity Analysis

A sensitivity analysis was performed to determine the effect of methodological quality on effects of the interventions. This was achieved by temporarily removing *fair* quality studies (as identified by the PEDro scale) and comparing these results with the full set of results.

Analysis of Publication Bias

Funnel plots of the pooled study data were performed to allow for visual inspection of publication bias (Figures 6-9).

Results

The search process (Figure 1) identified 47 studies (48 articles) that met the inclusion criteria, of which 33 were suitable for meta-analysis. A list of excluded studies can be found in Supplementary file 2.

Characteristics of Included Studies

A detailed summary of all study characteristics and study identification (ID) numbers can be found in Table 1, whereby ID numbers are presented adjacent to first author name and year of publication.

Study design.

Of the 47 studies, 44 were individually randomized (study IDs: 1-14, 16-26, 28-43, 45-47) and three were cluster randomized trials (15, 27, 44). Forty-five studies used parallel arm designs (1, 2, 4, 6-47), one study used crossover designs (5), and one study used semi-crossover designs (3). Thirty-one studies were two-arm trials (1-3, 5, 10, 11, 13, 14, 17-23, 25-27, 29, 30, 33-36, 40-44, 46, 47), 13 studies were three-arm trials (7, 8, 12, 15, 16, 24, 28, 31, 32, 37-39, 45) and three studies were four-arm trials (9, 4, 6). Intervention arms from three studies were excluded from this review due to the intervention group undertaking a combination of different types of physical activity (9, 16) or including multicomponent intervention techniques (neuromuscular electrical stimulation during physical activity sessions) (4).

Participants.

Of the study arms that were included in this review, there was a total of N = 3,520 randomized older adult participants. Three studies did not report the sex of participants (6, 16, 38), however the majority of study samples were either mostly or all female.

Setting.

Twenty-two studies were set in community venues (2, 7, 10-12, 33, 16-18, 21-26, 28, 29, 32, 34, 38, 41, 43); seven studies were set in medical facilities (36, 14, 30, 35, 39, 42, 47); 13 studies were set in care homes (3, 4, 6, 9, 13, 15, 21, 27, 37, 40, 44, 45, 46); and five studies were set in research facilities (1, 5, 8, 19, 31).

Interventions.

Physical activity level.

Physical activity level was determined by calculating MET minutes (weekly volume of activity multiplied by estimated metabolic output of the type of activity). Summaries of physical activity level are shown in Supplementary file 3 for all individual intervention arms.

Physical activity type and multitask activity level.

A total of 15 different types of physical activity were identified across the individual study arms for *high* multitask activities: dancing (6, 10, 14, 17, 20); handball (46); *moderate* multitask activities: aquafit (21, 24, 38); balance training (15, 30, 39, 47); exergaming (22, 25, 35); tai chi (11, 13, 31, 37, 42); functional training (9, 12, 15); Pilates (5, 33, 36, 24, 28); qigong (43); yoga (18, 31, 32, 41, 37); and *low* multitask activities: flexibility training (28, 40); gardening (44); stationary cycling (1, 7, 45); strength training (2-4, 8, 9, 12, 16, 19, 34); walking (23, 26, 29, 32). Most interventions included a 5-

minute warm-up, main session of the physical activity type, and a 5-minute cool down. Summaries of physical activity types and multitask activity levels are presented in Supplementary file 3 for all individual intervention arms.

Duration of intervention.

Intervention duration was less than two months in five studies (5, 28, 34, 35, 47); between two and five months in 28 studies (2, 4, 12, 14-23, 25, 26, 29-31, 33, 36, 37, 39, 40, 41-45); and between six and eight months in 14 studies (1, 3, 6-11, 13, 24, 27, 32, 38, 46).

Control group activity.

Seven studies used standard care activities for the control group (2, 13, 31, 37, 39, 42, 44); 14 studies used a sham activity such as arts and crafts, or other recreational activities (3, 8, 9, 11, 18, 22, 27, 29, 33, 38, 40, 43, 45, 47); and 26 studies did not include any change to the control groups' normal activities (1, 4-7, 10, 12, 14-17, 19-21, 23-26, 28, 30, 32, 34-36, 41, 46).

Intervention Delivery.

Forty studies used an instructor to deliver physical activity sessions (2-5, 7, 9-15, 17-20, 22, 24-33, 35-47); two study interventions did not require an instructor (1, 23); and five studies did not report the presence or absence of an instructor (6, 8, 16, 21, 34).

Methodological Quality

According to the PEDro scale, methodological quality of 29 studies were rated as *good* (1-5, 7, 9-15, 17, 18, 22, 23, 28, 32-35, 37, 41-43, 45-47), and 18 studies were rated as *fair* (6, 8, 16, 19-21, 24-27, 29-31, 36, 38-40, 44). A rating of *excellent* was unachievable as it is not possible to blind participants or therapists in physical activity interventions.

Summary of Individual Study Arms

A summary of the effects of the 47 included studies is presented in Supplementary file 3. Of the 47 studies (60 intervention arms), 66.30% of relevant outcomes measures were statistically significant in favor of the intervention group. 60.78% of relevant outcome measures within the *low* physical activity level subgroup were statistically significant; 80% of relevant outcome measures within the *moderate* physical activity level subgroup were statistically significant; and 33.33% of relevant outcome measures within the *high* physical activity level subgroup were statistically significant. 90% of relevant outcome measures in the *high* multitask activity level subgroup were statistically significant; 72.9% of relevant outcome measures in the *moderate* multitask activity level subgroup were statistically significant; and 50% of relevant outcome measures in the *low* multitask activity level were statistically significant.

Effect of physical activity level on ADL (physical performance measures)

The effect of physical activity level (subcategorized as *low*, *moderate* and *high*) on directly measured ADL physical performance was analyzed via meta-analysis (Figure 2). Post data were available (or calculable) from 29 individually randomized, parallel trials. Pooling of the 29 studies resulted in a statistically significant, beneficial effect of the physical activity interventions versus control on ADL (*SMD* = 0.72, 95% CI [0.45, 1.00]; $p < 0.01$). No studies reporting physical performance measures fell into the *high* physical activity level subgroup, meaning that conclusions could not be drawn for this level. While the *low* and *moderate* physical activity level subgroups both produced significantly beneficial effects, the *moderate* subgroup produced the largest effect (*SMD* = 1.07, 95% CI [0.44, 1.70]; $p < 0.01$) and the *low* subgroup produced a smaller effect (*SMD* = 0.57, 95% CI [0.29, 0.86]; $p < 0.01$). However, substantial heterogeneity was present across studies.

Effect of physical activity level on ADL (self-reported measures)

The effect of physical activity level (subcategorized as *low, moderate* and *high*) on ADL self-reported measures was analyzed via meta-analysis (Figure 3). Post data were available (or calculable) from nine individually randomized, parallel trials. Pooling of the nine studies resulted in a non-significant, beneficial effect of the physical activity interventions versus control on ADL (*SMD* = 0.41, 95% CI [-0.12, 0.94]; $p < 0.01$). The *moderate* physical activity level subgroup produced a significant, beneficial effect (*SMD* = 1.12, 95% CI [0.74, 1.49]; $p < 0.01$), whereas the *low* subgroup did not produce a consistent effect (*SMD* = 0.02, 95% CI [-0.46, 0.49]; $p = 0.95$). Only a single study fell into the *high* subgroup, which demonstrated a significant effect in favor of the control group (*SMD* = -0.82, 95% CI [-1.34, -0.29]; $p < 0.01$), however, the limited number of studies meant that conclusions could not be drawn for this level. Again, substantial heterogeneity was present across studies.

Effect of multitask activity level on ADL (physical performance measures)

The effect of multitask activity level (subcategorized as *low*, *moderate*, and *high*) versus control on directly measured ADL physical performance was analyzed via meta-analysis (Figure 4). Post data were available (or calculable) from 27 individually randomized, parallel trials. The *high* multitask activity level subgroup produced the largest, significantly beneficial effect on ADL (*SMD* = 1.36, 95% CI [0.46, 2.26]; $p < 0.01$), followed by the *moderate* multitask subgroup (*SMD* = 0.74, 95% CI [0.41, 1.06]; $p < 0.01$). The *low* multitask subgroup produced the smallest, beneficial effect, which failed to reach statistical significance (*SMD* = 0.45, 95% CI [-0.01, 0.91]; $p = 0.06$). However, substantial heterogeneity was present across studies.

Effect of multitask activity level on ADL (self-reported measures)

The effect of multitask activity level (subcategorized as *low*, *moderate* and *high*) versus control on ADL self-reported measures was analyzed via meta-analysis (Figure 5). Post data were available (or calculable) from eight individually randomized, parallel trials. The *moderate* multitask activity subgroup produced a significantly beneficial effect on ADL (*SMD* = 1.12, 95% CI [0.55, 1.69]; $p = 0.47$). The *low* (*SMD* = 0.53, 95% CI [-0.34, 1.40]; *p*

= 0.23) and *high* (*SMD* = -0.10, 95% CI [-1.53, 1.32], *p* = 0.89) subgroups did not produce a consistent effect. Again, substantial heterogeneity was present across studies.

Sensitivity Analysis

Studies of *poor* methodological quality (PEDro <4) were already excluded from this review. Removing studies of *fair* methodological quality (PEDro 4-5) resulted in a similar pooled effect size of physical activity versus control on physical performance measures (*SMD* = 0.68, 95% CI, [0.30, 1.07]; *p* = 0.0005), with the *moderate* physical activity level subgroup remaining with the largest effect size (*SMD* = 1.36, 95% CI [0.26, 2.47]; *p* = 0.02) and the *low* level subgroup producing a smaller, but significant effect (*SMD* = 0.42, 95% CI [0.08, 0.76]; *p* = 0.02). Removing studies of *fair* methodological quality also produced a similar pooled effect size of physical activity on self-reported measures (*SMD* = 0.18, 95% CI [-0.37, 0.72]; *p* = 0.52), with the *moderate* physical activity level subgroup producing the largest effect (*SMD* = 0.99, 95% CI [0.30, 1.67]; *p* = 0.005) and no change in the *low* and *high* physical activity level subgroups. Removing studies of *fair* methodological quality produced similar effects of *low* (*SMD* = 0.39, 95% CI [-0.32, 1.10]; *p* = 0.28), *moderate* (*SMD* = 0.44, 95% CI [0.14, 0.74]; *p* = 0.004), and *high* (*SMD* = 2.19, 95% CI [0.24, 4.14]; *p* = 0.03) multitask activity levels on physical performance measures. Finally, removing studies of *fair* methodological quality produced similar effects of *low* (*SMD* = 0.30, 95% CI [-0.69, 1.28]; *p* = 0.55), *moderate* (*SMD* = 0.95, 95% CI [0.21, 1.68]; *p* = 0.01), and *high* (*SMD* = -0.10, 95% CI [-1.53, 1.32]; *p* = 0.89) multitask activity levels on self-reported ADL measures. Results suggest that there was no statistically significant effect of removing the *fair* methodological quality studies from the pooled data.

Analysis of Publication Bias

Visual inspection of the four funnel plots (Figures 6-9) containing 33 studies in total suggests some asymmetry, indicating possibility of some publication bias. Methods for correcting intervention effect estimates such as ‘trim and fill’ were considered, however, the presence of substantial between-study heterogeneity suggested that this approach was unsuitable for the present data set (Peters, Sutton, Jones, Abrams, & Rushton, 2007).

Discussion

As far as the authors are aware, no other study or review to date has attempted to examine the underlying demands of different types of physical activity, and to relate differences in these demands to a key health outcome: ADL (both directly measured physical performance and self-reported outcomes). Forty-seven randomized controlled trial studies were included in the review, of which, 35 reported a statistically significant, positive effect of physical activity on ADL in older adults. A limited number of studies analyzed the effect of physical activity on self-reported ADL outcomes, of which, results were inconsistent. However, the effect of physical activity on ADL physical performance measures produced a statistically significant, beneficial effect. While the limited number of studies assessing *high* physical activity levels mean that conclusions cannot be drawn for this level, *moderate* physical activity levels and *high* multitask activity levels appear to produce the greatest effects. These results demonstrate for the first time that differences in the physical, mental and social demands of different physical activity types produce predictable changes in the beneficial health effects obtained by participating older adults. This finding has both theoretical implications, in terms of advancing thinking about the processes underlying the established association between physical activity and health, and practical implications for the design of health promoting interventions for older adults.

The current review pooled physical performance measures together, demonstrating that physical activity had a significant, beneficial effect on ADL. Giné-Garriga et al., (2014) also investigated the effect of physical activity on physical function and ADL via meta-analysis, and found that while some physical performance measures were significantly improved (e.g. Short Physical Performance Battery, Berg Balance Scale, 5-Times Sit to Stand) others failed to demonstrate a difference, such as the Timed Up and Go (TUG). Given the high prevalence of TUG, 8FUG and SUG (highly similar outcomes) within the current review, a similar result would have been expected. This difference may be due to the inclusion of both frail and healthy older adults in the current review, that is, the inclusion of healthy participants who have greater functional capacities than frail participants (Lenardt et al., 2016) and are therefore, more likely to improve.

Similar to the present review, Giné-Garriga et al., (2014) did not find a consistent effect of physical activity on self-reported measures of ADL, and reported high levels of heterogeneity. Research suggests that self-reported ADL however, are prone to weak face validity, reproducibility (Guralnick & Simonsick, 1993), and may not be responsive to detecting significant functional changes in community-dwelling older adults (Lin et al., 2012), which may explain the inconsistent findings. Findings may also differ across included studies of the present review as the majority of participant samples included both males and females, whereas only a few study samples were gender-specific. Given that females are more prone to dependence in ADLs than males (Millan-Calenti et al., 2010), more studies are needed that analyze the effects of physical activity on ADL outcomes across males and females separately.

Burge, Kuhne, Berchtold, Maupetit, and von Gunten (2012) undertook a critical review, with meta-analysis, to investigate the impact of physical activity on functional independence and ADL in older adults suffering from moderate-to-severe dementia. While physical activity tended to positively impact ADL performance, ADL status did not significantly change between pre-and-post measures. However, ADL status in control participants significantly declined. This trend was similar to some of the individually included studies within the current review (e.g. Dechamps et al., 2010). Despite lack of significant improvements, these are still promising findings as they suggest that physical activity may offer a protective effect on ADL ability within the context of dementia. Burge et al., suggested that the small number of studies with inconsistent reporting methods meant that questions relating to key characteristics of physical activity level (e.g. intensity and duration) remained unanswered.

Regarding physical activity level, the present review found that *low* and *moderate* subgroups produced a significantly beneficial effect on physical performance measures of ADL, with the *moderate* subgroup producing the largest effect. The effect of physical activity level on self-reported measures of ADL revealed that only the *moderate* subgroup produced a significantly beneficial effect. No studies fell into the *high* subgroup for physical performance measures, and only a single study fell into the *high* subgroup for self-reported measures, meaning that it was not possible for firm conclusions to be drawn regarding *high* physical activity levels, which has been associated with a reduced risk of disability in basic ADLs in previous studies (Tak et al., 2013). Paterson and Warburton (2010) undertook a systematic review that investigated the relationship between physical activity, functional limitations, disability, and loss of independence among community-dwelling older adults. Although an optimal dose of physical activity could not be determined, moderate-to-vigorous levels of physical activity had a greater effect on functional limitations and disability compared with lower levels. Paterson and Warburton’s review differed from the present review in terms of the measurement and analysis of physical activity levels, alongside their inclusion of multiple study designs (the present review was restricted to RCTs), which may explain the differences in findings. However, the most likely reason that findings of the current review did not concur that *high* physical activity levels had the largest, beneficial effect is due to the insufficient number of studies that fell into the *high* physical activity level subgroup. Thus, future RCT interventions investigating the effect of *high* physical activity levels on ADL in old age are warranted. However, the present review found evidence that *moderate* physical activity levels produce a larger, beneficial effect than *low* levels, which suggests that increasing levels of physical activity may produce a greater, beneficial effect on ADL.

Findings of the current review builds on a recent meta-analytic review, which investigated whether physical activity could prevent or reduce disability in ADLs (Tak et al., 2013). Tak and colleagues found that, compared with lower levels of physical activity, risk of disability was reduced with moderate to high physical activity levels. The review, however, relied on prospective, longitudinal studies that measured and reported physical activity variables in different ways. By restricting the inclusion criteria to RCTs, the current review was able to use gold standard evidence to provide an accurate summation of physical activity levels across such interventions. RCT study designs were particularly ideal for the current review as each intervention arm evaluated a single type of physical activity, which was then coded to determine multitask activity level.

The current review used a novel coding system to determine multitask activity level by quantifying the underlying mental, physical and social demands of different types of physical activity. While this method has a subjective element, differences found in the scores between different multitask levels warrant future research in this area. Dancing and handball were coded as *high* multitask activities, due to a combination of their underlying mental, physical and social demands. Dancing is usually accompanied by sequential movements to music, thus requiring higher levels of attention, memory and coordination. Handball, on the other hand, requires speeded reactions and decision making skills. Dancing and handball are inherently social activities, thus requiring social interaction. Due to their coordination and speeded reaction demands, dancing and handball also have a higher demand for balance.

Both activities require moderate to high levels of attention skills, relating to either keeping focus on a ball or an opponent (handball), or following the movements of an instructor or partner (dancing). In contrast, *low* multitask activities (i.e. strength training, flexibility training, stationary cycling, and walking) require little or no attention, memory, decision-making, coordination, balance and social interaction due to their simple, repetitive movement patterns, which may easily be undertaken in social isolation. Interestingly, the underlying demands of *high* multitask activities mirror the underlying demands of several ADL and IADL activities (e.g. shopping for groceries requires decision-making skills over what to buy; memory of shopping list requirements; calculation of monetary values; balance and functional flexibility needed to reach items off a high shelf or maneuver a shopping cart; and possible interaction with fellow customers and retail staff). This may offer insight as to why the *high* multitask activity level subgroup had a larger effect on ADL physical performance measures than *moderate* and *low* multitask activity level subgroups.

De Vries et al., (2012) performed a meta-analysis of physical exercise on ADL-related outcomes pertaining to mobility and physical function in older adults, reporting a large intervention effect for three studies that all had a strength training component. In contrast, the current review placed strength training in the *low* multitask activity level subgroup, which had the smallest effect size compared with the *high* multitask activity level subgroup. However, the studies highlighted by de Vries et al., combined strength training with balance and functional task training making these interventions higher in terms of multitasking, which may explain the contrasting results. The hypothesis of greater benefits arising from high multitask activities is further supported by Anderson-Hanley et al., (2012) who found that cycling with a simultaneous cognitive task (i.e. *cybercycling*) had a greater positive effect on cognitive functioning (which underlies ADL ability) than cycling alone. Thus, the evidence combined suggests that physical activities with greater multitask demands have a larger positive impact on ADLs in older adults, possibly due to their close resemblance of actual ADL activities, which also have underlying mental, physical and social demands. In addition, one of the three studies in De Vries' review incorporated behavioural and cognitive strategies to maximise participation. In doing so, it is plausible that the positive effects are partly due to cognitive/behavioural conditioning rather than purely from strength training alone. By excluding such studies, the present review was able to rule out the possibility of results being contaminated by cognitive/behavioural intervention.

Both Giné-Garriga et al's., (2014) and de Vries et al's., (2012) reviews included physical activity interventions consisting of multiple types of activities, meaning that statistical analysis of physical activity type could not be undertaken. The present review excluded interventions that did not focus on a single type of physical activity. Using this approach, the present review was able to adopt a coding system to investigate the combined, underlying mental, physical and social demands of individual types of physical activities, and found that the *high* multitask activity level subgroup (activities with high mental, physical and social demands) had the largest effect on ADL, sequentially followed by *moderate*, then *low* multitask activity level subgroups. Howe et al's., (2011) Cochrane review of exercise interventions on balance outcomes in older adults found that exercise programs involving gait, balance, co-ordination and functional exercises; muscle strengthening exercise; three-dimensional (3D) activities (e.g. tai chi, dancing) and multiple exercise types had the greatest impact on some indirect measures of balance. While there are key differences between Howe et al's review and the present review (such as the types of included activity interventions, groupings of activities, and outcome measures) there are several similar findings pertaining to the types of activities that appear to be most beneficial (e.g. 3D exercises that require dynamic, coordinated movements, memory, attention and social interaction). By using a coding system to identify the underlying mental, physical and social demands of physical activity types, the present review advances the current field of knowledge by moving beyond attempts to identify optimal types of physical activities, but to also theorize why some types of physical activities may be more effective than others.

Given the high prevalence of functional limitations, disability and disease within the older adult population, health status often poses a barrier to entry into physical activity (Chen, 2010). For older adults with mobility limitations, the promotion of gentler levels, and simpler types of physical activities may still be of benefit. However, findings of the present review demonstrate that *moderate* physical activity levels and *high* multitask activities provide the greatest benefits to ADL performance.

Strengths of the Review

This is the first systematic review to investigate the underlying mental, physical and social demands of different types of physical activity on ADLs in older adults. These findings have been coupled with physical activity levels to provide a more comprehensive investigation into the characteristics of different modalities of physical activity. Relying solely on quality-assessed RCTs improved the quality of evidence considered. The current review extends previously undertaken reviews (e.g. de Vries et al., 2012) by incorporating all four physical activity variables (frequency, intensity, time, type) into the results, in addition to a preliminary investigation regarding the intrinsic (multitask) nature of different types of physical activity.

Limitations

Substantial heterogeneity was present across the studies included in the meta-analyses; only a single study fell into the *high* physical activity level subcategory, meaning that conclusions for this level could not be drawn; classification of activities as having *high*, *moderate* and *low* levels of multitasking relied on subjective scoring methods and group consensus; asymmetry of the funnel plots (Figures 6-9) suggest that publication bias may be present; and due to a limited number of studies that met our inclusion criteria, participant samples from multiple different settings (e.g. community, care homes) were analyzed together.

Conclusion

In conclusion, this review demonstrates that engagement in physical activity has a beneficial effect on ability to undertake activities of daily living in older adults. While there are no clear effects of physical activity on self-reported measures of ADL, *moderate* physical activity levels that combine *high* levels of physical, mental and social demands are more advantageous for enhancing physical performance of ADLs. More RCTs are needed to explore the effect of increased physical activity (particularly *high* physical activity levels) on ADL, and further research is needed to develop reliable, valid measures of underlying, non-metabolic demands of different types of physical activity.

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Table 1

Characteristics of Included Studies

ID	Author, date	Design	Sample (n, IG and CG) IG:CG	Intervention (FITT)	Control (FITT)	Outcomes relevant to this review	Results
1	Antunes (2005)	RCT, Parallel trial, Individual randomization	Randomized, 23:23; Analyzed, 23:23	Stationary cycling, 20-60 minutes, 3 x weekly, 6 months	None	SF36-PF	The IG showed significant improvements in SF36-PF (p = <0.05), however, no change was detected in the CG
2	Barrett (2002)	RCT, Parallel trial, Individual randomization	Randomized, 22:22; Analyzed, 20:20	Strength training, 60 minutes, 2 x weekly, 10 weeks	Stretching	5STS, SF36-PF	Both groups significantly improved 5STS (p = <0.003), but only small improvements in the groups were seen in SF36-PF (p = >0.05)

3	Baum (2003)	RCT, Semi-crossover trial, Individual randomization	Randomized, 11:9; Analyzed, 11:9	Strength training 60 minutes, 3 x weekly, 6 months	Recreational therapy	TUG, BBS, PPT	Statistically significant improvements across all measures in IG (*p* = <0 .05) compared with CG (*p* = 0.068)
4	Benavent-Caballer (2014)	RCT, Parallel trial, Individual randomization	Randomized, 22:23 Analyzed, 22:23	Strength training, 30-35 minutes, 3 x weekly, 16 weeks	None	TUG, BBS, 6MWT, BI	All scores improved in the IG, with BI reaching statistical significance (*p* = 0.003) but not for the CG
5	Bird (2012)	RCT, Crossover trial, Individual randomization	Randomized, 17:15; Analyzed, 14:13	Pilates, 60 minutes, 2 x weekly, 5 weeks (6 week washout period)	None	TUG	Pooled data at study completion showed significant improvements for TUG in the IG (*p* = <0.001) but not the CG

6	Borges (2012)	RCT, Parallel trial, Individual randomization	Randomized, 80 (total); Analyzed, 39:36	Dancing, 50 minutes, 3 x weekly, 8 months	None	FA	The IG significantly improved in FA (*p* = <0.001), but no improvement was found in the CG
7	Buchner (1997)	RCT, Parallel trial, Individual randomization	Randomized, IG1, 25; IG2, 25; CG, 30; Analyzed, IG1, 21; IG2, 22; CG, 29;	IG1 stationary cycling; IG2 strength training. 60 minutes, 3 x weekly, 6 months	None	IADL	There were no changes in IADL for any group (*p* = >0.05)
8	Cassilhas (2007)	RCT, Parallel trial, Individual randomization	Randomized, IG1, 20; IG2, 19; CG, 23; Analyzed,	IG1 strength training (50% 1RM); IG2 strength training (80% 1RM). 60 minutes,	Light exercises	SF36-PF	Groups did not differ significantly on SF36-PF measures (p = >0.05)

			IG1, 20; IG2, 19; CG, 23	3 x weekly, 24 weeks			
9	Chin A Paw (2006)	RCT, Parallel trial, Individual randomization	Randomized, IG1, 57; IG2, 60; CG, 51; Analyzed, IG1, 40; IG2, 44; CG, 31	IG1 strength training (45-60 minutes); IG2 functional skills training (40-55 minutes). 2 x weekly, 6 months	Educational program	5STS	No significant differences between groups were observed (p = >0.05)
10	Cruz-Ferreira (2015)	RCT, Parallel trial, Individual randomization	Randomized, 39:39; Analyzed, 32:25	Dancing 50 minutes, 3 x weekly, 6 months	None	8FUAG, 6MWT	The IG significantly improved 8FUAG (p = 0.02) and 6MWT (p = 0.1) compared with the CG

11	Day (2012)	RCT, Parallel trial, Individual randomization	Randomized, 250:253; Analyzed, 190:171	Tai Chi 60 minutes, 2 x weekly, 24 weeks	Flexibility exercise	TUG, 6MWT, BBS-Mod	Little difference was observed within or between the two groups for TUG, 6MWT or BBS (*p* = >0.05)
12	De Vreede (2005)	RCT, Parallel trial, Individual randomization	Randomized, IG1, 33; IG2, 34; CG, 31; Analyzed, IG1, 30; IG2, 28; CG, 26	IG1 Functional training; IG2 Strength training. 60 minutes, 3 x weekly, 12 weeks	None	ADAP, TUG, SF36-PF	ADAP scores improved significantly more in IG1 compared with IG2 (*p* = 0.007) and CG (*p* = 0.001). Groups did not differ in TUG (*p* = 1.0). SF36-PF scores increased more in IG2 (*p* = 0.02) compared with the other groups.
13	Dechamps (2010)	RCT, Parallel trial,	Randomized, 51:60; Analyzed,	Tai chi, 30 minutes, 4 x weekly, 6 months	Usual care	Katz ADL, TUG, 5STS	The CG significantly declined in ADL (*p* = <0.001), TUG (*p* = 0.003)

		Individual randomization	45:54				and 5STS (p = <0.001) whereas IG scores did not change (p = >0.05).
14	Eyigor (2009)	RCT, Parallel trial, Individual randomization	Randomized, 40 (total); Analyzed, 19:18	Dancing, 60 minutes, 3 x weekly, 8 weeks	None	6MWT, BBS, SF36-PF	The IG improved significantly in 6MWT, BBS and SF36-PF (p = <0.05), while the CG showed no change
15	Faber (2006)	RCT, Parallel trial, Cluster randomization	Randomized, IG1, 80; IG2, 94; CG, 104; Analyzed, IG1, 54; IG2, 70; CG, 84	IG1 functional training; IG2 balance training 90 minutes, 1 x weekly, 4 weeks, then 2 x weekly, 16 weeks	Usual activity	GARS	Compared with the CG, the IG1 demonstrated small, significant improvements in GARS ($p < 0.05$).

16	Fahlman (2007)	RCT, Parallel trial, Individual randomization	Randomized, 39:33; Analyzed, 39:33	Strength training 40 minutes, 3 x weekly, 16 weeks	None	6MWT	All groups improved 6MWT performance (*p* = <0.5),
17	Federici (2005)	RCT, Parallel trial, Individual randomization	Randomized, 20:20; Analyzed, 20:20	Dancing, 60 minutes, 2 x weekly, 3 months	None	SUG	Compared with the CG, the IG significantly improved in SUG scores (*p* = <0.001)
18	Gothe (2015)	RCT, Parallel trial, Individual randomization	Randomized, 61:57; Analyzed, 58:50	Yoga, 60 minutes, 3 x weekly, 8 weeks	Stretching	8FUAG	Both groups showed improvements, with a significant time effect for 8FUAG (*p* = <0.001)
19	Granacher (2012)	RCT, Parallel trial, Individual randomization	Randomized, 16:16; Analyzed, 16:16	Core instability strength training, 60 minutes, 2 x weekly, 9 weeks	None	TUG	The IG significantly improved TUG scores (*p* = <0.05) whereas the CG showed no change

20	Holmerova´ (2010)	RCT, Parallel trial, Individual randomization	Randomized, 90 (total); Analyzed, 27:25	Dancing, 75 minutes, 1 x weekly, 12 weeks	None	TUG	The IG significantly outperformed the CG in TUG (*p* = 0.14)
21	Hosseini (2011)	RCT, Parallel trial, Individual randomization	Randomized, 15:15; Analyzed, 15:15	Aquafit, 60 minutes, 3 x weekly, 8 weeks	None	BBS, 5STS, TUG	BBS, 5STS and TUG scores improved significantly in the IG (*p* = <0.05) whereas the CG showed no change
22	Jorgensen (2013)	RCT, Parallel trial, Individual randomization	Randomized, 28:30; Analyzed, 27:30	Wii fit, 40 minutes, 2 x weekly, 10 weeks	Usual activity	TUG	The IG improved significantly in TUG (*p* = 0.01) compared to the CG
23	Kalapotharakos (2006)	RCT, Parallel trial,	Randomized, 12:11; Analyzed,	Walking, 20-40 minutes, 3 x weekly, 12 weeks	None	6MWT, 5STS	The IG significantly improved in 6MWT and 5STS (*p* = <0.05), whereas

		Individual randomization	12:10				no improvement was seen in the CG
24	Kovách (2013)	RCT, Parallel trial, Individual randomization	Randomized, IG1, 22; IG2, 17; CG, 15; Analyzed, IG1, 22; IG2, 17; CG, 15	IG1 Pilates; IG2 aquafit. 60 minutes, 3 x weekly, 6 months	None	6MWT, 8FUAG	Both IG's significantly improved in 6MWT (*p* = <0.001) and 8FUAG (IG1, *p* = <0.001; IG2, *p* = <0.01), with the IG1 improving the most, whereas the CG showed little change
25	Maillot (2012)	RCT, Parallel trial, Individual randomization	Randomized, 16:16; Analyzed, 15:15	Exergaming (Wii), 60 minutes, 2 x weekly, 12 weeks	None	6MWT, 8FUAG	The IG significantly improved in both measures (*p* = <0.5) compared with the CG.

26	McKinley (2008)	RCT, Parallel trial, Individual randomization	Randomized, 15:15; Analyzed, 14:11	Dancing, 90 minutes, 2 x weekly, 10 weeks	Walking	5STS	Both groups improved, with the IG reaching statistical significance (*p* = <0.5)
27	McMurdo (1993)	RCT, Parallel trial, Cluster randomization	Randomized, 20:29; Analyzed, 15:26	Strength training 45 minutes, 2 x weekly, 7 months	Reminiscence sessions	BI	The IG post-test BI scores were significantly different to the CG (*p* = <0.5)
28	Mesquita (2015)	RCT, Parallel trial, Individual randomization	Randomized, IG1, 21; IG2, 21; CG, 21; Analyzed, IG1, 20; IG2, 20; CG, 18	IG1 Stretching; IG2 Pilates. 50 minutes, 3 x weekly, 4 weeks	None	BBS, TUG	Both IG's improved significantly in TUG (*p* = <0.001) and BBS (*p* = 0.001) with little change in the CG

29	Moore-Harrison (2008)	RCT, Parallel trial, Individual randomization	Randomized, 13:13; Analyzed, 12:12	Walking, 30-60 minutes, 3 x weekly, 16 weeks	Nutritional intervention	SF36-PF	The IG significantly improved in SF36-PF (*p* = <0.001), while the CG showed little change
30	Nagai (2012)	RCT, Parallel trial, Individual randomization	Randomized , 24:24; Analyzed, 24:24	Balance training, 40 minutes, 2 x weekly, 8 weeks	None	TUG	The IG improved significantly in TUG (*p* = <0.5) whereas the CG did not change
31	Ni (2014)	RCT, Parallel trial, Individual randomization	Randomized, IG1, 16; IG2, 16; CG, 16; Analyzed, IG1, 11; IG2, 13; CG, 15	IG1 Tai chi; IG2 yoga 60 minutes, 2 x weekly, 12 weeks	Standard balance	8FUAG	Significant 8FUAG improvements were observed in all groups (*p* = <0.5), with the IG2 showing the greatest improvement
32	Oken (2006)	RCT, Parallel trial,	Randomized,	IG1 Yoga, 90 minutes, 1 x	None	SF36-PF, 5STS	SF36-PF scores did not change in either IG,

		Individual randomization	IG1, 44; IG2, 47; CG, 42; Analyzed, IG1, 38; IG2, 38; CG, 42	weekly, 6 months; IG2 Walking, 60 minutes, 1 x weekly, 6 months			whereas the CG scores declined (*p* = 0.62). Small improvements in 5STS were seen in IG1 and CG, whereas the IG2 declined in performance (*p* = 0.5)
33	Oliveira (2015)	RCT, Parallel trial, Individual randomization	Randomized, 16:16; Analyzed, 16:16	Pilates, 60 minutes, 2 x weekly, 12 weeks	Stretching	BBS, TUG, SF36-PF	The IG significantly improved in TUG, BBS and SF36-PF (*p* = <0.05). The CG showed no change
34	Pinto (2014)	RCT, Parallel trial, Individual randomization	Randomized, 19:17; Analyzed, 19:17	Strength training, 35-40 minutes, 2 x weekly, 6 weeks	None	8FUAG	The IG significantly improved in 8FUAG (*p* = <0.001) while the CG showed no change

35	Rendon (2012)	RCT, Parallel trial, Individual randomization	Randomized, 20:20; Analyzed, 16:18	Exergaming, 35-45 minutes, 3 x weekly, 6 weeks	None	8FUAG	The IG significantly improved in 8FUAG compared with the CG (p = 0.0385)
36	Rodrigues (2010)	RCT, Parallel trial, Individual randomization	Randomized, 27:25; Analyzed, 27:25	Pilates, 60 minutes, 2 x weekly, 8 weeks	None	FA	The IG significantly improved in FA compared with the CG (p = 0.0003)
37	Saravanakumar (2014)	RCT, Parallel trial, Individual randomization	Randomized, IG1, 11; IG2, 11; CG, 11 Analyzed, IG1, 8; IG2, 5; CG, 10	IG1 Tai chi; IG2 Yoga. 30 minutes, 2 x weekly, 14 weeks	Usual care	BBS	IG2 was the only group to show an improvement in BBS, while the other groups declined in performance (p = 0.456)
38	Sato (2007)	RCT, Parallel trial,	Randomized,	Aquafit	Recreation activities	SF36-PF, FIM	Significant pre-post differences were found for

		Individual randomization	IG1, 10; IG2, 12; CG, 8; Analyzed, IG1, 10; IG2, 11; CG, 8	60 minutes, once/twice x weekly, 6 months			IG1 (*p* = 0.004) and IG2 (*p* = 0.002) in FIM. No significant differences were observed in SF36-PF (*p* = >0.05)
39	Shimanda (2003)	RCT, Parallel trial, Individual randomization	Randomized, IG1 12, IG2 12, CG 10; Analyzed, IG1 12, IG2 11, CG 9	IG1 balance training; IG2 walking 40 minutes, 2-3 x weekly, 12 weeks	Usual care (physiotherapy)	TUG	All three groups improved in TUG scores, with only IG2 scores reaching statistical significance (*p* = <0.05).
40	Stanziano (2009)	RCT, Parallel trial, Individual randomization	Randomized, 8:9; Analyzed, 5:8	Active, assisted stretching, 30 minutes, 2 x weekly, 8 weeks	Arts and crafts	8FUAG	The IG showed significant improvement in the 8FUAG (*p* = 0.041) while the CG significantly

							declined in performance (*p* = 0.007)
41	Tiedemann (2013)	RCT, Parallel trial, Individual randomization	Randomized, 27:27; Analyzed, 27:25	Yoga, 60 minutes, 2 x weekly, 12 weeks	None	5STS	The IG improved significantly in 5STS (*p* = <0.001) whereas the CG showed a decline in scores.
42	Tousignant (2012)	RCT, Parallel trial, Individual randomization	Randomized, 76:76; Analyzed, 26:34	Tai chi, 60 minutes, 2 x weekly, 15 weeks	Physiotherapy	BBS, TUG	Both groups improved similarly over time in both measures (*p* = .0.001)
43	Tsang (2013)	RCT, Parallel trial, Individual randomization	Randomized, 69:65; Analyzed, 42:35	Qigong 60 minutes, 2 x weekly, 12 weeks	Newspaper reading	TUG	TUG scores improved in the IG and declined in the CG, but this did not reach statistical significance (*p* = 0.54)

44	Tse (2010)	RCT, Parallel trial, Cluster randomization	Randomized, 26:27; Analyzed, 26:27	Gardening, 1 hour per week (over 3-5 days), 8 weeks	Normal care	BI	There were no significant differences in BI for either group (*p* = >0.05)
45	Varela (2011)	RCT, Parallel trial, Individual randomization	Randomized, IG1, 27; IG2, 26; CG, 15; Analyzed, IG1, 27; IG2, 26; CG, 15	IG 1 stationary cycling (40% HRR); IG 2 stationary cycling (60% HRR). 30 minutes, 3 x weekly, 12 weeks	Recreation activities	TUG	TUG scores improved across all groups, but did not reach statistical significance (*p* = >0.05)
46	Wei (2014)	RCT, Parallel trial, Individual randomization	Randomized, 30:30; Analyzed, 30:30	Handball 30 minutes, 5 x weekly, 6 months	None	IADL	ADL decreased in the IG group (*p* = <0.05), while there were no changes in the CG

47	Wolf (2001)	RCT, Parallel trial, Individual randomization	Randomized, 47:47; Analyzed, 37:40	Balance training 30 minutes, 2-3 x weekly, 4-6 weeks (12 sessions total)	Arts and crafts	BBS	The IG improved significantly in BBS compared with the CG (*p* = <0.001)

Note. ID = Study Identification; QA = Quality Assessment; IG = Intervention Group; CG = Control Group; RCT = Randomized Controlled Trial; FITT = Frequency, Intensity, Time, Type; 5STS = 5-times-Sit-to-Stand; 6MWT = 6-meter Walk Test; 8FUG = 8-Foot Up-and-Go; ADAP = Assessment of Daily Activity Performance; BBS = Berg Balance Scale; BI = Barthel Index; FIM = Functional Independence Measure; FA = GDLAM's protocol of Functional Autonomy evaluation; GARS = Groningen Activities Restriction Scale; IADL = Lawton Instrumental Activities of Daily Living; Katz ADL = Katz Index of Independence in Activities of Daily Living; PPT = Physical Performance Test; SUG = Sit-Up-and-Go; SF36-PF = MOS Short form, physical functioning subscale; TUG = Timed Up-and-Go.

Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram of identification and selection of studies

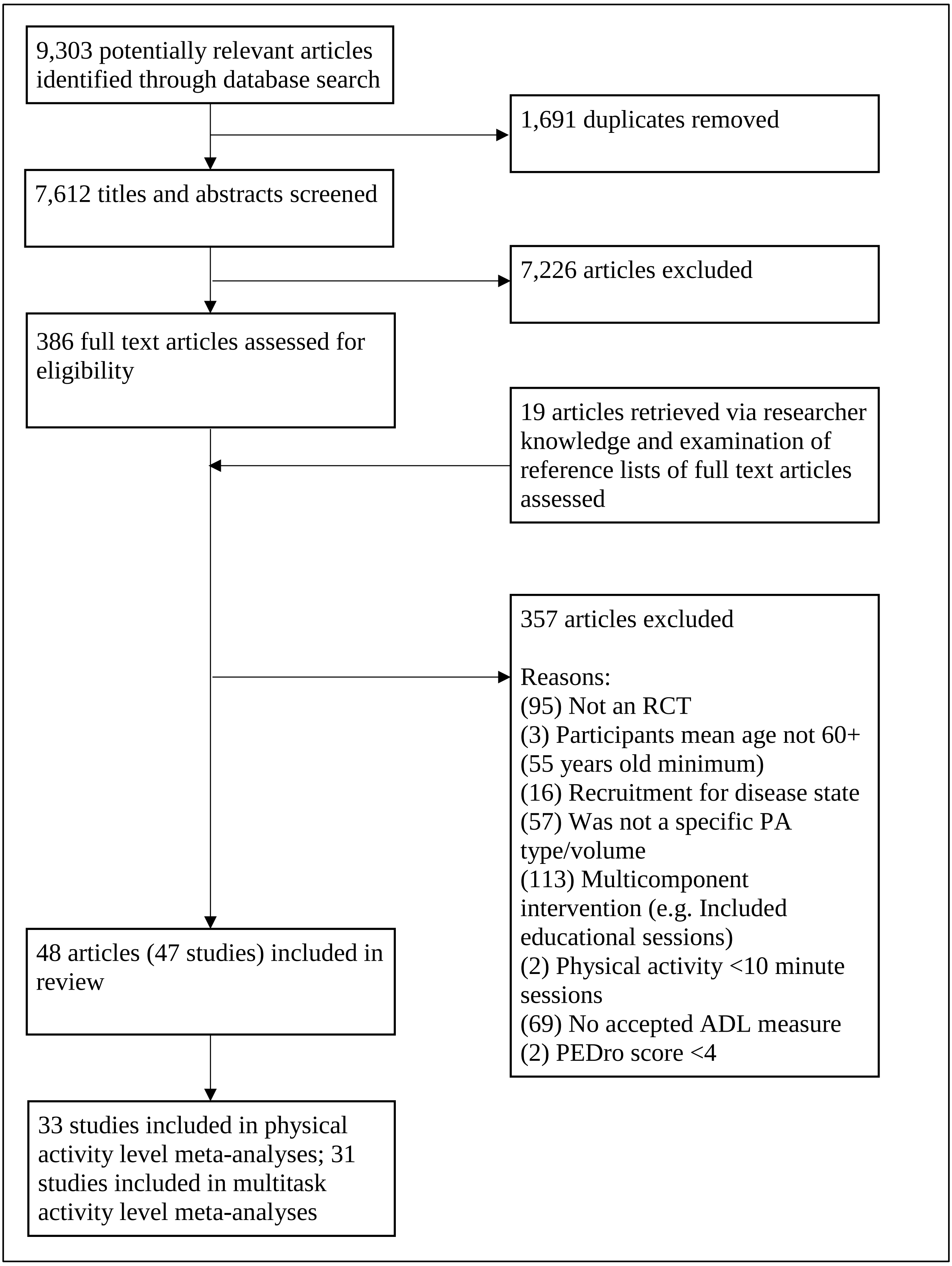


Figure 2. Physical Activity Level (with *low*, *moderate* and *high* subgroups) versus control on physical performance ADL outcomes

	Experimental			Control				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.1.2 *Low* physical activity level								
Barrett (2002)	-10.2	2.3	20	-9.2	1.2	20	3.5%	-0.53 [-1.17, 0.10]
Benavent-Caballer (2014)	-10.97	3.09	22	-12.41	7.42	23	3.6%	0.25 [-0.34, 0.83]
Fahlman (2007)	-1,327	437.15	39	-1,404	413.61	33	3.8%	0.18 [-0.29, 0.64]
Granacher (2012)	-9.1	0.6	16	-9.8	0.8	16	3.3%	0.96 [0.23, 1.70]
Holmerova (2010)	-11.7	5.9	27	-23.4	14.5	25	3.6%	1.06 [0.47, 1.64]
Jorgensen (2013)	-9	3.2	27	-10.9	5.1	30	3.7%	0.44 [-0.09, 0.96]
Kalapotharakos (2006)	-11.5	1.4	12	-12.1	1.7	10	3.1%	0.37 [-0.47, 1.22]
Nagai (2012)	-7.5	1.7	24	-9.2	2.3	24	3.6%	0.83 [0.24, 1.42]
Ni (2014)	-6.65	0.04	24	-7.23	0.39	15	3.1%	2.35 [1.50, 3.20]
Oken (2006)	-9.6	2.55	76	-9.1	2.1	42	4.0%	-0.21 [-0.58, 0.17]
Oliveira (2015)	-5.7	1	16	-7.4	1.1	16	3.2%	1.58 [0.77, 2.38]
Pinto (2014)	-3.83	0.35	19	-4.74	0.59	17	3.2%	1.86 [1.06, 2.66]
Rodrigues (2010)	-23.58	3.96	27	-27.19	3.58	25	3.6%	0.94 [0.36, 1.52]
Saravanakumar (2014)	33.57	16.57	13	29.6	14.3	10	3.1%	0.24 [-0.58, 1.07]
Shimanda (2003)	-23.17	17.76	23	-17	4.9	9	3.2%	-0.39 [-1.17, 0.39]
Stanziano (2009)	-7.6	2.4	5	-14.6	11	8	2.4%	0.73 [-0.43, 1.90]
Tiedmann (2013)	-8.8	2.6	27	-13.6	6.1	25	3.6%	1.02 [0.44, 1.60]
Tousignant (2012)	-20.5	6.8	26	-21.7	3	34	3.8%	0.24 [-0.28, 0.75]
Tsang (2013)	-22.18	12.7	42	-22.17	11.72	35	3.9%	-0.00 [-0.45, 0.45]
Wolf (2001)	42.5	11.11	37	38	12.75	40	3.9%	0.37 [-0.08, 0.82]
Subtotal (95% CI)			**522**			**457**	**69.2%**	**0.57 [0.29, 0.86]**
Heterogeneity: Tau² = 0.32; Chi² = 85.22, df = 19 (P < 0.00001); I² = 78%								
Test for overall effect: Z = 3.92 (P < 0.0001)								
1.1.4 *Moderate* physical activity level								
Borges (2012)	-55.56	8.21	39	-62.34	9.58	36	3.8%	0.75 [0.28, 1.22]
Cruz-Ferreira (2015)	-6.57	0.2	32	-9.01	0.76	25	2.7%	4.59 [3.57, 5.61]
Eyigor (2009)	55.3	0.85	19	53.9	1.7	18	3.4%	1.03 [0.34, 1.72]
Federici (2005)	-6.3	0.5	20	-6.9	0.6	20	3.4%	1.06 [0.40, 1.73]
Gothe (2015)	-5.23	0.8	58	-5.52	1.03	50	4.0%	0.32 [-0.07, 0.70]
Hosseini (2011)	-6.75	0.38	15	-7.59	0.52	15	3.0%	1.79 [0.93, 2.66]
Kovach (2013)	-5.2	0.62	39	-5.6	0.8	15	3.6%	0.59 [-0.02, 1.19]
McKinley (2008)	-12.36	4.4	14	-12.31	3.39	11	3.2%	-0.01 [-0.80, 0.78]
Varela (2011)	-16.92	3.29	53	-17.65	6.81	15	3.6%	0.17 [-0.41, 0.74]
Subtotal (95% CI)			**289**			**205**	**30.8%**	**1.07 [0.44, 1.70]**
Heterogeneity: Tau² = 0.81; Chi² = 74.58, df = 8 (P < 0.00001); I² = 89%								
Test for overall effect: Z = 3.34 (P = 0.0008)								
1.1.6 *High* physical activity level								
Subtotal (95% CI)			**0**			**0**		**Not estimable**
Heterogeneity: Not applicable								
Test for overall effect: Not applicable								
Total (95% CI)			**811**			**662**	**100.0%**	**0.72 [0.45, 1.00]**
Heterogeneity: Tau² = 0.45; Chi² = 166.16, df = 28 (P < 0.00001); I² = 83%								
Test for overall effect: Z = 5.16 (P < 0.00001)								
Test for subgroup differences: Chi² = 1.98, df = 1 (P = 0.16), I² = 49.6%								

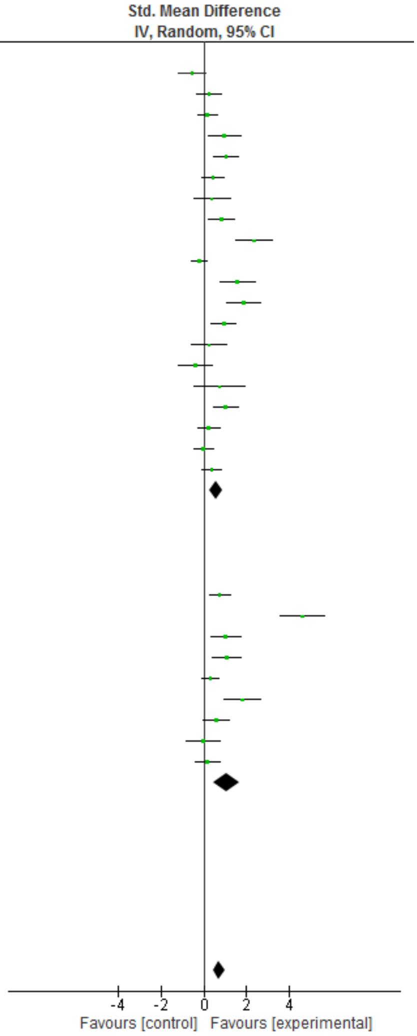


Figure 3. Physical Activity Level (with *low*, *moderate* and *high* subgroups) versus control on self-reported ADL outcomes

	Experimental			Control				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.1.1 *Low* physical activity level								
Barrett (2002)	73.8	19	20	78.5	16.9	20	11.4%	-0.26 [-0.88, 0.37]
Benavent-Caballer (2014)	92.22	6.69	22	93.33	6.51	23	11.6%	-0.17 [-0.75, 0.42]
Oken (2006)	83.55	14.92	76	86.7	9.6	42	12.6%	-0.24 [-0.61, 0.14]
Oliveira (2015)	93.4	10.9	16	76.2	22.6	16	10.7%	0.95 [0.21, 1.68]
Subtotal (95% CI)			**134**			**101**	**46.3%**	**0.02 [-0.46, 0.49]**
Heterogeneity: Tau² = 0.15; Chi² = 8.49, df = 3 (P = 0.04); I² = 65%								
Test for overall effect: Z = 0.07 (P = 0.95)								
1.1.3 *Moderate* physical activity level								
Antunes (2005)	97.82	2.53	23	91.08	6.56	23	11.2%	1.33 [0.69, 1.98]
Eyigor (2009)	88.8	12.2	19	79.6	16	18	11.1%	0.64 [-0.03, 1.30]
Moore-Harrison (2008)	85.8	13.6	12	65	16.4	12	9.7%	1.33 [0.43, 2.23]
Sato (2007)	30.19	8.75	21	16.1	12.8	8	9.7%	1.38 [0.48, 2.27]
Subtotal (95% CI)			**75**			**61**	**41.8%**	**1.12 [0.74, 1.49]**
Heterogeneity: Tau² = 0.00; Chi² = 3.00, df = 3 (P = 0.39); I² = 0%								
Test for overall effect: Z = 5.86 (P < 0.00001)								
1.1.5 *High* physical activity level								
Wei (2014)	14.43	0.639	30	15.47	1.66	30	11.9%	-0.82 [-1.34, -0.29]
Subtotal (95% CI)			**30**			**30**	**11.9%**	**-0.82 [-1.34, -0.29]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 3.03 (P = 0.002)								
Total (95% CI)			**239**			**192**	**100.0%**	**0.41 [-0.12, 0.94]**
Heterogeneity: Tau² = 0.55; Chi² = 52.84, df = 8 (P < 0.00001); I² = 85%								
Test for overall effect: Z = 1.51 (P = 0.13)								
Test for subgroup differences: Chi² = 36.84, df = 2 (P < 0.00001), I² = 94.6%								

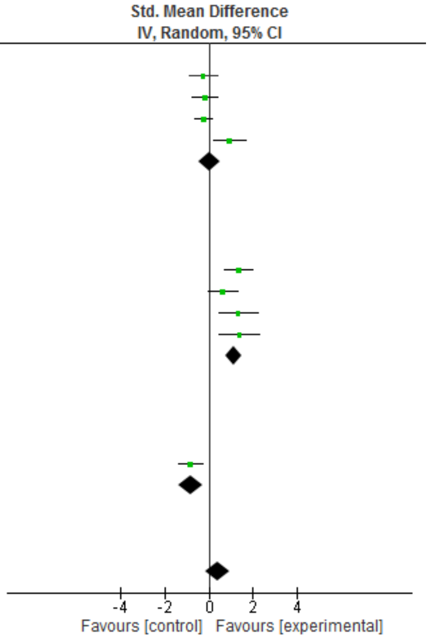


Figure 4. Multitask Activity Level (with *low*, *moderate* and *high* subgroups) versus control on physical performance ADL outcomes

	Experimental			Control				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.1.1 *Low* multitask activity level								
Barrett (2002)	-10.2	2.3	20	-9.2	1.2	20	3.8%	-0.53 [-1.17, 0.10]
Benavent-Caballer (2014)	-10.97	3.09	22	-12.41	7.42	23	3.9%	0.25 [-0.34, 0.83]
Fahlman (2007)	-1,327	437.15	39	-1,404	413.61	33	4.2%	0.18 [-0.29, 0.64]
Granacher (2012)	-9.1	0.6	16	-9.8	0.8	16	3.6%	0.96 [0.23, 1.70]
Kalapotharakos (2006)	-11.5	1.4	12	-12.1	1.7	10	3.3%	0.37 [-0.47, 1.22]
Pinto (2014)	-3.83	0.35	19	-4.74	0.59	17	3.4%	1.86 [1.06, 2.66]
Stanziano (2009)	-7.6	2.4	5	-14.6	11	8	2.6%	0.73 [-0.43, 1.90]
Varela (2011)	-16.92	3.29	33	-17.65	6.81	15	3.8%	0.15 [-0.46, 0.77]
Subtotal (95% CI)			**166**			**142**	**28.6%**	**0.45 [-0.01, 0.91]**
Heterogeneity: Tau² = 0.31; Chi² = 25.44, df = 7 (P = 0.0006); I² = 72%								
Test for overall effect: Z = 1.91 (P = 0.06)								
1.1.2 *Moderate* multitask activity level								
Gothe (2015)	-5.23	0.8	58	-5.52	1.03	50	4.3%	0.32 [-0.07, 0.70]
Hosseini (2011)	-6.75	0.38	15	-7.59	0.52	15	3.3%	1.79 [0.93, 2.66]
Jorgensen (2013)	-9	3.2	27	-10.9	5.1	30	4.0%	0.44 [-0.09, 0.96]
Kovach (2013)	-5.2	0.62	39	-5.6	0.8	15	3.9%	0.59 [-0.02, 1.19]
Nagai (2012)	-7.5	1.7	24	-9.2	2.3	24	3.9%	0.83 [0.24, 1.42]
Ni (2014)	-6.65	0.04	24	-7.23	0.39	15	3.3%	2.35 [1.50, 3.20]
Oliveira (2015)	-5.7	1	16	-7.4	1.1	16	3.4%	1.58 [0.77, 2.38]
Rodrigues (2010)	-23.58	3.96	27	-27.19	3.58	25	3.9%	0.94 [0.36, 1.52]
Saravanakumar (2014)	33.57	16.57	13	29.6	14.3	10	3.3%	0.24 [-0.58, 1.07]
Tiedmann (2013)	-8.8	2.6	27	-13.6	6.1	25	3.9%	1.02 [0.44, 1.60]
Tousignant (2012)	-20.5	6.8	26	-21.7	30	34	4.1%	0.05 [-0.46, 0.56]
Tsang (2013)	-22.18	12.7	42	-22.17	11.72	35	4.2%	-0.00 [-0.45, 0.45]
Wolf (2001)	42.5	11.11	37	38	12.75	40	4.2%	0.37 [-0.08, 0.82]
Subtotal (95% CI)			**375**			**334**	**49.7%**	**0.74 [0.41, 1.06]**
Heterogeneity: Tau² = 0.25; Chi² = 48.70, df = 12 (P < 0.00001); I² = 75%								
Test for overall effect: Z = 4.48 (P < 0.00001)								
1.1.3 *High* multitask activity level								
Borges (2012)	-55.56	8.21	39	-62.34	9.58	36	4.2%	0.75 [0.28, 1.22]
Cruz-Ferreira (2015)	-6.57	0.2	32	-9.01	0.76	25	2.9%	4.59 [3.57, 5.61]
Eyigor (2009)	55.3	0.85	19	53.9	1.7	18	3.7%	1.03 [0.34, 1.72]
Federici (2005)	-6.3	0.5	20	-6.9	0.6	20	3.7%	1.06 [0.40, 1.73]
Holmerova (2010)	-11.7	5.9	27	-23.4	14.5	25	3.9%	1.06 [0.47, 1.64]
McKinley (2008)	-12.36	4.4	14	-12.31	3.39	11	3.4%	-0.01 [-0.80, 0.78]
Subtotal (95% CI)			**151**			**135**	**21.8%**	**1.36 [0.46, 2.26]**
Heterogeneity: Tau² = 1.13; Chi² = 54.92, df = 5 (P < 0.00001); I² = 91%								
Test for overall effect: Z = 2.95 (P = 0.003)								
Total (95% CI)			**692**			**611**	**100.0%**	**0.79 [0.51, 1.07]**
Heterogeneity: Tau² = 0.44; Chi² = 145.97, df = 26 (P < 0.00001); I² = 82%								
Test for overall effect: Z = 5.51 (P < 0.00001)								
Test for subgroup differences: Chi² = 3.20, df = 2 (P = 0.20), I² = 37.5%								

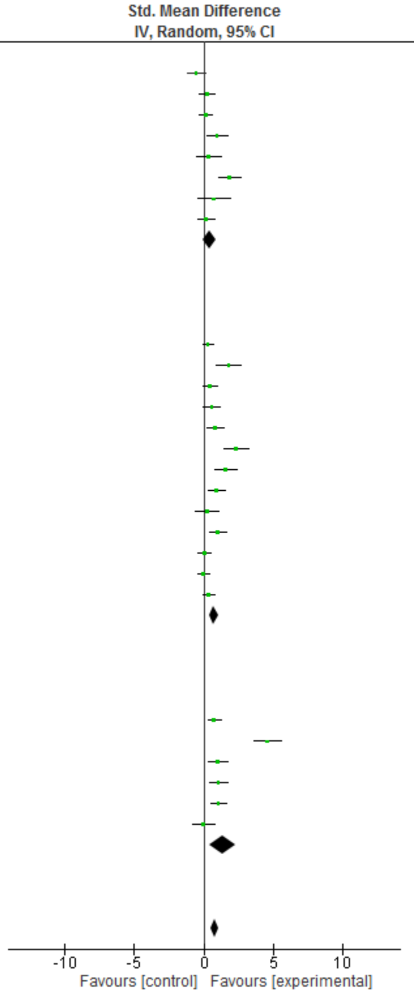


Figure 5. Multitask Activity Level (with *low*, *moderate* and *high* subgroups) versus control on self-reported ADL outcomes

	Experimental			Control				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.1.4 *Low* multitask activity level								
Antunes (2005)	97.82	2.53	23	91.08	6.56	23	12.8%	1.33 [0.69, 1.98]
Barrett (2002)	73.8	19	20	78.5	16.9	20	12.9%	-0.26 [-0.88, 0.37]
Benavent-Caballer (2014)	92.22	6.69	22	93.33	6.51	23	13.1%	-0.17 [-0.75, 0.42]
Moore-Harrison (2008)	85.8	13.6	12	65	16.4	12	11.3%	1.33 [0.43, 2.23]
Subtotal (95% CI)			**77**			**78**	**50.2%**	**0.53 [-0.34, 1.40]**
Heterogeneity: Tau² = 0.66; Chi² = 20.02, df = 3 (P = 0.0002); I² = 85%								
Test for overall effect: Z = 1.20 (P = 0.23)								
1.1.5 *Moderate* multitask activity level								
Oliveira (2015)	93.4	10.9	16	76.2	22.6	16	12.3%	0.95 [0.21, 1.68]
Sato (2007)	30.19	8.75	21	16.1	12.8	8	11.3%	1.38 [0.48, 2.27]
Subtotal (95% CI)			**37**			**24**	**23.6%**	**1.12 [0.55, 1.69]**
Heterogeneity: Tau² = 0.00; Chi² = 0.53, df = 1 (P = 0.47); I² = 0%								
Test for overall effect: Z = 3.85 (P = 0.0001)								
1.1.6 *High* multitask activity level								
Eyigor (2009)	88.8	12.2	19	79.6	16	18	12.7%	0.64 [-0.03, 1.30]
Wei (2014)	14.43	0.639	30	15.47	1.66	30	13.4%	-0.82 [-1.34, -0.29]
Subtotal (95% CI)			**49**			**48**	**26.2%**	**-0.10 [-1.53, 1.32]**
Heterogeneity: Tau² = 0.96; Chi² = 11.27, df = 1 (P = 0.0008); I² = 91%								
Test for overall effect: Z = 0.14 (P = 0.89)								
Total (95% CI)			**163**			**150**	**100.0%**	**0.51 [-0.11, 1.13]**
Heterogeneity: Tau² = 0.67; Chi² = 46.99, df = 7 (P < 0.00001); I² = 85%								
Test for overall effect: Z = 1.62 (P = 0.11)								
Test for subgroup differences: Chi² = 3.09, df = 2 (P = 0.21), I² = 35.3%								

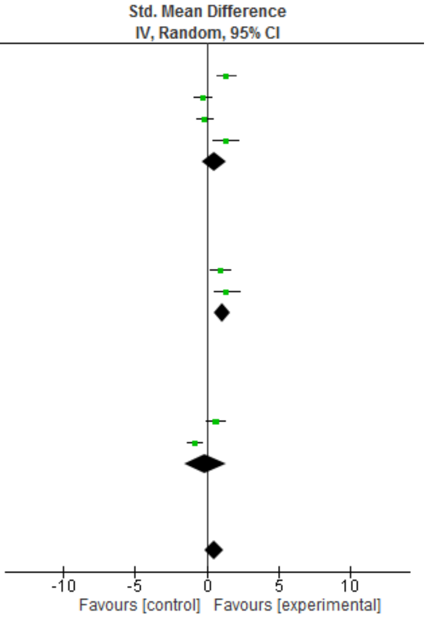
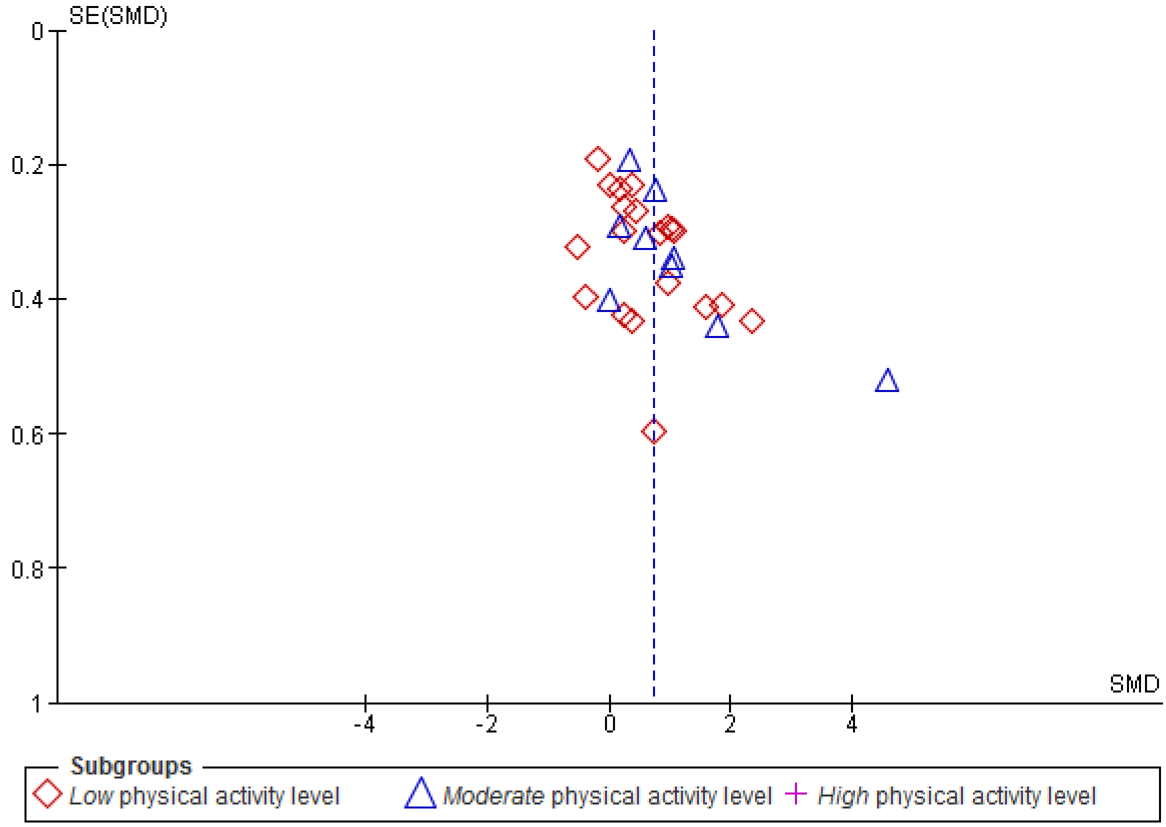
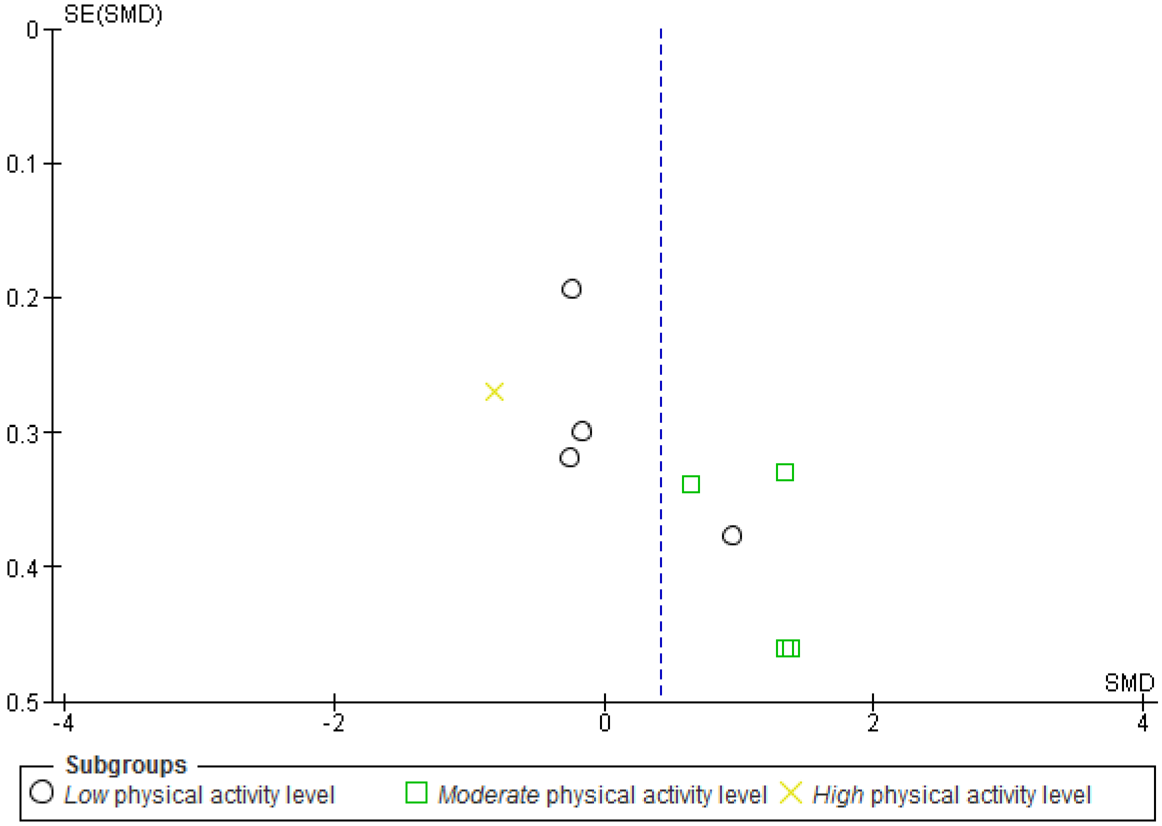


Figure 6. Funnel plot of physical activity level (subcategorized as *low*, *moderate* and *high*) versus control on ADL physical performance measures



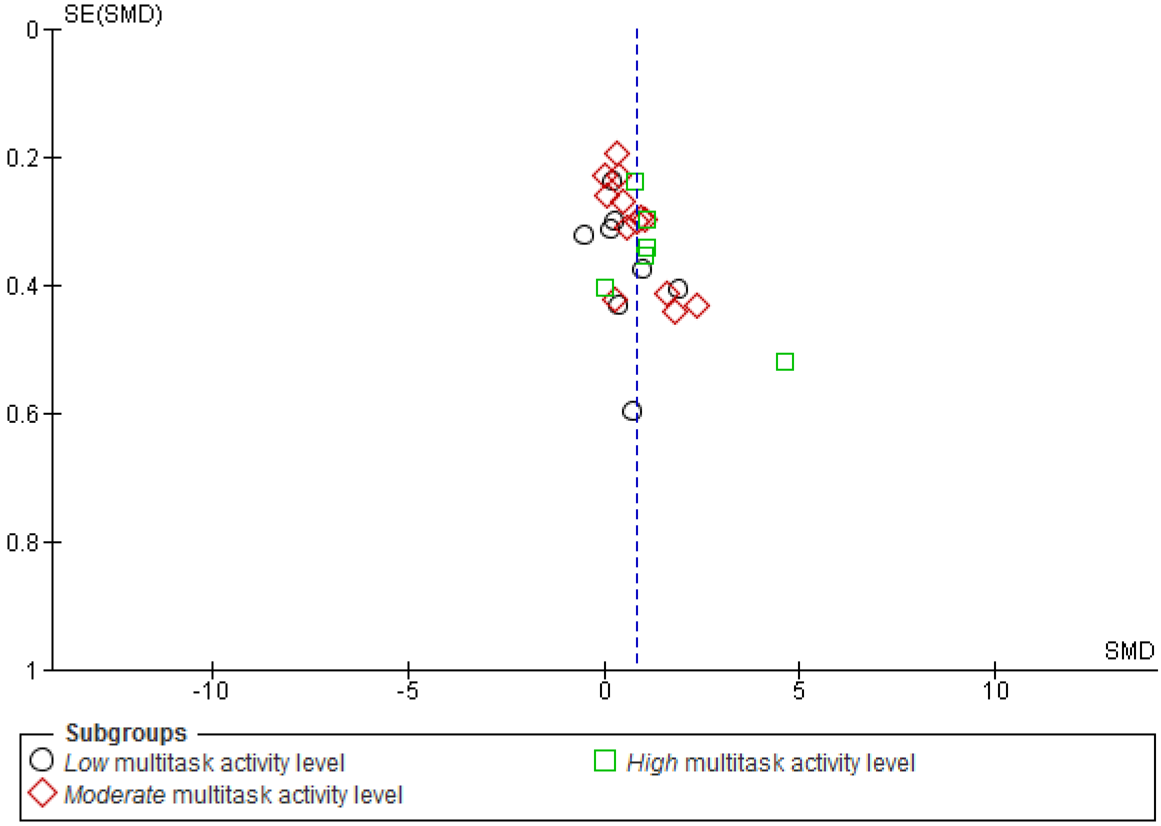
Note. *SMD* = Standardized Mean Difference

Figure 7. Funnel plot of physical activity level (subcategorized as *low*, *moderate* and *high*) versus control on ADL self-reported measures



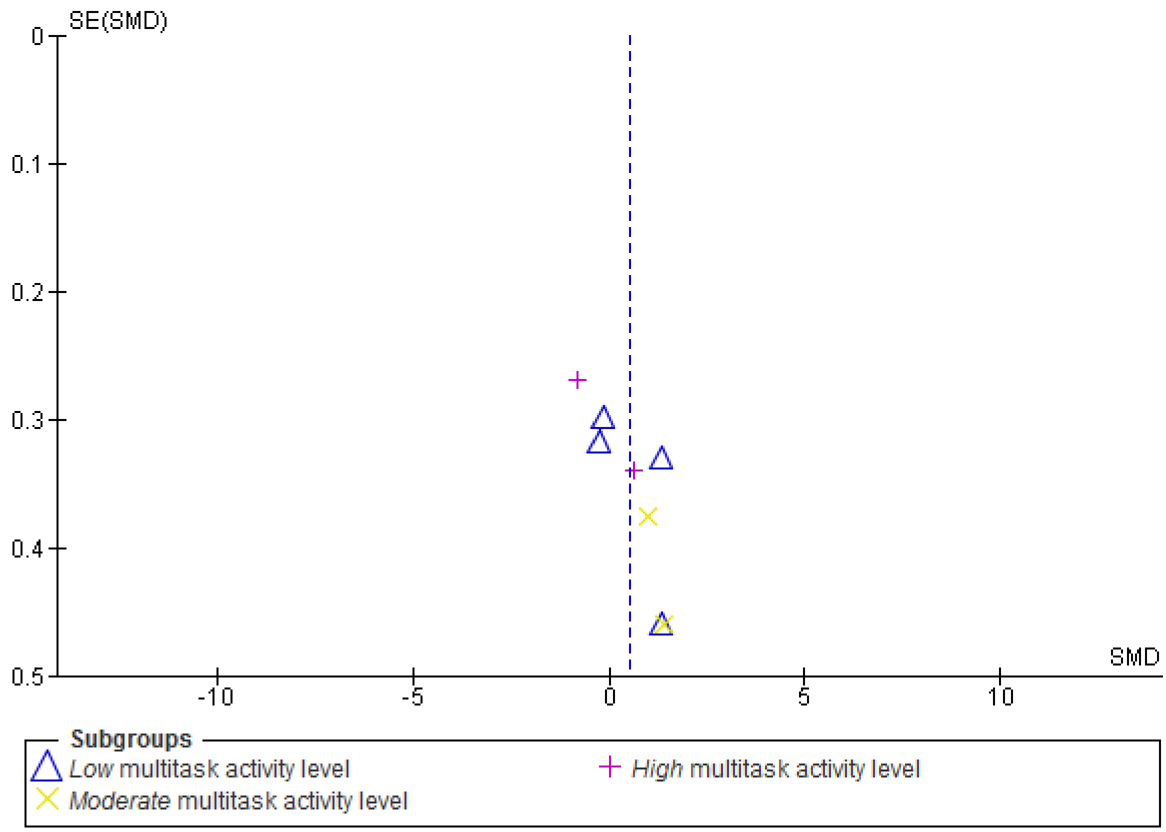
Note. *SMD* = Standardized Mean Difference

Figure 8. Funnel plot of multitask activity level (subcategorized as *low*, *moderate* and *high*) versus control on ADL physical performance measures



Note. *SMD* = Standardized Mean Difference

Figure 9. Funnel plot of multitask activity level (subcategorized as *low*, *moderate* and *high*) versus control on ADL self-reported measures



Note. *SMD* = Standardized Mean Difference

Supplementary File 1: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) <1946 to Present>

1. exp exercise/

2. recreation/ or camping/ or dancing/ or gardening/ or hobbies/

3. exp sports/

4. exp exercise movement techniques/

5. (physical adj2 (activit$ or inactivit$)).ti.

6. exercis$.ti.

7. or/1-7

8. "Activities of Daily Living"/

9. geriatric assessment/

10. disability Evaluation/

11. mobility limitation/

12. Disabled Persons/

13. Hypokinesia/

14. Cognitive Disorders/ or mild cognitive impairment/

15. ((cognitive or cognition or physical or mobility or functional) adj2 (limit$ or impair$ or deteriorat$ or decreas$ or declin$ or status or independence)).ti.

16. ((cognitive or cognition or physical or mobility) adj2 (status or function$ or assess$ or evaluat$)).ti.

17. or/8-16

18. exp aged/

19. (aged or elder$ or geriatric or old).ti.

20. 18 or 19 (2492671)

21. 7 and 17 and 20 (5308)

22. 21 not (letter or editoral or comment or case reports).pt. (4860)

23. limit 22 to english language (4530)

24. remove duplicates from 24 (4447)

Supplementary File 2: References of excluded studies

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Supplementary File 3: Summary of Individual Intervention Arms

Reference, study arm (when more than one IG)	METs	PA level	PA Type	Multi-task level	5STS	6MWT	8FUG	ADAP	BBS	BI	FIM	GARS	FA	IADL	Katz ADL	PPT	SUG	SF36-PF	TUG
Antunes (2005)	576	M	Stationary cycling	L														↑↑	
Barrett (2002)	420	L	Strength training	L	↑↑													↑	
Baum (2003)	450	M	Strength training	L					↑↑							↑↑			↑↑
Benavent-Caballer (2014)	341.3	L	Strength training	L		↑			↑	↑↑									↑
Bird (2012)	540	M	Pilates	M															↑↑
Borges (2012)	450	M	Dancing	H									↑↑						
Buchner (1997) IG1	1224	H	Stationary cycling	L										⇔					
Buchner (1997) IG2	630	M	Strength training	L										⇔					
Cassilhas (2007) IG1	1080	H	Strength training	L														↑	
Cassilhas (2007) IG2	900	H	Strength training	L														↑	
Chin (2006) IG1	367.5	L	Strength training	L	⇔														
Chin (2006) IG2	332.5	L	Functional training	M	↑														
Cruz-Ferreira (2015)	675	M	Dancing	H		↑↑	↑↑												
Day (2012)	360	L	Tai chi	M		⇔			⇔										⇔
De Vreede (2005 &7) IG1	540	M	Functional training	M				↑↑										⇔	⇔
De Vreede (2005/7) IG2	630	M	Strength training	L				↑										↑↑	⇔
Dechamps (2010)	360	L	Tai chi	M	↑↑										↑↑				↑↑
Eyigor (2009)	810	M	Dancing	H		↑↑			↑↑									↑↑	
Faber (2006) IG1	540	M	Functional training	M								↑↑							

Reference, study arm (when more than one IG)	MET score	PA level	PA Type	Multi-task level	5STS	6MWT	8FUG	ADAP	BBS	BI	FIM	GARS	FA	IADL	Katz ADL	PPT	SUG	SF36-PF	TUG
Faber (2006) IG2	540	M	Balance training	M								⇔							
Fahlman (2007)	420	L	Strength training	L		↑													
Federici, (2005)	540	M	Dancing	H													↑↑		
Gothe (2015)	450	M	Yoga	M			↑↑												
Granacher (2013)	336	L	Strength training	L															↑↑
Holmerová (2010)	225	L	Dancing	H															↑↑
Hosseini (2011)	810	M	Aquafit	M	↑↑				↑↑										↑↑
Jorgensen (2013)	184	L	Exergaming	M															↑↑
Kalapotharakos (2006)	315	L	Walking	L	↑↑	↑↑													
Kovách (2013) IG1	540	M	Pilates	M		↑↑	↑↑												
Kovách (2013) IG2	990	H	Aquafit	M		↑↑	↑↑												
Maillot (2012)	456	M	Exergaming	M		↑↑	↑↑												
McKinley (2008)	540	M	Dancing	H	↑↑														
McMurdo (1993)	315	L	Strength training	L						↑↑									
Mesquita (2015) IG1	276	L	Flexibility training	L					↑↑										↑↑
Mesquita (2015) IG2	360	L	Pilates	M					↑↑										↑↑
Moore-Harrison (2008)	472.5	M	Walking	L														↑↑	
Nagai (2012)	184	L	Balance training	M															↑↑
Ni (2014) IG1	360	L	Tai chi	M			↑↑												
Ni (2014) IG2	480	M	Yoga	M			↑↑												
Oken (2006) IG1	225	L	Yoga	M	↑													⇔	

Reference, study arm (when more than one IG)	METs	PA level	PA Type	Multi-task level	5STS	6MWT	8FUG	ADAP	BBS	BI	FIM	GARS	FA	IADL	Katz ADL	PPT	SUG	SF36-PF	TUG
Oken (2006) IG2	210	L	Walking	L	↓													⇔	
Oliveira (2015)	360	L	Pilates	M					↑↑									↑↑	↑↑
Pinto (2014)	375	L	Strength training	L			↑↑												
Rendon (2012)	276	L	Exergaming	M			↑↑												
Rodrigues (2010)	360	L	Pilates	M									↑↑						
Saravanakumar (2014) IG1	180	L	Tai chi	M					↓										
Saravanakumar (2014) IG2	150	L	Yoga	M					↑										
Sato (2007) IG1	330	L	Aquafit	M							↑↑							↑↑	
Sato (2007) IG2	660	M	Aquafit	M							↑↑							↑↑	
Shimanda (2003) IG1	230	L	Balance training	M															↑
Shimanda (2003) IG2	350	L	Walking	L															↑↑
Stanziano (2009)	138	L	Flexibility training	L			↑↑												
Tiedemann (2013)	300	L	Yoga	M	↑↑														
Tousignant (2012)	360	L	Tai chi	M					↑↑										↑↑
Tsang (2013)	360	L	Qigong	M															↑
Tse (2010)	138	L	Gardening	L						⇔									
Varela (2012) IG1	315	L	Stationary cycling	L															↑
Varela (2012) IG2	612	M	Stationary cycling	L															↑
Wei (2014)	1200	H	Handball	H										↓					
Wolf (2001)	207	L	Balance training	M					↑↑										

Note. ID = Identification; IG = Intervention Group; METs = Weekly MET-minutes; PA = Physical Activity; L = Low; M = Moderate; H = High; 5STS = 5-times-Sit-to-Stand; 6MWT = 6-meter Walk Test; 8FUG = 8-Foot Up-and-Go; ADAP = Assessment of Daily Activity Performance; BBS = Berg Balance Scale; BI = Barthel Index; FIM = Functional Independence Measure;

FA = GDLAM's protocol of Functional Autonomy evaluation; GARS = Groningen Activities Restriction Scale; IADL = Lawton Instrumental Activities of Daily Living; Katz ADL = Katz Index of Independence in Activities of Daily Living; PPT = Physical Performance Test; SUG = Sit-Up-and-Go; SF36-PF = MOS Short form, physical functioning subscale; TUG = Timed Up-and-Go; ↑↑ = a significant ($p<0.05$) effect in favor of the IG; ↑ = an improvement in IG scores that is not statistically significant; ⇔ = no change in IG scores; ↓ = a decline in IG scores that is not statistically significant.

Supplementary File 4: Multitask Activity Level Coding Results

Round 1: Independent scoring by three researchers

Physical activity	Attention/ concentration	Memory	Decision-making and strategy	Social interaction	Flexibility	Balance	Coordination	Speeded reaction
Balance training	A = 1 B = 1 C = 2	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 2 B = 1 C = 2	A = 2 B = 2 C = 2	A = 3 B = 3 C = 3	A = 2 B = 2 C = 2	A = 1 B = 1 C = 1
Functional training	A = 1 B = 1 C = 2	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 2 B = 1 C = 2	A = 1 B = 2 C = 2	A = 2 B = 2 C = 2	A = 2 B = 2 C = 2	A = 1 B = 1 C = 1
Flexibility training	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 2 B = 1 C = 2	A = 2 B = 2 C = 2	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1
Yoga	A = 2 B = 2 C = 2	A = 2 B = 3 C = 2	A = 1 B = 1 C = 1	A = 2 B = 2 C = 2	A = 3 B = 3 C = 3	A = 3 B = 3 C = 3	A = 2 B = 2 C = 2	A = 1 B = 1 C = 1
Pilates	A = 2 B = 2 C = 2	A = 2 B = 2 C = 2	A = 1 B = 1 C = 1	A = 2 B = 2 C = 2	A = 2 B = 3 C = 3	A = 3 B = 3 C = 3	A = 2 B = 2 C = 2	A = 1 B = 1 C = 1
Tai chi	A = 2 B = 3 C = 2	A = 2 B = 3 C = 2	A = 1 B = 1 C = 1	A = 2 B = 2 C = 2	A = 3 B = 2 C = 2	A = 3 B = 3 C = 3	A = 3 B = 2 C = 2	A = 1 B = 1 C = 1
Qigong	A = 2 B = 3 C = 2	A = 2 B = 3 C = 2	A = 1 B = 1 C = 1	A = 2 B = 2 C = 2	A = 3 B = 2 C = 2	A = 3 B = 3 C = 3	A = 3 B = 2 C = 2	A = 1 B = 1 C = 1

Strength training	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 2 B = 2 C = 2	A = 2 B = 2 C = 2	A = 1 B = 2 C = 2	A = 1 B = 2 C = 1	A = 1 B = 1 C = 1
Aqua Fit	A = 2 B = 3 C = 3	A = 2 B = 1 C = 2	A = 1 B = 1 C = 1	A = 3 B = 3 C = 3	A = 2 B = 2 C = 2	A = 1 B = 2 C = 2	A = 2 B = 2 C = 2	A = 1 B = 1 C = 1
Exergaming e.g. Wii Sports	A = 2 B = 2 C = 2	A = 2 B = 1 C = 2	A = 2 B = 1 C = 3	A = 1 B = 1 C = 2	A = 1 B = 1 C = 2	A = 2 B = 2 C = 2	A = 3 B = 2 C = 2	A = 3 B = 2 C = 3
Cycling (stationary)	A = 2 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 2 B = 2 C = 1	A = 2 B = 1 C = 1	A = 2 B = 1 C = 2
Walking	A = 2 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 2 B = 1 C = 2	A = 1 B = 1 C = 1	A = 2 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1
Gardening	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 2 B = 2 C = 2	A = 2 B = 1 C = 2	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1	A = 1 B = 1 C = 1
Handball	A = 2 B = 3 C = 3	A = 2 B = 2 C = 2	A = 2 B = 3 C = 3	A = 3 B = 3 C = 3	A = 1 B = 2 C = 2	A = 2 B = 1 C = 2	A = 2 B = 3 C = 3	A = 3 B = 3 C = 3
Dancing	A = 2 B = 2 C = 2	A = 3 B = 3 C = 3	A = 2 B = 2 C = 2	A = 2 B = 2 C = 2	A = 2 B = 2 C = 3	A = 2 B = 3 C = 3	A = 3 B = 3 C = 3	A = 2 B = 3 C = 3

Note: shaded areas indicate items that did not reach 100% agreement in Round 1; A = researcher 1 scores; B = researcher 2 scores; C = researchers 3 scores; 1 = little or none required; 2 = a moderate amount required; 3 = a high amount required.

Round 2: Group discussion of remaining non-agreed items

Physical activity	Attention/ concentration	Memory	Decision-making and strategy	Social interaction	Flexibility	Balance	Coordination	Speeded reaction
Balance training	2			2				
Functional training	2			2	2			
Flexibility training				2				
Yoga		2						
Pilates					3			
Tai chi	2	3			2		2	
Qigong	2	3			2		2	
Strength training						2	1	
Aqua Fit	2	2				2		
Exergaming e.g. Wii Sports		2	2	2	2		2	2
Cycling (stationary)	1					1	1	1
Walking	1			2		1		
Gardening				1				
Handball	3		2		2	2	3	
Dancing					2	3		2

Note: 1 = little or none required; 2 = a moderate amount required; 3 = a high amount required.

Completed Scores and Assigned Multitask Level

Physical activity	Attention/ concentration	Memory	Decision-making and strategy	Social interaction	Flexibility	Balance	Coordination	Speeded reaction	Total score	Outcome
Balance training	2	1	1	2	2	3	2	1	14	Moderate
Functional training	2	1	1	2	2	2	2	1	13	Moderate
Flexibility training	1	1	1	2	2	1	1	1	10	Low
Yoga	2	2	1	2	3	3	2	1	16	Moderate
Pilates	2	2	1	2	3	3	2	1	16	Moderate
Tai chi	2	3	1	2	2	3	2	1	16	Moderate
Qigong	2	3	1	2	2	3	2	1	16	Moderate
Strength training	1	1	1	2	2	2	1	1	11	Low
Aqua Fit	2	2	1	3	2	2	2	1	15	Moderate
Exergaming e.g. Wii Sports	2	2	2	2	2	2	2	2	16	Moderate
Cycling (stationary)	1	1	1	1	1	1	1	1	8	Low
Walking	1	1	1	2	1	1	1	1	9	Low
Gardening	1	1	2	1	1	1	1	1	9	Low
Handball	3	2	2	3	2	2	3	3	20	High
Dancing	2	3	2	2	2	3	3	2	19	High

Note: 1 = little or none required; 2 = a moderate amount required; 3 = a high amount required. Total score: 8-11 = low; 13-16 = moderate; 19-20 = high.